

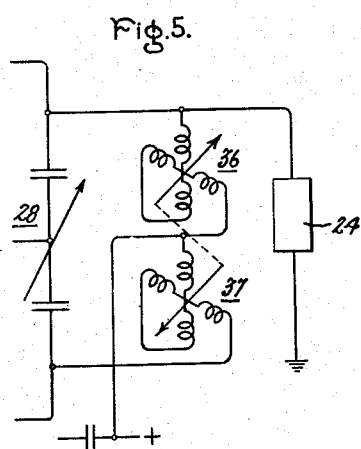
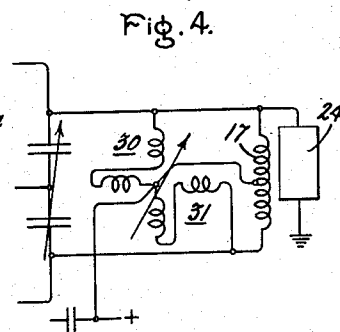
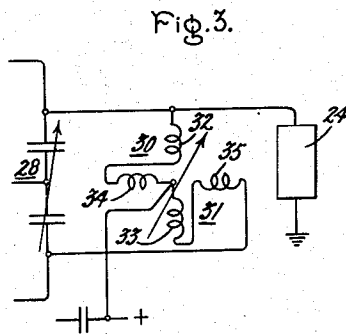
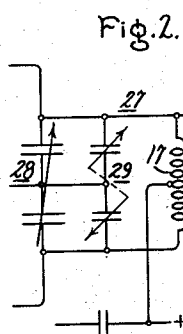
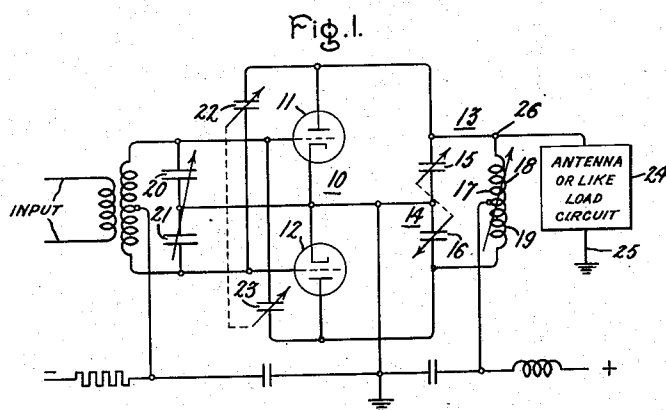
July 31, 1945.

P. D. ANDREWS

2,380,389

BALANCING SYSTEM

Filed May 7, 1942



Inventor:
Paul D. Andrews,
by *Harry E. Dunkane*
His Attorney.

UNITED STATES PATENT OFFICE

2,380,389

BALANCING SYSTEM

Paul D. Andrews, Schenectady, N. Y., assignor to General Electric Company, a corporation of New York

Application May 7, 1942, Serial No. 442,046

3 Claims. (Cl. 178-44)

My invention relates to radio or like circuits incorporating balanced push-pull devices, particularly to circuits in which a push-pull amplifier or like device is coupled to a single-ended load circuit, and its object is to provide an improved balancing arrangement for circuits employing a push-pull device coupled to a load circuit of this character.

It is desirable at times to supply from the output circuit of a push-pull amplifier a single-ended load circuit having one end at ground radio-frequency potential. For example, such a push-pull device or amplifier may be required to supply a single wire antenna.

It has been found that if the single-ended load circuit is resistive only, then although the neutralizing of the amplifier circuit is not affected, nevertheless the introduction of the resistive load has the serious effect of changing the relative amplitude and phase of the radio frequency output voltages of the two amplifier tubes, the loading of the tubes thereby becoming unbalanced. Further, if the load includes a reactive component still greater unbalancing is produced.

It has been necessary heretofore, in order to restore the push-pull device to proper balance when coupled to the single-ended load circuit, to effect turning adjustments in one or more of the capacitive and inductive tuning elements in the output circuit of the device. Since the tuned output circuit must be maintained at approximate resonance at the same time that these adjustments are made, therefore such readjustments of the individual output circuit elements to restore balance have been found to be very difficult to make and such method of restoring balance to be impracticable in practice.

In accordance with the present invention the foregoing difficulty is avoided by the provision of variable impedances in the output circuit of the push-pull device or amplifier so arranged that balancing of each tube of the amplifier and in general the compensating for the unbalancing effect of the single-ended load circuit is accomplished without disturbing the total tuning of the output circuit for resonance. For this purpose the variable impedances may be constituted by capacitive or by inductive elements.

The novel features which are considered 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 wherein Fig. 1 is a diagrammatic representation of a push-pull circuit arrangement incorporating my invention and including ca-

pacitive compensating elements; Fig. 2 represents a modification employing capacitive compensating elements; and Figs. 3 to 5 represent modifications employing inductive compensating elements.

In Fig. 1 the numeral 10 designates a usual push-pull amplifier or like push-pull device comprising a pair of electron discharge devices 11 and 12. The numeral 13 designates an output circuit which includes a capacitive means 14 constituted by capacitors or capacitor sections 15 and 16 in series, and the numeral 17, an inductive means having windings 18 and 19 in series. Usual input circuit tuning capacitors 20 and 21 and usual neutralizing capacitors 22 and 23 are provided.

The rectangle 24 designates generally a single-ended load circuit grounded at one extremity 25, and to which one extremity 26 of the output circuit 13 is connected. The load circuit 24 may be constituted by an antenna circuit or other like circuit, and may be resistive only or may include a reactive component. The output circuit inductance 17 may be made variable for tuning the output circuit to resonance. The capacitors or capacitor sections 15, 16 of the capacitive means 14 in the output circuit are so arranged as to be made oppositely variable simultaneously as indicated by the oppositely extending arrows, for a purpose which will be explained presently.

In operation of the system illustrated schematically in Fig. 1, to compensate for the unbalance in the loading of the discharge devices 11 and 12 tending to be produced because of the coupling of the push-pull device 10 to the single-ended load circuit 24, the capacitive means 14 is adjusted to increase or decrease as desired the reactance of one of the capacitor sections, as 15, while making a corresponding change in the opposite direction in the reactance of the other section, 16. The design of the capacitive means 14 is such, however, that the reactance of the capacitors or capacitor sections 15 and 16 in series remains substantially constant.

For a capacitance means meeting the above mentioned requirements for use, for example, in a high frequency push-pull system, a typical calibration may be as follows:

Rotor position in degrees	Capacity of sec. 15 in mmfds.	Capacity of sec. 16 in mmfds.
0.....	6.0	30.0
45.....	6.7	20.0
90.....	10.0	10.0
135.....	20.0	6.7
180.....	30.0	6.0

Assuming that the calibration of the variable capacitive means 14 is substantially as above given for compensating for the load unbalance in discharge devices 11 and 12 occasioned by the

single-ended load, it will be seen that when the capacitances of sections 15 and 16 are simultaneously varied oppositely the total output circuit capacitance of the two sections in series remains practically constant at a value of approximately five micromicrofarads. Therefore, the tuning of the output circuit 13 to resonance is not affected by the varying of the capacitor sections 15 and 16 for the purpose of compensating for load unbalance in the discharge devices.

In a practical case the constant capacitance thus provided by the capacitor sections 15 and 16 in series may be utilized as the total output circuit capacitance, any necessary tuning of the output circuit 13 to resonance being then accomplished by the inductance means 17 which may be made variable for this purpose.

Referring to Fig. 2, the system illustrated therein is in general the same as that illustrated in Fig. 1 except that Fig. 2 represents a case in which it is desired that the tuning to resonance of the output circuit, 27, be effected by means of a usual variable capacitance 28. In this case a capacitance means 29, corresponding to the capacitance means 14 of Fig. 1, for compensating the unbalance caused by the single-ended load 24, is connected in shunt with the usual tuning capacitance 28, and is operated in the same manner as described in connection with Fig. 1.

Referring to Fig. 3, the system illustrated therein is similar in general to that of Figs. 1 and 2, differing therefrom in the means for compensating unbalance. In the system of Figs. 1 and 2 the unbalance of the push-pull stage is compensated by capacitive means. In some cases, however, the desired load balancing is more conveniently accomplished by variable inductance means such, for example, as provided by the two inductance elements 30 and 31 the reactance values of which are varied while the total reactance of these two elements in series in the output circuit remains constant. In the example shown in Fig. 3 the inductance means may be in the form of a variometer or similar rotating winding device having a stator constituted by stator windings 32 and 33, and a rotor constituted by rotor windings 34 and 35. One inductance element 30 of the above mentioned two inductance elements thus comprises a stator winding 32 and a rotor winding 34, and the other inductance element 31 comprises the other stator winding 33 and the other rotor winding 35.

In order that the reactances of the two inductance elements 30 and 31 may vary oppositely for compensating the unbalance caused by the single-ended load 24, either the two rotor windings or the two stator windings are so wound or connected as to be in "bucking" or opposing relation. In the present case rotor windings 34 and 35 are illustrated as in opposing relation, the stator windings 32 and 33 being in "boosting" or aiding relation.

With the inductance elements 30 and 31 arranged as above described, the total inductance of the rotor constituted by the two rotor windings 34 and 35 is equal to the sum of the inductances of each of the latter windings minus twice the mutual inductance between them. Also the total inductance of the stator constituted by the stator windings 32 and 33 is equal to the sum of their inductances plus twice the mutual inductance between them. Thus, assuming the winding arrangement of inductance elements 30

and 31 respectively to be identical except that the rotors are in opposed relation, the balancing means constituted by these inductance elements 30 and 31 provides a total reactance in the output circuit which is of constant value regardless of the position of the rotor. At the same time when the rotors are moved to desired positions for compensating the unbalance caused by the single-ended load circuit 24, the reactance of one rotor winding, as 34, in combination with a corresponding stator winding, as 32, varies inversely as the reactance of the other rotor winding 35 in combination with the other stator winding 33.

In the system above described in connection with Fig. 3, the rotor winding 34 in series or parallel with the stator winding 32 may constitute one section of the usual output circuit inductance, thus corresponding, for example, to winding 18 of output circuit inductance 17 in Fig. 1, the other rotor winding 35 together with the other stator winding 33 constituting the other section of the usual output circuit inductance and corresponding to winding 19 of inductance 17. The inductance element 30 constituted by windings 32 and 34, and 31 constituted by windings 33 and 35 therefore may provide the total output circuit inductance means in cases where, as illustrated in Fig. 3, the normal output circuit tuning to resonance is accomplished by means of a suitable variable capacitance, 28.

Referring to Fig. 4, the system shown therein is similar to that of Fig. 3 except that in Fig. 4 the inductance means 30, 31 for compensating the load unbalance caused by the single-ended load 24 may be provided, if desired, in shunt with the usual output circuit inductance 17.

In Fig. 5, the variable inductance means for compensating the load unbalance is illustrated as being constituted by two separate but similarly arranged and connected variometers or rotating winding elements 36 and 37. To produce the desired compensating effect the two devices are made oppositely variable as indicated by the oppositely extending arrows. Since the total output circuit inductance is the sum of the inductance of the various stator and rotor windings plus the sum of the mutual inductances between corresponding sections of the stator and rotor windings, therefore the value of this total output circuit inductance remains constant during the load balancing operation.

As in the system of Fig. 3, the load balancing elements 36 and 37 of Fig. 5 may constitute the entire inductance for the output circuit, as illustrated in Fig. 5, the tuning of the output circuit to resonance then being accomplished by a usual capacitive means 28, or, similarly to the system of Fig. 4, the load balancing elements 36 and 37 may be connected in shunt with a usual output circuit inductance.

My invention has been described herein in particular embodiments for purposes of illustration. It is to be understood, however, that the invention is susceptible of various changes and modifications and that by the appended claims I intend 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 push-pull device and a tuned coupling circuit for connecting said device to a single ended load circuit tending to cause unbalance of said device, said push-pull device

comprising two electron discharge devices having cathodes connected together and anodes connected to opposite ends of said tuned circuit, said tuned circuit comprising two branches connected in parallel, one of said branches comprising two tunable reactance elements of one sign connected in series and having their center connection connected to said cathode and the other of said branches comprising a reactance element of the opposite sign whereby said circuit may be tuned to parallel resonance, said load circuit being connected between said center connection and one of said anodes whereby said push-pull device is unbalanced, and means for simultaneously varying oppositely the reactances, respectively, of said two elements while maintaining substantially constant the total reactance of said two elements in series whereby compensation for said unbalance of said device may be effected without disturbing the tuning of said tuned circuit.

2. In combination, a push-pull device and a tuned coupling circuit for connecting said device to a single ended load circuit tending to cause unbalance of said device, said push-pull device comprising two electron discharge devices having cathodes connected together and anodes connected to opposite ends of said tuned circuit, said tuned circuit comprising two branches connected in parallel, one of said branches comprising two tunable capacitance elements connected in series and the other of said branches comprising an inductance element whereby said circuit may be tuned to parallel resonance, said load circuit being connected between said center connection and one of said anodes whereby said push-pull device is unbalanced, and means for

simultaneously varying oppositely the capacitance, respectively, of said two capacitors while maintaining substantially constant the total capacitance of said capacitors in series whereby compensation for said unbalance of said device may be effected without disturbing the tuning of said tuned circuit.

3. In combination, a push-pull device and a tuned coupling circuit for connecting said device to a single ended load circuit tending to cause unbalance of said device, said push-pull device comprising two electron discharge devices having cathodes connected together and anodes connected to opposite ends of said tuned circuit, said tuned circuit comprising two branches connected in parallel, one of said branches comprising tunable capacitors and the other of said branches comprising two inductance elements in series and having their center connection connected to said cathode whereby said circuit may be tuned to parallel resonance, one of said elements comprising a stator section and a rotor section in aiding relation, the other of said elements comprising a stator section and a rotor section in opposing relation, said load circuit being connected between said center connection and one of said anodes whereby said push-pull device is unbalanced, and means for varying the relative positions of said stators and their respective rotors thereby to vary oppositely the inductances, respectively, of said elements while maintaining substantially constant the total inductance of said tuning circuit to effect compensation for unbalance without disturbing the tuning of said tuned circuit.

PAUL D. ANDREWS.