

March 10, 1936.

E. T. BURTON

2,033,274

AMPLIFIER

Filed April 7, 1933

2 Sheets-Sheet 1

FIG. 1

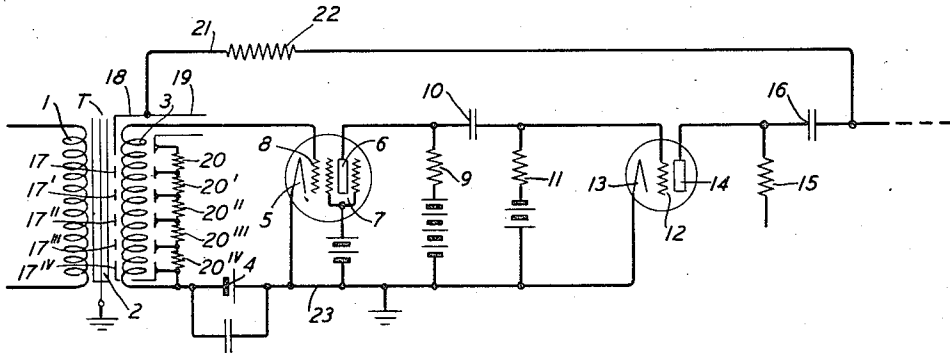
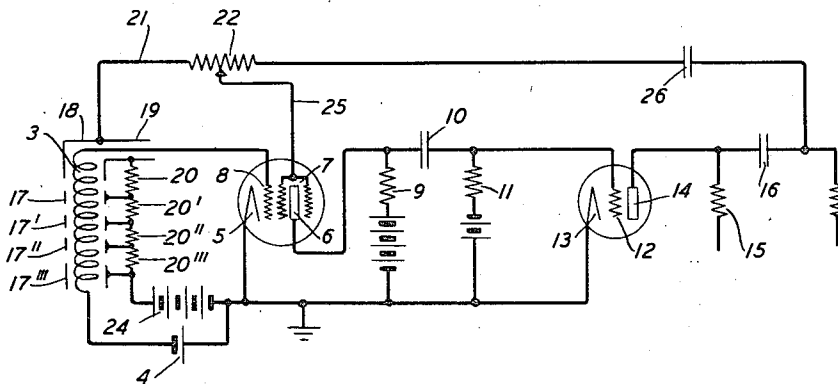


FIG. 2



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FIG. 3

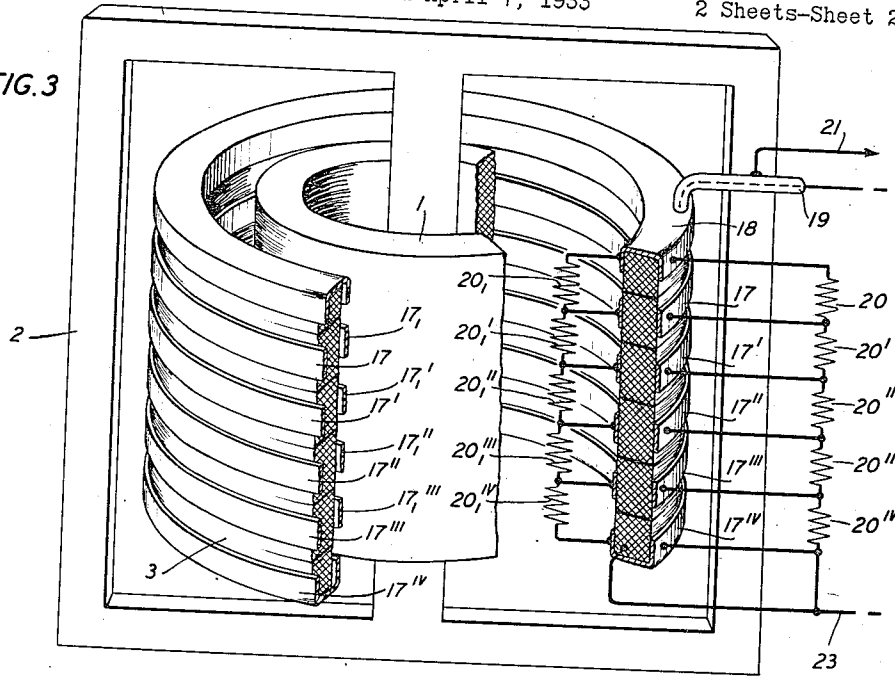
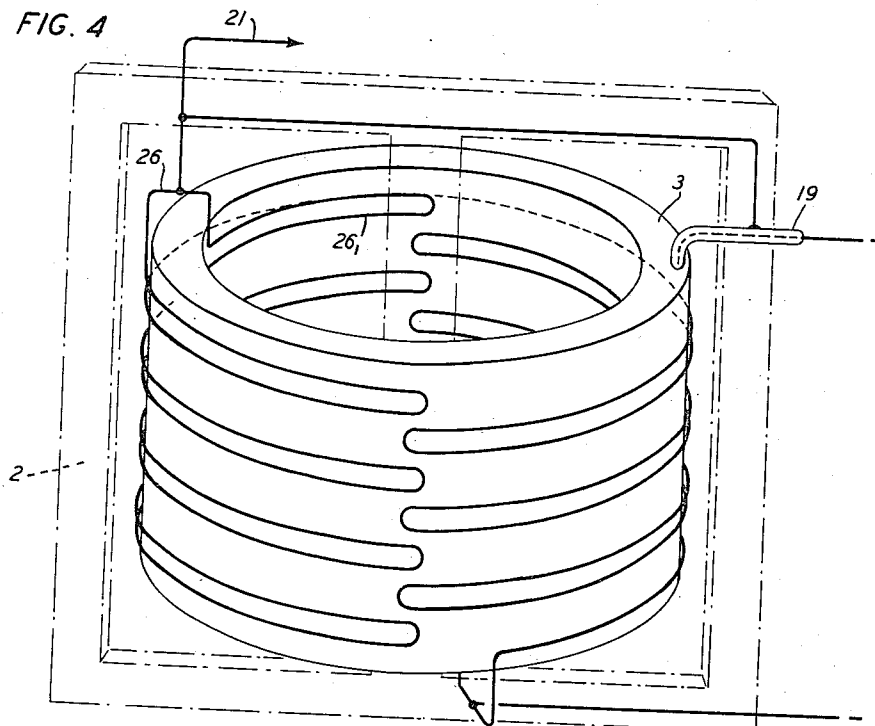


FIG. 4



INVENTOR
E. T. BURTON
BY
E. V. Griggs
ATTORNEY

UNITED STATES PATENT OFFICE

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AMPLIFIER

Everett T. Burton, Millburn, N. J., assignor to
Bell Telephone Laboratories, Incorporated, New
York, N. Y., a corporation of New York

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17 Claims. (Cl. 179—171)

This invention relates to transmission systems and more especially to amplifiers where high quality amplification is imperative.

In amplifiers used in connection with sound recording and reproducing equipments, present day practice requires apparatus which will produce practically no distortion over the entire audible frequency range.

The inefficiency of input transformers to faithfully reproduce the impressed voltage wave where a high voltage step-up is desired has given rise to various expedients which in some cases have taken the form of equalizing networks designed to accentuate or attenuate certain of the frequencies or to do both. The disadvantages of such arrangements are obvious.

It is an object of this invention to improve the operation of amplifying systems.

A further object of this invention is an amplifier transformer combination which will faithfully repeat voltages having a wide frequency range.

A further object of the invention is a substantially distortionless audio frequency amplifier provided with a minimum of apparatus.

In the design of transformers for operation over a wide frequency range, it is necessary to use comparatively high inductances in order to insure efficient response at the lowest frequencies. The highest frequency at which the transformer is efficient is determined by resonance of the inductance with capacities in the transformer circuits. In a voltage repeating transformer such as is used for the input of space discharge amplifiers, it is usually desirable to obtain the greatest possible voltage step-up consistent with the form of response characteristic desired. In the input transformer the low frequency cut-off is determined by the primary inductance and the high frequency cut-off is determined by resonance of the secondary with its distributed capacity plus any grid circuit capacity which may be present.

In general two forms of capacity are active in the secondary. The first, interwinding capacity, is active throughout the secondary but may not increase with increase of turns and in certain cases may decrease. The second form, the effective capacity of the inner and outer winding surfaces to core and other adjacent conductors, is determined by the spacing and potential differences. The latter or second form is effective in the second power. Assuming one end of the transformer to be connected to a common point of the circuit and the other end to be

practically free and varying according to induced voltages, the capacities existing at and near the high end of the secondary are the most effective in determining the resonance point of the transformer. Since these effective capacities exist between the outer, inner and high end surfaces of the transformer secondary, their effect may be reduced or neutralized by so constructing and operating the transformer that the nearest adjacent conductors are kept at potentials which approximate that of the corresponding coil surfaces.

In the use of screen grid space discharge devices, there is also a further capacity to be neutralized. This capacity is that existing between control grid and anode and is due to the slight exposure of the control grid to the anode through the mesh of the screen grid. This effective capacity in a screen grid device is equal to the static capacity multiplied by the amplification of the device plus one. Since in screen grid devices the amplification may be of the order of 100 the effective control grid-anode capacity may be fairly large. This is especially true at high frequencies when the capacity may become an effective shunt to the input.

A further object of the invention is to counteract the control grid-anode capacity of a screen grid device forming a part of an amplifier.

A complete understanding of the invention may be had from the following description and attached drawings forming a part thereof and in which Fig. 1 is a schematic circuit of one form the invention may take;

Fig. 2 is a schematic circuit of a form the invention may take to neutralize the control grid-anode capacity of a screen grid space discharge device; and

Figs. 3 and 4 illustrate practical forms which the input transformer may take when used as indicated schematically in Figs. 1 and 2.

Referring now to Fig. 1 input transformer T is provided with a primary winding 1, grounded core 2 and secondary winding 3. One end of the secondary winding is connected through grid biasing battery 4 to cathode 5 of a screen grid space discharge device which is also provided with an anode 6, a screen grid 7 and a control grid 8. Screen grid 7 and anode 6 are provided with connections to appropriate sources, which sources may be batteries, sources of rectified alternating current, etc.

Resistance 9, condenser 10 and resistance 11 provide a resistance capacity coupling to the succeeding stage provided with a space discharge

device having a control grid 12, a cathode 13 and an anode 14.

Resistance 15 and condenser 16 form part of the coupling to a succeeding stage of amplification or to some load.

Primary winding 1 of transformer 2 may be connected to a transmitter, a detector of a radio receiver or any other source of audio frequency waves. The secondary winding is provided with shields consisting of cylindrical conducting bands 17, 17', 17'', etc. and a cap 18 provided with a sleeve 19 which sleeve encloses the lead from the transformer to the control grid 8. The cap and conducting bands are electrically separate except as they are connected by means of resistances 20, 20', 20'', etc.

The cap 18 and hence the sleeve 19 and shields 17, etc. are connected by lead 21 through resistance 22 to the output of the second stage of amplification succeeding the input transformer T. With this arrangement as will be readily understood, the voltage fed back through resistance 22 is substantially in phase with the voltage impressed on control grid 8.

With the connections as shown and described, the end of the secondary winding of the transformer connected to the cathodes through battery 4 is maintained at a constant potential as regards the remainder of the circuit. Conductor 23 is usually connected to ground and the potentials at all other points of the circuit are measured relative to it. That end of the secondary winding of the transformer which is connected to control grid 8 therefore varies in accordance with the inducing voltage in the primary winding and is referred to as the high end of the winding since its potential has the greatest variation relative to the core and case which are also usually grounded.

The most effective capacity for controlling the resonance of the winding therefore occurs near the high end.

Resistances 22, 20, 20', etc. constitute a potentiometer or voltage divider. Theoretically resistance 22 should be given a value such that it reduces the voltage of the output of the second amplifier stage to be applied to the shield by an amount equal to the product of the effective amplification of the two stages. In practice the shield voltage would be kept somewhat lower than this theoretical value to avoid the danger of regeneration in case the tube gain increased. The voltage impressed on the shield 18 and sleeve 19 is therefore substantially equal to and in phase with the voltage existing in the winding at the high end which is substantially that of the control grid. The values of resistances 20, 20', etc. will depend upon the number of bands 17, 17', etc. used and are such that these bands have impressed upon them a voltage substantially the same as that part of the winding which is adjacent to them.

There is therefore but slight if any difference between the potential of the winding and that of the adjacent shields and hence no capacity effect. The resonance frequency of the transformer is therefore raised to a high value and may be out of the audible range and hence ineffective to cause distortion in the audible frequency range.

Fig. 2 illustrates how the invention may be applied to an amplifier utilizing a screen grid space discharge device to also counteract or neutralize the control grid-anode capacity.

In this figure like elements have been given the

same indices as in Fig. 1 and only the differences between the figures will be pointed out. A battery or other source 24 to properly polarize the screen grid 7 is shown connected between the cathode and low end of the transformer second winding shield through resistances 20'', 20''', etc., lead 21, part of resistance 22 and lead 25, to screen grid 7. A lead 25 from the screen grid to resistance element 22 is also shown. Lead 25 is provided with a sliding contact so that adjustment may be made to insure that the grid neutralizing voltage from the feedback circuit is applied to the screen grid. A stopping condenser 26 prevents the unidirectional voltage from the screen grid polarizing source 24 from being impressed on the control grid of the succeeding space discharge device.

This feedback voltage on the screen grid is in phase with that of the control grid. Therefore there may be a slight increase in amplification. By impressing on the screen grid a small amount of the voltage in phase with that on the control grid, the effective capacity between the plate and the control grid is reduced, as may be seen from considering that the potential gradient in the space between the two grids is made smaller. As the amount of the voltage on the screen grid is increased the screen grid acts in a manner similar to the control grid in controlling the space current and a point is reached where a regenerative action occurs. In some cases this regeneration may be serious and instead of the fed back voltage completely neutralizing the control grid-anode capacity the adjustment may have to be made at a point where the neutralization is not complete.

Fig. 3 illustrates one practical form which the invention may take in reference to the input transformer. The secondary winding is shown sectionalized or made up of so-called "pancake" coils. It might, however, be a bank wound coil. The primary winding 1 is shown mounted on the middle leg of the transformer core 2. The secondary winding 3 as shown surrounds the primary winding 1.

Cap 18 and sleeve 19 surround the upper part of the secondary winding and lead to the control grid respectively. Two sets of shields are used, those shown at 17, 17', etc. and those shown at 17₁, 17'₁, etc. Normally there will also be required two sets of resistance connectors 20, 20', etc. and 20₁, 20'₁, etc. In case both inner and outer shields can be connected to the same potentiometer, only one set of resistances will be required. However, if the inner and outer shields are not directly opposite to each other the resistance element which connects the first shield to the cap will have values depending upon the spacing of the shield from the cap. The resistance values must be such that the potential of the shield section is substantially equal to that of the adjacent winding.

Fig. 4 illustrates how resistance wire may be used as the shielding. In this case the individual resistance units are not required. In order to simplify the drawings the secondary winding has not been shown sectionalized as in Fig. 3.

The resistance wire is connected to the sleeve 19 and the feedback lead 21 as shown. Two branches are required 25 and 25₁ on the outer and inner surfaces of the secondary winding 3. To avoid any inductive effects the resistance wire shielding is reversed after each turn as shown. In practice it probably will not be necessary to "reverse" after each turn, however the shielding

should be non-inductive. The result in this case is the same as in that of Fig. 3. That is the potential of the shields corresponds to that of the adjacent portion of the secondary winding.

Obvious modifications of this invention will occur to those skilled in the art as, for example, if there is but one stage of amplification or if the gain or phase varies between the first and second stages, an additional space discharge device may be connected to the output of the first device. This would supply the feedback voltage and if necessary could operate through filters or networks to insure correct amplitude and phase of the feedback voltage. Such modifications are clearly within the scope of this invention which should be limited only as defined in the following claims.

What is claimed is:

1. An amplifier comprising an input transformer and space discharge devices, shielding associated with the secondary winding of said transformer and a lead from said shielding to a point in said amplifier such as to maintain the shielding in a predetermined substantially constant voltage relationship to the grid associated with said transformer secondary.

2. In combination, an amplifier and an input transformer, shielding associated with the secondary winding of said transformer and a connection from said amplifier to said shielding, said connection being attached to said amplifier at such a point that there is impressed on said shielding a voltage derived from said amplifier which is in phase with the voltage in the portion of the secondary shielded by said shielding.

3. In combination, an amplifier and an input transformer, shielding associated with the secondary winding of said input transformer, a lead connecting said shielding to a point in said amplifier, resistance associated with said shielding and connections from intermediate points of said resistance to correspondingly spaced points on said shielding so that said shielding has applied to it a voltage corresponding to the voltage of the secondary winding adjacent said shielding.

4. In combination, an amplifier, and an input transformer, a shield for the secondary winding of said input transformer comprising resistance wire wound non-inductively on the inner and outer surfaces of said secondary winding and a connection from said shielding to a point in said amplifier separated from said transformer by at least one stage of amplification.

5. In combination, an amplifier and an input transformer, a shield for the secondary winding of said input transformer comprising a plurality of bands near the inner and outer surfaces of said winding, resistance elements connecting adjacent bands and a connection from said shielding to a point in said amplifier separated from said transformer by at least one stage of amplification.

6. In combination, an amplifier and an input transformer, a shield for the secondary winding of said input transformer, a screen grid space discharge device in the first stage of said amplifier, a connection from a point in said amplifier to said shielding, a resistance in said connection, and means to connect the screen grid of said screen grid space discharge device to a point on said resistance.

7. In combination, an amplifier and an input transformer, a shield for the secondary winding of said input transformer, a screen grid space

discharge device in the first stage of said amplifier, a connection from one end of said shield to the cathode of said device, a source of potential for the screen grid in said connection, a second connection from a point in said amplifier to the other end of said shield, a resistance element in said second connection, and means to connect said screen grid to a point on said resistance.

8. The combination as in claim 7 with a condenser arranged in said second connection to shut off from the latter point in the amplifier the potential for said screen grid.

9. An amplifier comprising a transformer and space discharge devices operating under control of the voltage output of the secondary windings of said transformer, shielding associated with the secondary winding of the transformer and a lead having a predetermined voltage condition relative to ground extending from a point in said amplifier to said shielding.

10. An amplifier comprising a transformer and space discharge devices operating under control of the voltage output of the secondary winding of said transformer, shielding means associated with the transformer, a lead from a point in said amplifier to said transformer shielding means and resistance connections from said shielding means to ground.

11. In combination in an electrical circuit for transmitting varying currents, a transformer connected to said circuit, shield means for a winding of said transformer, said shield means comprising sections adjacent different parts of the winding that have different potentials, and means for reducing the potential between a section of said shield and the adjacent portion of the winding comprising a connection to said section of said shield for imparting a varying potential thereto.

12. An amplifier comprising an input transformer and space discharge devices, a shielding means associated with the transformer, and means for feeding back from a predetermined portion of the amplifier a voltage to maintain the shielding means at desired varying potentials relative to ground.

13. An amplifier comprising an input transformer and space discharge devices, a winding of the transformer being arranged in sections, shielding means associated with each section, and means for maintaining a predetermined voltage condition in each shielding means to neutralize a capacitive condition between the adjacent windings and the shielding means.

14. An amplifier as in the next preceding claim characterized in that the sectional shielding is maintained at substantially identical voltage and phase conditions with the adjacent winding section.

15. An amplifier having successive stages of amplification, and a transformer for impressing signals on one of said stages, shielding means for a winding of said transformer, and a voltage-feeding connection to the shielding means from a portion of the amplifier removed a plurality of stages from the shielding means.

16. In combination, inductive windings, individual shielding means for said windings, resistance connections between said shielding means, and means for applying a potential at one end of the resistance connections to maintain the voltage conditions in the shielding means substantially identical with voltage con-

ditions in adjacent windings of the inductive device.

17. In combination, a source of voltage, inductive windings energized from said source of voltage and of unlike potentials at opposite ends and arranged in sections, shielding means substan-

tially surrounding each of said sections, and means for maintaining the shielding of the sections at predetermined varying potentials relative to either end of the windings.

EVERETT T. BURTON.