April 29, 1947. W. E. BRADLEY 2,419,882

WIDE BAND INTERSTAGE COUPLING NETWORK

Filed Jan. 10, 1944

Fig. 1.

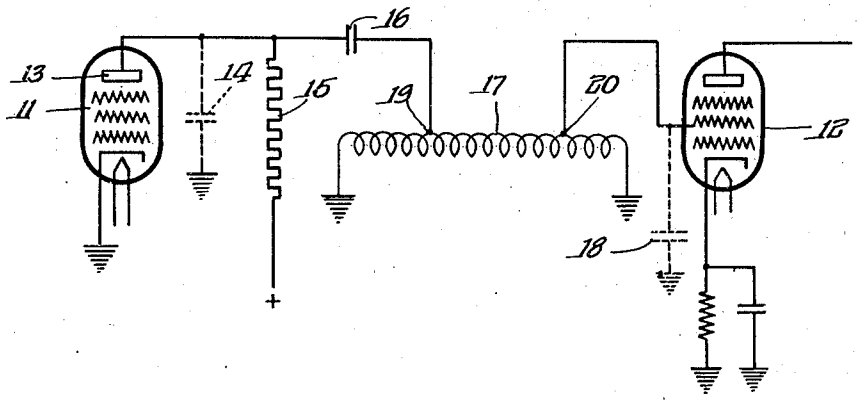
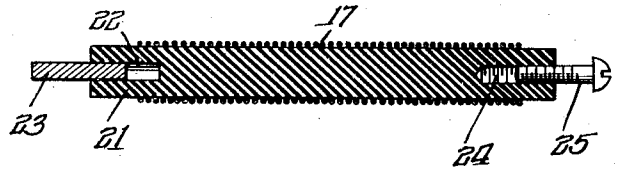


Fig. 2.



INVENTOR.
William E. Bradley
by his Attorneys
Howson & Howson

Patented Apr. 29, 1947

2,419,882

UNITED STATES PATENT OFFICE

2,419,882

WIDE BAND INTERSTAGE COUPLING NETWORK

William E. Bradley, Swarthmore, Pa., assignor, by mesne assignments, to Philco Corporation, Philadelphia, Pa., a corporation of Pennsylvania

Application January 10, 1944, Serial No. 517,650

11 Claims. (Cl. 179—171)

1

The present invention relates to amplifier circuits, and more particularly to amplifier circuits such as are suitable for operation at relatively high frequencies in the range of ten to two hundred megacycles, and for amplifying relatively wide frequency bands of the order of five to twenty megacycles.

Heretofore numerous wide frequency band amplifiers have been devised such as those commonly utilized in television receivers. The interstage coupling networks ordinarily used consist of two tuned circuits with reactive coupling provided by a π or T network of reactances joining the two circuits or by mutual inductive coupling, which is equivalent to an inductance T network.

Such amplifiers are adequate for present day television receivers, but when much wider bands are required the above mentioned arrangements are unnecessarily complicated mechanically, difficult of realization, or difficult to construct and align in mass production.

It is, therefore, desirable to provide a wide-band inter-stage coupling network requiring less mechanical accuracy in its construction and which, for that reason, is better adapted to mass production methods. In accordance with the present invention, that end is achieved by substituting for the plural coupling inductances heretofore employed, a single inductance having a high ratio of length to diameter and having two intermediate taps which preferably are connected respectively to the plate and control grid of the vacuum tubes which are to be coupled, which inductance is tuned by the electrode-to-ground capacity of the intercoupled vacuum tubes to the band of frequencies which it is intended to transmit.

One of the primary objects of this invention is to provide a wide-band interstage coupling network which is well adapted to economical mass production.

Another object is to provide a coupling network of the above indicated character wherein necessary tuning adjustments can easily and quickly be made.

The invention itself is set forth in particularity in the appended claims, and other objects and advantages will become apparent by referring to the following description taken in connection with the accompanying drawing, wherein—

Figure 1 is a circuit diagram illustrating an interstage coupling network for a wide band high frequency amplifier constructed in accordance with the present invention; and

2

Figure 2 is a cross-sectional view through an inductive device such as used in the circuit of Figure 1 which, furthermore, has been provided with suitable adjusting means for modifying the inductive effect of the coupling unit.

Referring to the drawing, it will be seen that in Figure 1 there are shown two vacuum tubes, 11 and 12, of a wide band amplifier arranged to operate over a particular band in the vicinity of ten to one hundred megacycles. Since it is quite customary to utilize vacuum tubes of the multigrid type in such circuits, the vacuum tubes 11 and 12 have been shown to be of such type, although it is to be understood that the invention is not to be limited to the use of these tubes or any tubes of any particular number of grids or control elements. The vacuum tube 11 has an anode 13 which, together with the connections thereto, has a certain capacity with respect to ground represented by the dotted line capacitor 14. Anode voltage is supplied through a suitable coupling resistor 15 connected between the anode and a suitable source of power. The anode of the vacuum tube 11 is capacitively coupled through a capacitor 16 to the interstage coupling network comprising a single inductance 17. The inductance 17 is formed so as to have a relatively small diameter and a great length and, hence, the ratio between the length and the diameter is relatively high. For example, in one particular embodiment the inductance had a diameter of ¼ inch and a length of 1½ inches, and was composed of 45 turns tapped so as to provide sections having 10, 20 and 15 turns, respectively.

The vacuum tube 12 is provided with a control grid which, together with its associated connections, has a certain capacity with respect to ground, indicated by the dotted line capacitor 18. The interstage coupling inductance 17 is arranged with two taps 19 and 20, the first tap being connected to the capacitor 16 and the latter tap being connected to the control grid of the vacuum tube 12. Each end of the inductance 17 is preferably connected directly to ground as shown. Such an arrangement operates in a manner analogous to a double tuned transformer, but may conveniently have a larger band width transmission characteristic than those commonly employed for television receivers.

It furthermore will be appreciated that the interstage coupling network thus provided has its frequency range determined by the total in-

ductance and the inductance of each section, the outer ends of which are effectively in parallel with the electrode to ground capacities 14 and 18 of the associated vacuum tubes 11 and 12. This arrangement has a great advantage over two coils coupled by mutual inductance because, with this arrangement, a high coefficient of coupling is easily and reproducibly maintained with percentage band widths as high as 50%. If it is desired to provide for inductive trimming without substantial disturbance of the coupling, this may be accomplished in the manner illustrated in Figure 2. The inductor 17 is wound on a suitable insulating form 21, which may be of any material having a good radio frequency power factor characteristic and low loss. If inductive trimming arrangements are desired, the ends of the coil form support 21 may be provided with coaxial recesses for receiving either an adjustable powdered iron core member or a brass or copper screw. To illustrate such an arrangement, one end of the coil supporting structure 21 has been shown as provided with a recess 22 in which there is positioned an adjustable powdered iron core member 23. In order to illustrate another manner of inductive trimming, the other end of the coil support 21 has been provided with a recess 24 which is threaded so as to permit the adjustment of a copper or brass screw 25. It, of course, will be appreciated that in mass production the tolerances permitted in the winding of the coil 17 may either tend to be over or tend to be under, depending upon the type of inductive trimming adjusting device provided.

Since in effect the accumulative mechanical errors of two or three coils and their leads have been reduced to a relatively small possible error in a single coil, it will readily be appreciated that with a large ratio between the length and the diameter of the coil 17, it is possible to manufacture this coil by mass production methods without incurring the disadvantages of other prior art arrangements.

While for the purposes of explanation of the present invention, a particular embodiment has been disclosed, it is, of course, to be understood that the invention is not limited thereto, since obviously such modifications and alterations may be made, both in the circuit arrangement and in the structure, as may be commensurate with the spirit and scope of my invention as set forth in the appended claims.

I claim:

1. A radio frequency amplifier adapted for operation in a range generally including the limits of ten to two hundred megacycles, comprising a vacuum tube having a certain anode to ground capacity, a succeeding vacuum tube having a certain control grid to ground capacity, an inductive coupling means interconnecting said vacuum tubes, said inductive coupling means together with said electrode to ground capacities operating as a broad band amplifier device, said inductive coupling means comprising a single inductance coil having a high ratio of length to diameter and being provided at intermediate points with two taps, means connecting the two ends of said coil to each other and to the cathodes of said tubes, means connecting one tap to the anode of said first tube, means connecting the other tap to the grid of said second tube, and means for preventing unidirectional current from passing between said anode and said grid.

2. In a high frequency amplifier, the combination comprising a plurality of vacuum tubes and

an interstage coupling network interconnecting said vacuum tubes, said network comprising a single winding inductor having a relatively high ratio of length to diameter, and means interconnecting each end portion of said inductor to an electrode of a different one of said vacuum tubes so as to be effectively in parallel with the capacity existing between ground and said electrode.

3. A high frequency amplifier for operation at frequencies of the order of or greater than ten megacycles, comprising a pair of vacuum tubes interconnected by an interstage coupling network, said coupling network comprising a single coil winding having a high ratio of length to diameter and being divided into three sections by two intermediate taps, means connecting each end of said coil to ground, means connecting one of said taps to an electrode of one of said vacuum tubes, and means connecting the other of said taps to an electrode of the other tube, thereby to connect the end sections of said coil in parallel with the capacity existing between said electrodes and ground.

4. A broad band amplifier adapted for operation at frequencies of the order of or greater than ten megacycles, comprising a plurality of vacuum tubes each having a certain capacity between its anode and ground and another certain capacity between its control grid and ground, an interstage coupling network interconnecting successive vacuum tubes, said network comprising a single inductive winding having a high ratio of length to diameter, means connecting each end of said winding to ground, means connecting an intermediate point of said winding to the anode of the preceding tube, and means connecting another intermediate point of said winding to the control grid of the succeeding vacuum tube, each end portion of said winding being effectively in parallel with the capacity existing between the ground and the electrode with which said end portion is associated, thereby to produce a broad band transmission characteristic.

5. In a high frequency amplifier, an interstage coupling network comprising a single winding inductor having a relatively high ratio of length to diameter and a plurality of taps whereby each end portion of said inductor may be associated with an electrode of the vacuum tubes which said inductor is adapted to interconnect, and adjustable means located at each end of said inductor for varying the inductive effect of said network.

6. In a high frequency amplifier, the combination comprising a plurality of vacuum tubes and an interstate coupling network interconnecting said tubes, said network comprising a single winding inductor having a relatively high ratio of length to diameter and a plurality of taps thereon to divide said inductor into three sections, each end section of said inductor being connected to an electrode of a different one of said vacuum tubes so as to be effectively in parallel with the capacity between ground and said electrode, and means arranged at the end of said inductor for varying the inductive effect thereof, said means comprising a longitudinally adjustable member of a material having a permeability differing appreciably from that of air.

7. The combination with a pair of cascaded amplifier tubes, of a coupling means interposed between said tubes and comprising an inductance coil having its ends connected to ground, and

having two intermediate taps connected respectively to an output electrode of the first tube and to an input electrode of the second tube.

8. The combination with a pair of cascaded amplifier tubes, of a coupling means interposed betwen said tubes and comprising an inductance coil having its ends connected to ground, and having two intermediate taps connected respectively to an output electrode of the first tube and to an input electrode of the second tube, and means associated with said coil for varying the inductance thereof.

9. In a high frequency amplifier, a pair of vacuum tubes, an interstage coupling network interconnecting said tubes, said network comprising a single inductance coil, means connecting one portion of said coil between the output electrodes of the first tube, and means connecting a different portion of said coil between the input electrodes of the second tube, said coil portions being distinct from one another.

10. In a high frequency amplifier, a pair of vacuum tubes, a network coupling the output of the first of said tubes to the input of the second of said tubes, said network comprising an elongate continuous inductance coil having two end terminals and two spaced intermediate taps, one of said end terminals and the adjacent intermediate tap being connected respectively to the output electrodes of the first tube, the remaining end terminal and intermediate tap being connected respectively to the two input terminals of the second tube.

11. In a high frequency amplifier, a pair of vacuum tubes, a network coupling the output of the first of said tubes to the input of the second of said tubes, said network comprising an elongate continuous inductance coil having two end terminals and two spaced intermediate taps, one of said end terminals being connected to the cathode of the first tube, the next adjacent intermediate tap being connected to the anode of the first tube, the remaining intermediate tap being connected to the control grid of the second tube, and the other end terminal being connected to the cathode of the second tube.

WILLIAM E. BRADLEY.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,990,781	Fitch	Feb. 12, 1935
1,952,579	Black	Mar. 27, 1934