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BROAD BAND AUDIO AMPLIFIER

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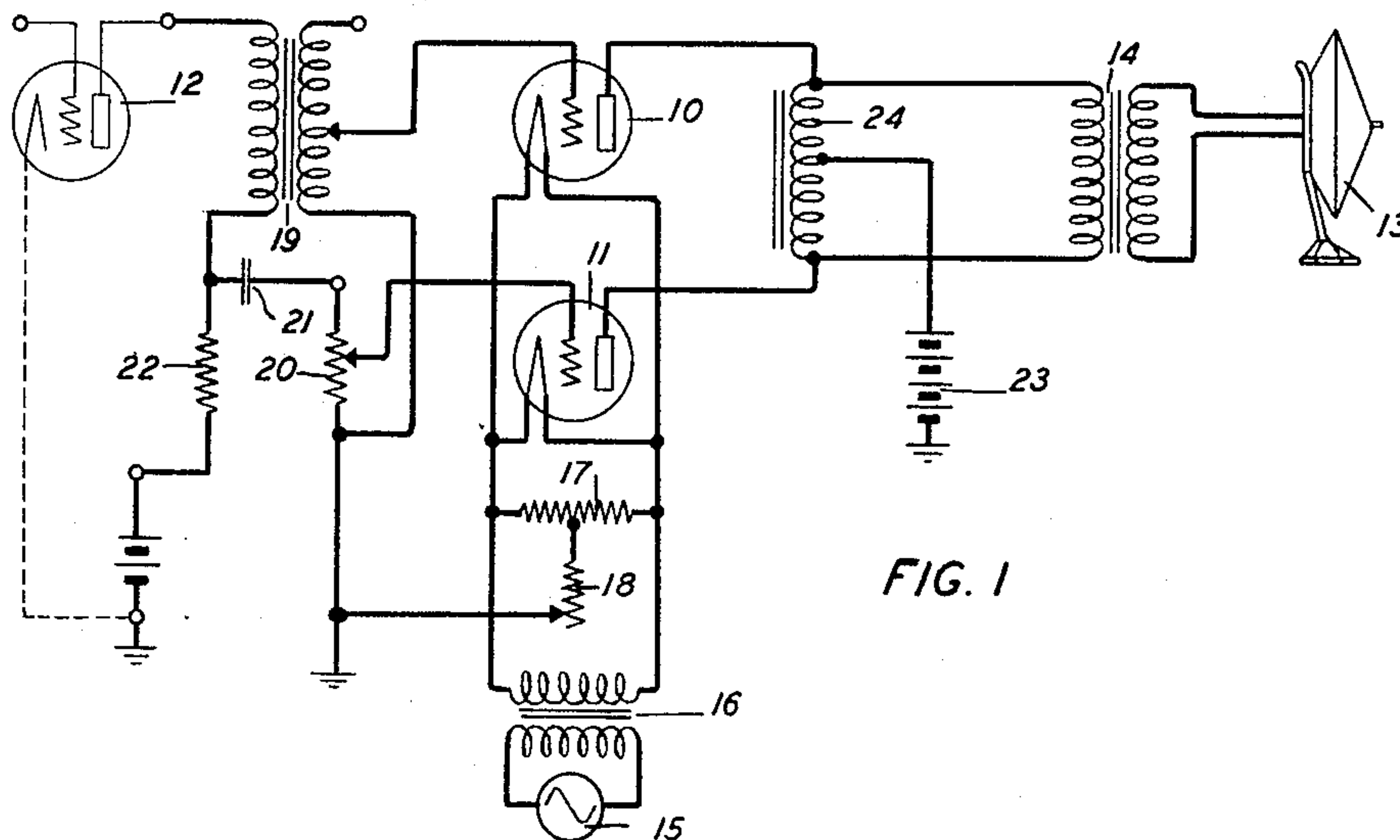


FIG. 1

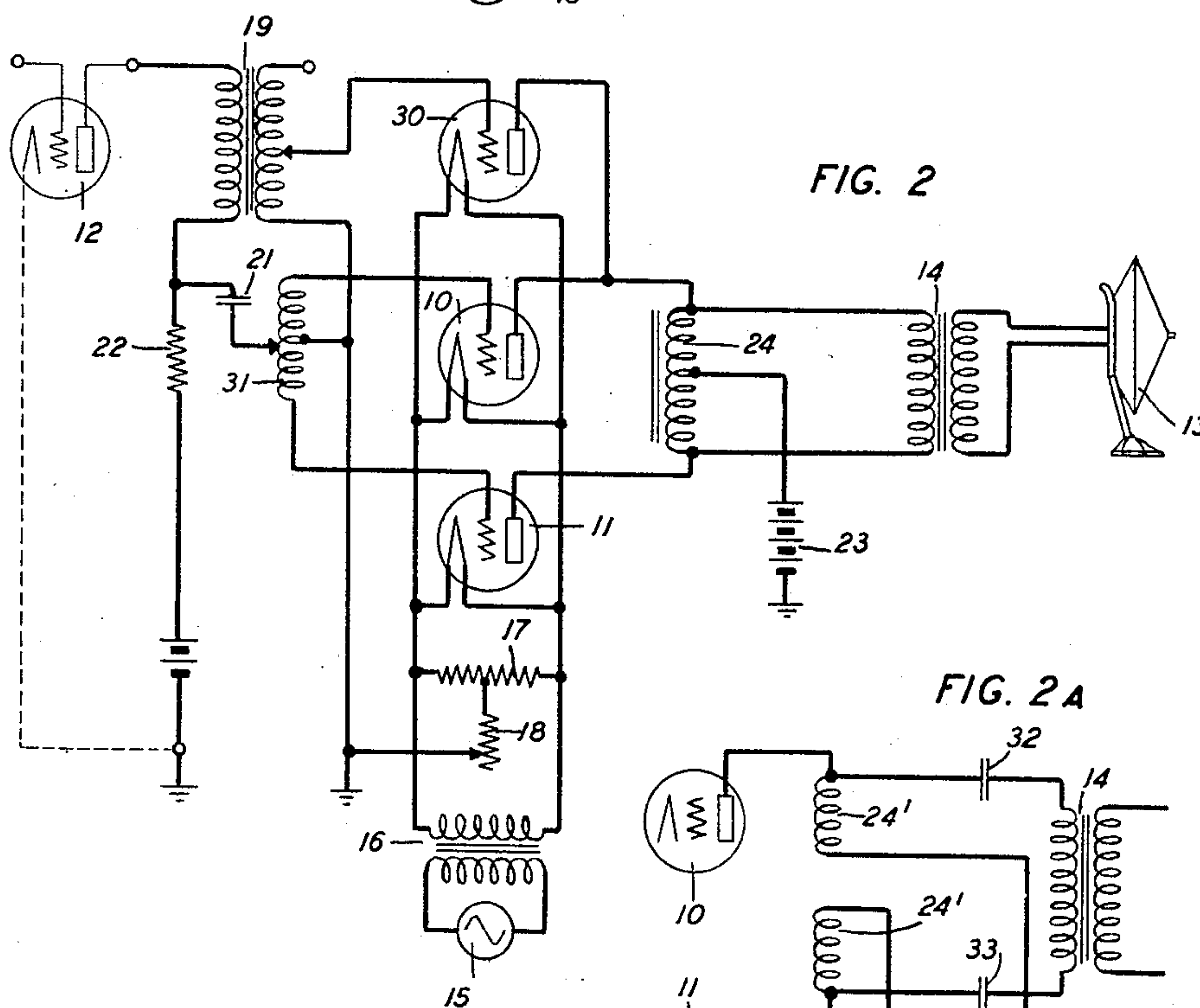


FIG. 2

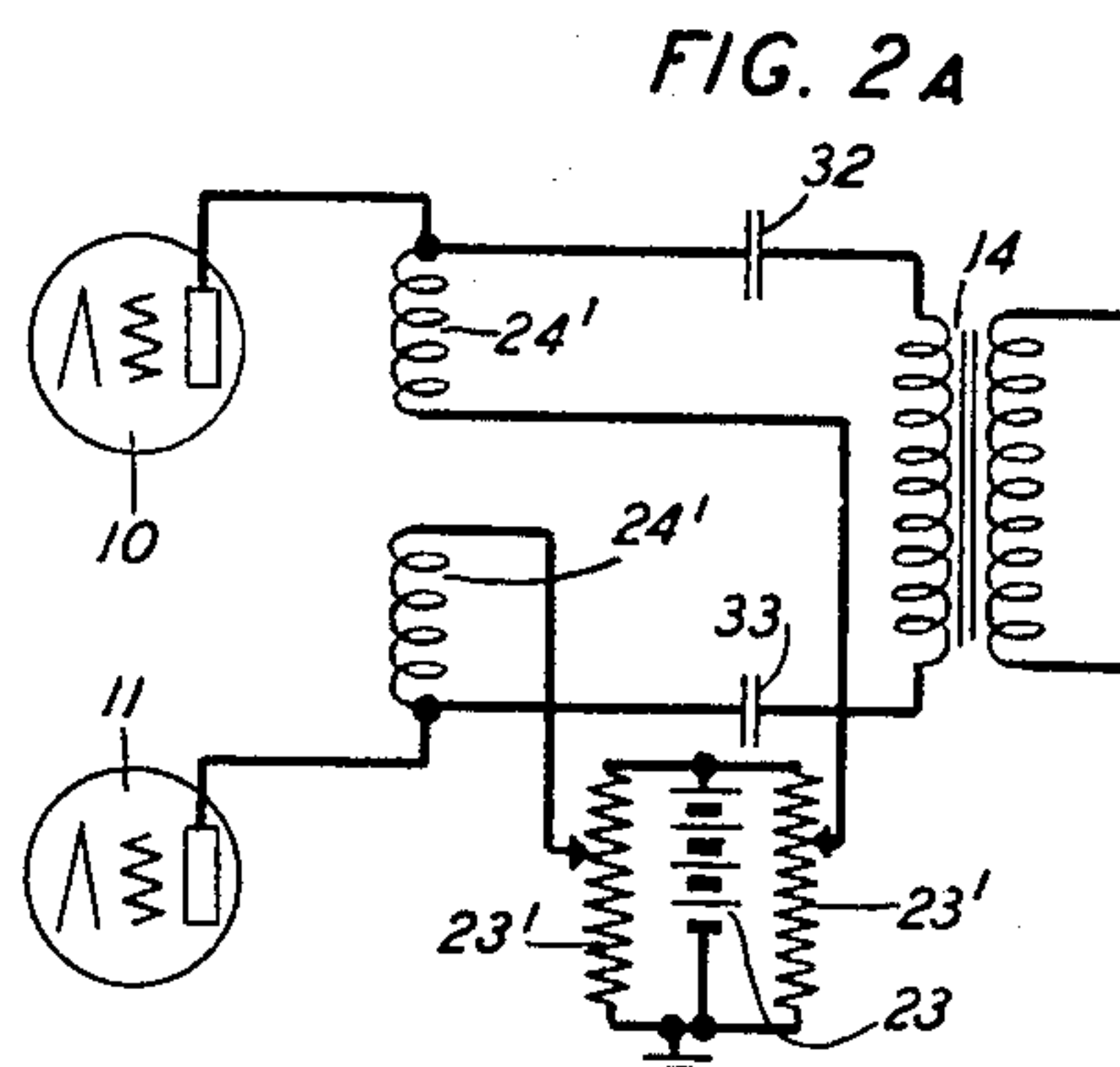


FIG. 2A

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BROAD-BAND AUDIO-AMPLIFIER

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The present invention relates to amplifiers adapted for use at any frequency level but especially applicable to the speech and music range where it is desirable to secure high quality transmission over a broad frequency band.

It is an object of this invention to provide high quality amplification which may be uniform throughout a broad frequency band or which may be varied in different parts of the band by suitable adjustment of the circuit.

While the amplifier circuit of the invention may be used in various connections and at various power levels it will be shown and described as a power amplifying stage the input of which may be connected to the output of a radio receiver or to any other source of waves to be amplified, such as a microphone or photoelectric cell.

It is well known in the prior art that a push-pull connection enables a higher power level to be obtained at the same quality than would be possible if the same tubes were connected in parallel or in some other relation. An outstanding advantage of the push-pull circuit is that the level may be increased and even made to approach the overload point of the tubes without sacrificing too much quality for many purposes. In accordance with the present invention this desirable property of the push-pull circuit is retained but the circuit is supplemented by means which secure faithful amplification of the speech or music waves over a wider frequency range than is obtainable with an ordinary push-pull circuit.

According to the present invention the limitations of a single input connection or of a single type of input connection are avoided and separate input connections which may have different frequency characteristics are provided. For example, one input connection may comprise a transformer and another input connection may be of the impedance-capacity type. These two types of input connections are used at one and the same time and better accommodate the extreme frequencies at both the high and low ends of the range than could a single input connection.

The nature and objects of the invention and the various features of it will be more apparent from the following detailed description of certain preferred modifications which are shown in the attached drawing.

In this drawing Figs. 1 and 2 are schematic circuit diagrams of two forms which the invention may take and Fig. 2A shows a modification applicable to either form.

Referring first to Fig. 1, amplifier tubes 10 and 11 are shown connected to receive waves from a preceding amplifier stage 12 and to drive loud speaker 13 through output transformer 14. The previous amplifier stage 12, the circuit of which is only partially indicated, may be an audio stage of a radio receiver or any other suitable circuit, such as a speech or music input circuit coming from a microphone, phonograph, photoelectric cell, etc.

The cathodes of the tubes 10 and 11 are heated by current from an alternating current source 15 which may be a house lighting circuit. This is connected through transformer 16 to the two filaments in parallel. Bridged across the filament circuit is a balancing resistance 17, the electrical midpoint of which is connected to ground through an adjustable portion of grid bias resistance 18.

The grid of tube 10 is connected through the secondary of transformer 19 to ground and also to a tap on resistance 18. The grid of vacuum tube 11 is connected through resistance 20 to this same grounded terminal. Cooperating with resistance 20 are the series condenser 21 and a second resistance 22, the latter of which is included in series with the primary of transformer 19 in the anode circuit of amplifier 12.

The input circuit of amplifier tube 10, therefore, comprises transformer 19 and the input circuit of tube 11 comprises the resistance condenser circuit 20—21—22. The grid connections in each case are shown variable so that an adjustable portion of the input voltage may be applied to the two grids.

Space current for the tubes 10 and 11 is supplied from a suitable plate source indicated as battery 23 although it will be understood that a rectifier or other suitable source

may be used. The plate circuits extend respectively from the two anodes of tubes 10 and 11 through opposite halves of the output impedance 24, battery 23 to ground and thence to the adjustable terminal on resistance 18, through a portion of resistance 18 to the midpoint of resistance 17, in parallel through both portions of resistance 17 and to the two cathodes in parallel. The output transformer 14 is connected across the outer terminals of output inductance 24.

The operation of the circuit will now be described. The waves in the output circuit of amplifier 12 will be assumed to comprise a wide frequency range. Where these waves are being transmitted at very low level there is less likelihood of serious distortion than where they are transmitted at high level. It is assumed that they are transmitted through tube 12 at sufficiently low level to retain the desired degree of quality. These waves are impressed on the tubes 10 and 11 through the respective input circuits comprising transformer 19 in the case of the tube 10 and impedance coupling circuit 20—21—22 in the case of tube 11. The direction of winding of the transformer and the manner of connection of the input circuits are such that the waves are impressed on the grids of the two tubes in opposite or nearly opposite phase relation. The amplified waves in the output circuits of tubes 10 and 11 are then impressed differentially on a loud speaker 13 through transformer 14.

The circuit may be variously adjusted to suit the particular requirements. For example, the adjustment may be such that the tubes 10 and 11 operate as an ordinary push-pull stage throughout the entire frequency range in which the two coupling circuits 19 and 20—21—22 transmit substantially equally. Outside of this range, that is at the extreme low or at the extreme high frequencies, one or the other of the two coupling circuits will transmit more effectively. In particular, at very low frequencies the transformer 19 may be less effective than the impedance coupling 20—21—22 and the latter will predominate in transmitting to the power stage 10, 11 components in this low frequency range. The circuit is thus enabled to accommodate a wider frequency band than would be the case if but a single type of input coupling were used. Similarly, at some other frequency range, for example at high frequencies, transformer 19 may be designed to transmit more effectively.

For those portions of the band in which the two input couplings do not overlap or in which transmission through them is widely different the amplifier stage does not act as a true push-pull circuit since the greater part of the transmission takes place through one of the tubes 10 or 11 as the case may be. However, at these extreme frequencies, par-

ticularly at the high frequencies, it may be sufficient for many purposes not to have the tubes 10 and 11 operate in true push-pull relation. The circuit is thus enabled to supplement the action of an ordinary push-pull stage by supplying to the loud speaker extreme frequencies both low and high that would be outside the efficient range of a single coupling element.

By providing variable taps to the transformer 19 and resistance 20 different effects may be secured. For example, the frequency components that are most efficiently transmitted by one or other of the two coupling circuits may be variably amplified at will.

Negative grid bias for the tubes 10 and 11 is obtained by the resistance 18 which is included in the space current path as noted above. By varying the amount of resistance included in the circuit the negative bias can also be adjusted at will.

Fig. 2 shows a modified type circuit in which push-pull operation of the tubes 10 and 11 is obtained for frequencies extending down to the lowest frequencies which the impedance coupling is able to transmit. In this circuit similar reference characters are used to indicate the same elements as in the circuit of Fig. 1. It will be noted that Fig. 2 differs from Fig. 1 mainly in the addition of a third tube 30, the filament and plate voltages of which are supplied in parallel with tubes 10 and 11. Also grid bias voltage is supplied from resistance 18 for the grid of tube 30.

The input coupling for tube 30 comprises transformer 19 and the output circuit extends from the anode to the upper terminal of impedance 24.

The input coupling for the push-pull tubes 10 and 11 comprises resistance 22, condenser 21 and inductance 31. The alternating current path from the upper terminal of resistance 22 to the input of tubes 10 and 11 comprises condenser 21 and the portion of coil 31 that is included between the movable condenser terminal and the center point which is grounded. Coil 31 acts as an auto-transformer and may induce the same or different voltages on the grids of tubes 10 and 11 depending upon the adjustment. In any case the voltages induced on the two grids of tubes 10 and 11 are of opposite phase.

The operation of the circuit of Fig. 2 will now be described. The frequency characteristics of the two coupling circuits will in part overlap and will in part be different, as in the case of Fig. 1. Assuming that the coupling circuit 21—22—31 is most efficient at the very low frequencies and also through the middle range up toward the higher speech frequencies tubes 10 and 11 will operate as a push-pull amplifier giving high quality of reproduction from the extreme low end upward toward the high end of the total range.

The energy content of speech and music, as is well known, is greatest at the extreme low frequencies and lower middle frequencies and it is in the range of large amplitude that it is especially important to operate tubes in push-pull relation in order to secure high quality.

The high frequencies of speech and music are of much lower energy content and if transformer 19 is used to extend the transmission range above that obtainable with the coupling circuit 21—22—31 this high end of the range can be amplified at good quality with a single tube 30. Coupling circuit 19 and amplifier 30 therefore supplement the action of the push-pull tubes 10 and 11 at the high frequency end.

It may be desirable to provide other adjustments than those that have been already described, for example, it may be desirable to impress different anode voltages on the two tubes of the push-pull circuit. This may be done by providing a circuit as in Fig. 2A where the output impedance is indicated at 24' as being divided into two portions, the inner ends of which are connected to potentiometers 23' in shunt of battery 23. Stopping condensers 32 and 33 are provided for keeping direct current away from the signal output transformer 14.

Series impedance 22 has been shown as a resistance but it is to be understood that it may include a desired amount of inductance.

Various further modifications of the circuits described will occur to those skilled in the art in view of the foregoing description and the circuit modifications that have been disclosed. The invention is not to be construed, therefore, as limited to the particular forms that have been illustrated and described but the scope is to be determined from the claims.

What is claimed is:

1. In a speech and music frequency amplifying system, a source of speech or music waves to be amplified, a pair of space discharge tubes operating in push-pull relation for amplifying the waves from said source, and means comprising a plurality of input couplings individual to said tubes and having different frequency characteristics covering broad bands within the speech and music frequency range for enabling the amplifier to operate effectively over a wider frequency band than is accommodated by either coupling circuit alone.

2. In an amplifying system for the speech and music range, a source of speech or music waves to be amplified, a plurality of space discharge tubes, for amplifying the waves from said source, a common output circuit for said tubes, a plurality of input couplings individual to certain of said tubes and varying in their respective frequency characteristics, covering broad bands within the speech and music frequency range, and circuit con-

nections for causing certain of said tubes to operate in push-pull relation throughout a portion of the total frequency range and also to amplify frequency components outside the range effectively transmitted by either of the coupling circuits alone.

3. In an audio frequency amplifier, a pair of three-element space discharge tubes having input and output circuits, a source of waves of a broad frequency band to be amplified, representing speech or music, individual coupling circuits for impressing waves from said source on said respective input circuits in opposite phase, said coupling circuits having frequency characteristics in part overlapping and in part non-overlapping whereby waves of said broad band of frequencies are effectively amplified and a speech or music reproducing system differentially coupled to said output circuits.

4. In an audio frequency amplifier, a pair of three-element space discharge tubes having input and output circuits, a source of waves of a broad frequency band to be amplified, individual coupling circuits for impressing waves from said source on said respective input circuits in opposite phase, one of said coupling circuits comprising a two-winding transformer and the other comprising shunt-impedance and series capacity, said coupling circuits having frequency characteristics in part overlapping and in part non-overlapping whereby waves of said broad band of frequencies are effectively amplified, and a load circuit differentially coupled to said output circuits.

5. A broad-band amplifier circuit comprising a push-pull circuit for amplifying the low frequency range of speech or music waves and an auxiliary amplifier in parallel with the push-pull amplifier for amplifying the high frequency range, separate couplings for said amplifiers, that for the push-pull amplifier comprising shunt resistance and series capacity, and that for the auxiliary amplifier comprising a transformer.

6. The combination with a source of waves and a loud speaker of a pair of space discharge tubes having input and output circuits, said input circuits differentially coupled to said source of waves and said output circuits differentially coupled to said loud speaker, one of the input circuit couplings comprising a transformer and the other a shunt impedance series condenser circuit of partly overlapping and partly non-overlapping frequency characteristic with respect to said transformer.

In testimony whereof, I have signed my name to this specification this 10th day of July, 1930.

ELMER Z. LANE.