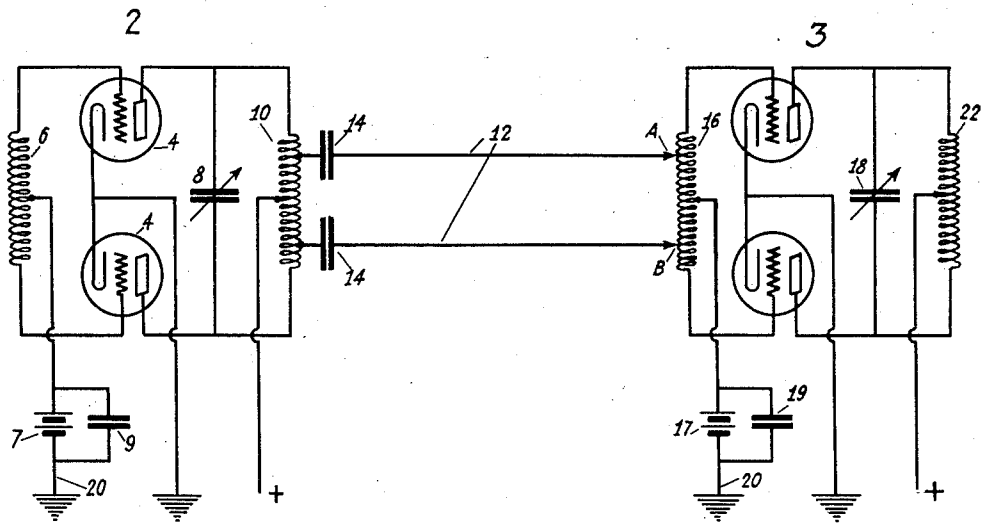
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COUPLING

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INVENTOR
C.W. HANSELL
BY Ira J. Adams
ATTORNEY

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CLARENCE W. HANSELL, OF ROCKY POINT, NEW YORK, ASSIGNOR TO RADIO CORPORATION OF AMERICA, A CORPORATION OF DELAWARE

COUPLING

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This invention relates to coupling between parts of electrical apparatus and more particularly to a method and means for coupling between stages of a high frequency transmitter.

In short wave apparatus considerable difficulty is experienced in coupling between parts of the apparatus owing to the fact that in some cases it is desirable to space these parts rather widely. In such a case it is found that the wires connecting widely separated portions of the apparatus have so great an inherent inductance or capacitance, that at the high frequencies involved, it becomes impossible to tune the circuits to the frequency desired. In addition to this the leads, at very high frequencies, may become considerable in length relative to the wave length, and high losses will be experienced in these leads. In fact, the potential gradient along a straight tube may be several hundred volts per inch. These facts have led to the enunciation and general adoption of the rule that all high frequency leads must be as short as possible, and heretofore the parts of high frequency apparatus have not been separated as they should, were it not for this requirement.

An object of my invention is to reconcile these conflicting requirements, and to efficiently couple parts of short wave apparatus while keeping them substantially spaced.

More especially, it is an object of my invention to efficiently couple the various amplification and frequency changer stages of a short wave transmitter while keeping these stages relatively far apart.

These objects I attain by utilizing for the coupling means a pair of conductors arranged as a transmission line, and by so coupling this transmission line that it will possess the characteristics of an infinite transmission line.

The specification is accompanied by a drawing, the single figure of which shows a wiring diagram for several embodiments of my invention.

Certain characteristics of a transmission line which may be demonstrated mathematically I shall more simply illustrate by reference to a supposititious transmission line extending to infinity. Such a transmission line of infinite length would obviously be characterized by a total absence of reflections and standing waves, for the reason that the impressed energy would never reach the end of the line to be reflected, and standing waves usually are caused by a reflected wave combining with the original wave.

If a source of current were connected to such a fictitious transmission line there would be no apparent difference between the consequent effect and that which would be caused by connecting a resistive load to the same source. The energy supplied to the line would be dissipated in it, for such energy could not conceivably reach the end of the line. As in the case of a resistive load, there would be a definite limit to the rate of flow of energy, because the rapidity of energy absorption would depend upon the flow velocity in the line, and this in turn depends, for both a finite and an infinite line, upon the relative inductive and capacitive characteristics of the line, as determined by the physical dimensions and spacing of the conductors composing it. This equivalent resistance or apparent impedance of a transmission line of specified transverse dimensions when supposed of infinite length is termed the characteristic impedance of the line.

Now suppose that at a finite distance from the beginning of such a fictitious infinite transmission line a break is made. Then, because a finite substracted from an infinite leaves an infinite, the line extending from the break to infinity would still be an infinite transmission line, and would still have the same characteristic impedance as before. The finite transmission line extending to the break typifies a transmission line in use, and if, across the remote terminals of this finite transmission line, an impedance is connected equal to the characteristic impedance of the infinite transmission line, then the finite transmission line will possess all of the desirable features already attributed to the fictitious line, namely, no reflections and standing waves, substantially unity power

factor, and substantially no wattless current losses.

Referring now to the drawing, and considering only amplification desired, the unit 2 represents one push-pull stage of amplification, while the unit 3 represents a succeeding stage of amplification which is to be coupled to the unit 2. In the unit 2 the control electrodes of the tubes 4 are influenced by the input coil 6. The midpoint of this coil is connected to the cathodes of the tubes through a C battery 7, and is placed directly at ground potential, for the high frequency energy, by means of the by-pass condenser 9. The output of the stage is applied to the tuned circuit comprising the condenser 8 and the coil 10, to which the conductors 12 are coupled by means of the blocking condensers 14.

The amplification stage 3 is similar to the amplification stage 2, and to the input coil 16 thereof, the conductors 12 are coupled at points "A" and "B" so spaced that the impedance therebetween is equal to the characteristic impedance of the conductors 12, considered as a transmission line.

It is desirable that the circuits involved be kept symmetrical with respect to ground potential. It is obvious that the circuit here disclosed is perfectly symmetrical with respect to the ground potential, as indicated by the location of the ground connection 20.

The same drawing serves to illustrate another application of my invention, which is to couple together frequency changers, or to couple an amplifier to a frequency changer or vice versa. For convenience and simplicity the frequency changer indicated employs vacuum tubes as the means to generate harmonics, and to obtain this effect it is merely necessary to alter the grid bias and radio frequency excitation of the tubes. Thus if a 20 meter wave were desired, the circuit 8, 10 might be tuned to 40 meters, and the circuit 18, 22 to 20 meters, while the bias potential and excitation of 17 would differ from that of 7 to cause the output of stage 3 to be rich in harmonics.

Obviously, stages 2 and 3 might both be frequency changers, or stage 2 might be a frequency changer and stage 3 an amplifier. In addition, by efficient adjustment it is possible to obtain the second harmonic in such degree that a single stage will both double frequency and amplify, as has been disclosed in my copending application Serial Number 177,505, filed March 23, 1927.

It is to be appreciated that the impedance between the points A and B may be resistive or capacitive, as well as inductive, so long as its value, at the working frequency, is equal to the characteristic impedance of the transmission line. As already indicated, the invention is not restricted to the coupling of amplification stages, but is equally applicable to the coupling together of any of the component parts of high frequency radio apparatus.

What I claim is:

1. In energy transformation in electron emission tubes, the method which includes increasing the separation between stages to reduce interaction between, and improve the accessibility of the successive electron emission tube stages, and reducing the coupling losses by joining them by direct coupling, and so adjusting the coupling points at the succeeding stage that the impedance between said coupling points equals the characteristic impedance of the direct coupling means.

2. In combination, the output circuit of one electron emission tube stage of a radio set, the input circuit of a succeeding electron emission tube stage of said radio set, and means to couple said output and input circuits comprising two conductors so coupled to the input circuit that the impedance across which the conductors are connected is equal to the characteristic impedance of the conductors, in order to reduce coupling losses and to permit convenient spacing of the stages.

3. The combination with a short wave transmitter having successive electron emission tube stages, of means for coupling said electron emission tube stages comprising a transmission line the external impedance across one terminus of which is so adjusted that there is substantially no wattless current in the transmission line, in order to reduce coupling losses and to permit convenient spacing of the stages.

4. The combination with a short wave transmitter having successive symmetrical stages of push-pull amplification, of means for symmetrically coupling said stages comprising a transmission line the external impedance across one terminus of which is so adjusted that there is substantially no wattless current in the transmission line, in order to reduce coupling losses and to permit convenient spacing of the stages.

5. In combination, a short wave transmitter having intermediate and final stages of amplification, blocking condensers, and a transmission line coupled to the intermediate stage through said blocking condensers, and to the final stage in such manner that the external impedance across the line is equal to the characteristic impedance of the line, in order to reduce coupling losses and to permit convenient spacing of the stages.

6. In communication equipment, a preceding stage push-pull output circuit, a succeeding stage push-pull input circuit, blocking condensers, and a transmission line coupled to the output circuit through the blocking condensers, and to the input circuit at points the impedance between which is such that no standing waves are set up in the transmission line.

7. In communication equipment, a preceding stage push-pull output circuit, a succeeding stage push-pull input circuit, an intermediate point of which is at ground potential, blocking condensers, and a transmission line coupled to the output circuit through the blocking condensers, and to the input circuit at points symmetrically located with respect to the point of ground potential, the impedance between which points is such that no standing waves are set up in the transmission line.

C. W. HANSELL.