June 17, 1941. H. RODER 2,246,188

TUNED CIRCUIT

Filed Nov. 12, 1938

Fig. 1.

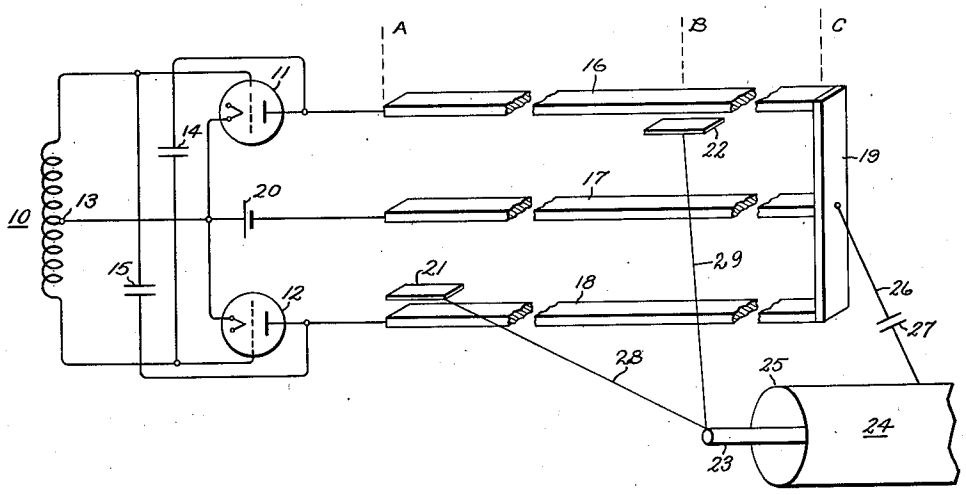
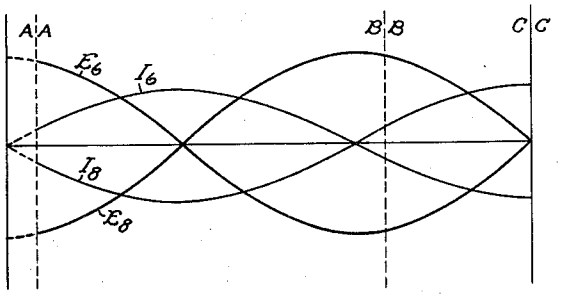


Fig. 2.



Inventor:
Hans Roder,
by Harry E. Dunham
His Attorney.

Patented June 17, 1941

2,246,188

UNITED STATES PATENT OFFICE

2,246,188

TUNED CIRCUIT

Hans Roder, Schenectady, N. Y., assignor to General Electric Company, a corporation of New York

Application November 12, 1938, Serial No. 240,142

3 Claims. (Cl. 179—171)

This invention relates to tuned circuits for transferring energy from an alternating current source to a consumption device.

The output stage of a radio transmitter is usually arranged in push-pull arrangement in order to facilitate satisfactory neutralization. The tuned circuits used for transferring the output of such an arrangement to the consumption circuit must then be arranged in what is known as a double ended circuit. The consumption device, which usually comprises a transmission line and an aerial, can usually be designed for more efficient operation if arranged as a single ended circuit. It is an object of this invention to provide an improved arrangement for the transfer of energy between double ended and single ended circuits, wherein equipotential points on both sides of the double ended circuit are connected to one terminal of the single ended circuit. This invention is especially useful at very short wave lengths in the region where tuned circuits having distributed inductance and capacity are practicable.

It is the further object of this invention to provide means for transferring the energy from a double ended circuit to a single ended circuit or from the latter to the former in which the adjustments for balance of the double ended circuit may be effected with increased facility.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof may best be understood by reference to the following description taken in connection with the accompanying drawing in which Fig. 1 illustrates schematically a circuit embodying my invention, and Fig. 2 shows curves illustrating the operation of the circuit of Fig. 1.

A source of sustained oscillations, not shown, is connected by means of a coupling transformer, the secondary winding only of which is indicated at 10, to a conventional push-pull circuit including two electron discharge amplifiers 11 and 12 having their cathodes connected together to a center tap 13 of coupling transformer 10, and their grids connected to opposite ends of transformer 10. The anode of the discharge device 11 is connected through a neutralizing condenser 14 to the grid of discharge device 12. Similarly the anode of discharge device 12 is connected through a neutralizing condenser 15 to the grid of discharge device 11.

The double ended tuned circuit which is connected in the anode-cathode circuit of discharge devices 11 and 12 may be a transmission line of any desired type having distributed inductance and capacity, and is preferably formed of flattened metal conductor strips 16, 17, and 18, which are arranged symmetrically and have their outer ends short circuited by a connection 19. The inner ends of the strips 16 and 18 are connected respectively to the anodes of discharge devices 11 and 12. The inner end of the electrically central strip 17 is connected through a suitable source of anode potential 20 to the cathodes of devices 11 and 12. The circuit described thus far comprises a neutralized push-pull amplifier in which a transmission line forms the tuned anode circuit.

A transmission line will be tuned to any particular wave length if its length be any odd multiple of one-quarter of a wave-length. By the term "odd multiple" in this specification I intend to include the multiple "one." In this particular circuit it is convenient to design the transmission line to have a length of three-quarter wave-lengths. Since the discharge devices 11 and 12 each have capacity between their anodes and their remaining electrodes, a transmission line of exactly three-quarter wave-lengths will not resonate due to the lumped capacity represented by the internal capacity of the discharge devices and the neutralizing capacity. If the transmission line be made somewhat shorter than three-quarter wave-lengths, it will resonate with that lumped capacity at the end of the line. The proper length of the transmission line may be determined from the relation: $L=\lambda/2+(\lambda/2\pi)\ \tan^{-1} X_c/Z_o$ where L is the length of the transmission line, λ is the operating wave-length, X_c is the reactance of the lumped capacity at the input end of one side of the transmission line, and Z_o is the surge impedance of one side of the transmission line, for example, strips 16 and 17.

The curves of Fig. 2 indicate the currents and voltages appearing along strips 16 and 18. Points AA, BB, and CC correspond to points A, B, and C, marked in Fig. 1 along the transmission line. Curves E_6 and I_6 represent respectively voltage and current appearing along strip 16, and curves E_8 and I_8 represent voltage and current appearing along strip 18. The voltages and currents indicated at AA on the curves are the voltages and currents at the point A at the end of the transmission line. These voltages and currents appear on the discharge devices.

It should be noted from the curves that the voltage (E_8) at point A on strip 18 is equal to and in phase with the voltage (E_6) at point B on strip 16. These points are therefore equi-potential points and may be connected together to feed a single ended circuit.

A small metal plate or electrode 21 is placed near the strip 18 at point A. A second metal plate 22 is placed near the strip 16 at B. These two impedance coupling electrodes are adapted to be variably spaced from their respective strips. The plates 21 and 22 are connected respectively by a pair of standing wave lines 28 and 29 to the terminal of the center line 23 of a concentric conductor 24 which may supply power to an antenna or radiator. The transmission line 16, 17, and 18; the concentric conductor; and these standing wave lines should all be as nearly geometrically symmetrical as possible. The standing wave lines from plates 21 and 22 to the center line 23 should be of equal length and equal surge impedance. The terminal of the outer conductor 25 of the concentric conductor 24 is connected to a suitable point on the electrically central strip 17, or to the short circuiting connection 19 by a symmetrical connection 26 in which is placed a blocking condenser 27. It will be noted that plates 21 and 22 need not be placed at points of maximum voltage, although in this embodiment of my invention they are placed at the point of highest available voltage. It is unnecessary to place the plates 21 and 22 at any particular place except to be certain that they are one-half wave-length apart and to avoid placing them near voltage nodes, such as that shown between AA and BB in Fig. 2. At such a node no energy could be picked up by a plate.

The plates 21 and 22 are adapted to regulate the balance of load on the two halves of the transmission line and the devices 11 and 12. By changing the spacing of plate 21 from strip 18, the amount of energy passing from strip 18 to concentric conductor 24 may be regulated. In like manner plate 22 may regulate the energy passing from strip 16 to conductor 24. It is, of course, clear that the positioning of plates 21 and 22 along the transmission line is not important, since the plates may be placed closer to strips 16 and 18 to pick up more energy if they are placed at a position of relatively low voltage and conversely they may be spaced farther from strips 16 and 18 if they be near the position of maximum voltage.

It will be seen that means are thus provided whereby a single ended consumption circuit such as the concentric conductor 24 may be conveniently connected to a double ended circuit, such as the transmission line comprising strips 16, 17, and 18, and whereby the respective loads taken from the half sections of the transmission line may be regulated or balanced to advantage. Although the particular embodiment of the invention is herein shown as a double ended anode circuit feeding into a single ended circuit, it is obvious that the invention may be used wherever it is desired to convert from single ended to double ended operation or vice versa. For example, a single ended circuit may, by use of the invention, energize a double ended tuned grid circuit for a pair of discharge devices in push-pull arrangement.

It will be understood that various modifications in application may be made without departing from the spirit of the invention. For instance, it is convenient, although not necessary, that the strips 16, 17, and 18 be made of flattened form. Likewise, other forms of tuned circuits having distributed inductances and capacity might be used, such as two concentric lines in place of the paired lines 16—17 and 18—17 respectively, rather than the transmission line shown. Although it is preferred that the consumption device be capacitively coupled to the respective half sections of the transmission line, it should be understood that it may be coupled by other types of impedance, such as inductance or resistance.

While I have shown a particular embodiment of my invention, it will, of course, be understood that I do not wish to be limited thereto since the different modifications may be made both in the circuit arrangement and instrumentalities employed, and I contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In combination, a balanced standing wave circuit comprising a first conductor and two conductors electrically symmetrical with respect thereto, a second circuit having one side arranged to transfer energy with said first conductor, and a pair of standing wave lines of equal length and surge impedance connecting the other side of said second circuit respectively to a pair of coupling means arranged to transfer energy with said two conductors of said balanced circuit, the positions of said coupling means along said conductors being spaced apart by an odd multiple of one-half wave-length of the operating frequency and being adjustable along said conductors to control the amount of energy transferable between said circuits.

2. In combination, a balanced standing wave circuit comprising two conductors arranged in parallel spaced relation, said conductors being in balanced electrical relation with respect to a third conductor and having standing waves impressed thereon which are opposite in phase with respect to each other, an unbalanced line having one conductor connected to said third conductor and having its opposite conductor connected through a pair of standing wave lines of substantially equal length and equal surge impedance to points on said two conductors of said balanced circuit, said points being spaced apart along the length of said balanced circuit by half of a wave length of said standing wave.

3. In combination, a balanced standing wave circuit comprising two conductors arranged in parallel spaced relation, said conductors being in balanced electrical relation with respect to a third conductor and having standing waves impressed thereon which are opposite in phase with respect to each other, an unbalanced line having one conductor connected to said third conductor and having its opposite conductor connected through a pair of standing wave lines of substantially equal length and equal surge impedance to respective capacitance electrodes, one of said electrodes being positioned near a point on one of said two conductors of said balanced circuit and the other capacitance electrode being positioned near a point on the other of said two conductors, said two points being spaced apart by half a wave length of said standing wave.

HANS RODER.