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F. L. DECHANT

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ELECTRON DISCHARGE AMPLIFIER

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Fig. 1.

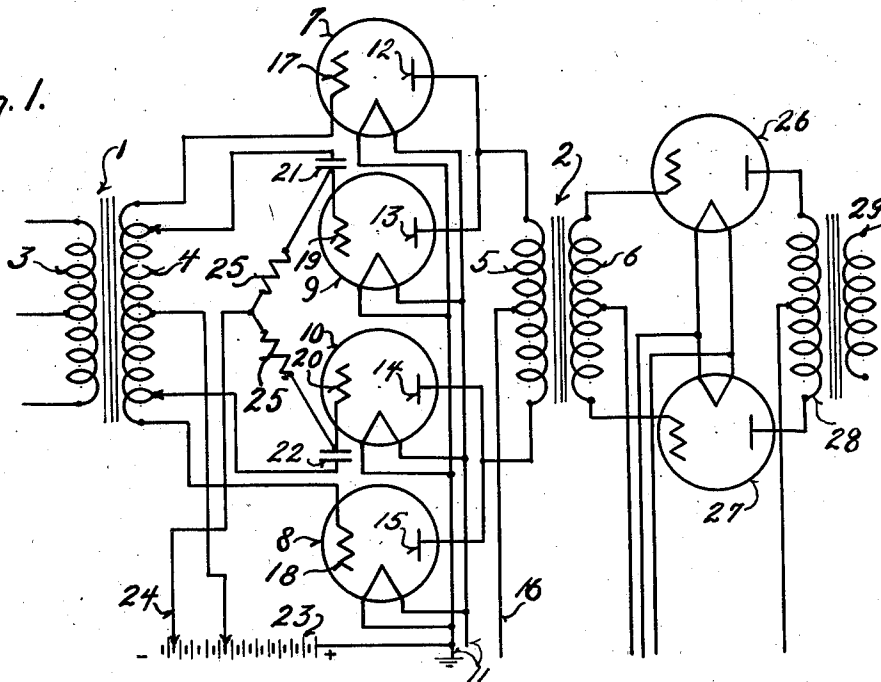


Fig. 2.

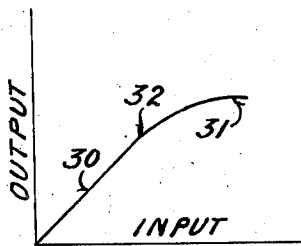


Fig. 3.

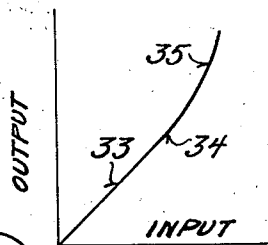


Fig. 4.

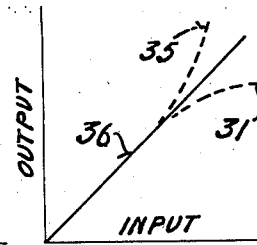
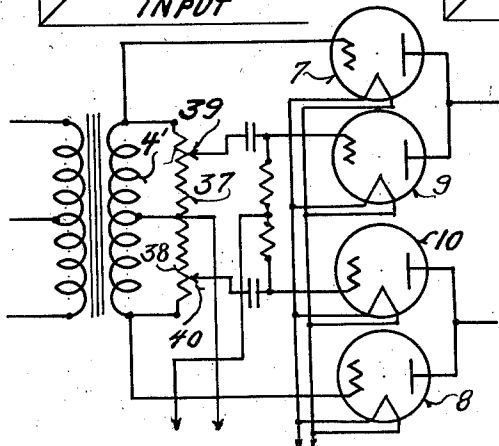


Fig. 5.

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ELECTRON DISCHARGE AMPLIFIER

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5 Claims. (Cl. 179—171)

This invention relates to electron discharge amplifiers and to a method of amplification.

Objects of this invention are to provide an apparatus for, and a method of obtaining wave distortion in one part of an audio frequency channel which will exactly counteract the equal and opposite wave distortion occurring at another point in the same channel. An important use for such a device occurs in the driving of Class B audio amplifiers.

In the system of audio frequency amplification commonly known as Class B power amplification, it is the practice to arrange two tubes in push-pull, each with a high grid bias somewhere near the cut-off point. In this system one tube works at a time, each tube being concerned with half cycles of power, and these half cycles being properly combined in the output plate circuit, which usually is a transformer with a center tapped primary. Unlike usual audio amplifiers, this system requires current as well as voltage to drive the grids and imposes a real power load on the exciting source. The exciting source, usually another amplifier, will hereinafter be referred to as the "driver." The driver can supply signal voltage to the grids of the Class B amplifier without delivering current, but only up to the point at which the instantaneous voltage on the driven grids is zero.

Progressing along the cycle toward the peak, current begins to flow in the driven grids in ever increasing amounts and rises at a greater rate thereafter than does the signal voltage. Thus it is obvious that the load impedance presented to the driver varies almost continuously over each half cycle and the wave form of the driver load current differs from the wave form of the load voltage. This non-linear load on the driver alters the wave form of the driver output causing distortion.

In practice an attempt is made to minimize the effect of this non-linear load by shunting the driven grids with resistors. In order to be effective these resistors must consume many times the power required by the Class B grids alone and are therefore wasteful and can never succeed completely in preserving the original wave form.

This invention is designed to overcome the defects noted above, and objects of this invention are to provide a novel system whereby a compensating amplifier is provided for driving what is commonly known as a Class B modulator or a Class B output power assembly or stage.

Further objects of this invention are to provide a special amplifier having the property of introducing equal and opposite distortion to that produced by the modulator or that produced by the unit or section driven by the compensating amplifier.

Further objects are to provide a compensating amplifier which is so made that under moderate loads one portion of the amplifier operates and at increasing loads another portion of the amplifier comes into operation and augments the power delivered by the first section of the amplifier, so that a rising characteristic is produced which compensates for the falling characteristics of the modulator or other unit driven from the compensating amplifier.

In greater detail objects of this invention are to provide a compensating amplifier interposed between the ordinary supply unit, such as the ordinary voltage amplifier and the Class B modulator, the compensating amplifier including two vacuum tubes in push-pull relation and normally functioning at moderate loads, and to provide two additional amplifier tubes also arranged in push-pull relation and coming into operation at an increased load, and to so select the particular portion of the characteristic of the additional tubes at which they will come into operation, that the point at which the non-linear relation of input and output voltage begins, i. e., the rising characteristic begins, will exactly match the point at which the characteristic of the modulator or other driven unit ceases to be linear and commences to drop off, thereby resulting in a linear characteristic for the entire system and avoiding distortion at any portion from low signal levels to high signal levels, so that a faithful reproduction is obtained.

Further objects are to provide a compensating amplifier which is of simple and relatively cheap construction, which may be easily applied to existing types of apparatus or which may be installed as a unit in a newly constructed system with a minimum of expense and with a minimum of difficulty.

Embodiments of the invention are shown in the accompanying drawing, in which:

Figure 1 is a diagrammatic view showing the compensating amplifier in the relation that it bears to the input source and the amplifier or other unit operated from the compensating amplifier.

Figure 2 is a curve showing the relation between the input voltage and the output voltage of an ordinary Class B amplifier, when driven from the usual power amplifier.

Figure 3 is a curve showing the relation between the input voltage and the output voltage of one form of the compensating amplifier.

Figure 4 is a curve showing the relation between the input voltage to the compensating amplifier and the output voltage of the Class B amplifier driven thereby when the compensating amplifier drives the Class B amplifier, either directly or through an intermediate stage or stages.

Figure 5 is a diagrammatic view showing a slightly different mode of connecting the grids of the auxiliary tubes in the compensating amplifier.

Referring to Figure 1, it will be seen that the compensating amplifier has been shown as connected to the input transformer indicated generally by the reference character 1 and to the output transformer indicated generally by the reference character 2. The input transformer's primary is indicated at 3 and the secondary at 4. The output transformer's primary is indicated at 5 and its secondary at 6.

The compensating amplifier comprises two main vacuum tubes 7 and 8 and two auxiliary vacuum tubes 9 and 10. The filaments of each of the tubes is supplied from a common source, the filament supply leads being indicated by the reference character 11. The plates 12 and 13 of the tubes 7 and 9 are connected together and to one side of the primary 5 of the output transformer, and the plates 14 and 15 of the tubes 10 and 8 are connected together and to the other side of the primary 5 of the output transformer, the primary being center tapped and supplied through the conductor 16 from a suitable source of power.

It is to be noted that the grids 17 and 18 of the tubes 7 and 8 are connected to opposite ends of the secondary 4 of the input transformer 1. The grids 19 and 20 of the tubes 9 and 10 are connected through condensers 21 and 22 to opposite portions of the secondary 4 of the input transformer. If desired, they may be connected at the extreme ends of the input transformer under certain conditions, or, as shown, they may be connected at an intermediate point spaced a slight distance from the ends of the secondary. Obviously, this secondary could be tapped and an adjustable connection could be provided for the points at which the grids 19 and 20 are connected.

The secondary 4 of the input transformer is center tapped and is connected to a suitable negative point on the grid biasing means, such as the battery 23, so as to supply a suitable grid bias for the tubes 7 and 8, the positive side of the battery being connected to one of the filament leads, for instance the grounded lead as shown in Figure 1. A conductor 24 leads through grid resistors 25 to the grids 19 and 20 of the tubes 9 and 10.

The compensating amplifier may be driven from any ordinary voltage amplifier, for example, and is designed to drive what is commonly known as a Class B stage or amplifier, such, for instance, as a Class B modulator.

The Class B amplifier may comprise tubes 26 and 27 whose grids are connected to opposite ends of the output transformer 2 from the compensating amplifier and whose plates may be connected to opposite ends of the secondary 28 of the output transformer, the primary thereof being indicated by the reference character 29. This output stage may in reality be an output stage if the device is used in the capacity of a receiver, though it is to be distinctly understood that one of the primary purposes of this invention is to provide a compensating amplifier driver for a Class B modulator for transmission, though the invention is not limited to this particular use.

The characteristic of the Class B amplifier stage as described hereinabove and as indicated in Figure 2, has a substantially linear portion

of its characteristic curve as indicated at 30 in Figure 2. However, when the grids are driven positive by a heavy signal load, there is a falling off in the relation between input and output voltage. This curved portion is indicated by the reference character 31, and as shown in Figure 2, may begin at the point indicated at 32.

The compensating amplifier has a characteristic curve, such as indicated in Figure 3. This characteristic curve shows a linear relation between the input and output voltage of the compensating amplifier, as indicated by the reference character 33. However, at the point 34 the characteristic curve is rising, as indicated by the curved portion 35, and this rise is controlled by the selection of the tube having the proper characteristics and used as the auxiliary tubes 9 and 10. Starting from zero voltage input to the amplifier, it is apparent that the tubes 7 and 8 will function. After a certain predetermined value of voltage input has been reached, the tubes 9 and 10 commence to function for the first time. In view of the fact that the tubes 9 and 10 begin to function on the lower curved portion of their static characteristic curve, it is apparent that their addition to that of tubes 7 and 8 will cause the rising characteristic indicated in Figure 3. The tubes 9 and 10 are only operated over the rising curved portion of their static characteristic curve. Also the rising characteristic and the point at which it occurs are controlled by the grid bias and the constants of the circuit in which it is used. At all events, this invention contemplates the selection of tubes and the control of the grid bias in such a manner that a rising portion indicated at 35 in the characteristic curve is provided which proportionately balances the drooping portion 31 of the Class B amplifier if no provisions had been made for power absorption in the Class B amplifier grid circuits.

Therefore, it is clear that when the compensating amplifier, whose characteristic curve is shown in Figure 3, drives the modulator or other stage, whose characteristic curve is shown in Figure 2, that a resultant curve having a linear relation of input and output voltage, as shown by the straight full line 36 in Figure 4, results, the portion 35 balancing the portion 31 hereinabove described and indicated by dotted lines in Figure 4. It is apparent, therefore, that a truly linear relation exists and that distortionless output from the Class B stage results.

The rising characteristic for the compensating amplifier will be readily understood when Figure 1 is considered. It will be seen that the tubes 9 and 10 do not come into operation when the signal is relatively small, but as the signal increases so that in spite of the relatively high negative bias for the tubes 9 and 10, they begin to function, it is apparent that their output supplements that of the tubes 7 and 8, which result becomes apparent when it is considered that the tubes 9 and 10, as previously pointed out, function only on the lower rising curved portion of their static characteristic curve. It is also clear that a suitable point on the characteristic curves of the tubes 9 and 10 may be selected so that the rising characteristic of the amplifier may be increased or lessened as required to exactly fit the drooping characteristic of the stage, such as the modulator, driven from the compensating amplifier. Further than this, it is obvious as indicated in

Figure 1, that the points at which the secondary 4 is tapped for driving the tubes 9 and 10 may also control the curvature indicated by the portion 35 in Figure 3 of the characteristic curve of the compensating amplifier. Thus it is clear that irrespective of the load placed on the apparatus, that a truly linear output may be obtained.

It is clear that the invention may take other forms from the precise form shown in Figure 1. For instance as shown in Figure 5, the secondary 4' of the input transformer may have its terminals bridged by the voltage divider type resistances 37 and 38 which are connected to the center point of the secondary 4' of the input transformer and lead outwardly to the grid bias for the normally working tubes 7 and 8. These voltage divider resistances 37 and 38 correspond in function to the tapping of the transformer shown in Figure 1.

These resistors 37 and 38 may act as potentiometers, that is to say, a sliding contact or other variable connection may be provided for each of the resistors as indicated at 39 and 40 to thereby determine the signal voltage impressed on the tubes 9 and 10. The grids of the tubes 9 and 10 may obviously otherwise be connected.

It will be seen that a novel form of compensating amplifier has been provided which may be used to drive a Class B stage, such as a Class B modulator, and that the entire output of the amplifier may be employed for driving this successive stage without, on the one hand, producing any distortion whatsoever and, on the other hand, without requiring a very high power input and by-pass resistors across the modulator grids for causing a high percent power loss in the output from the amplifier, as has heretofore been the practice in an unsuccessful attempt to secure distortionless amplification.

It will be seen, therefore, that the device conserves power to a remarkable degree and most important of all insures a distortionless output for the entire system.

It is to be understood that the term "signal", for instance as used in the expression "signal amplification", "signal energy", etc., is to be construed as meaning telegraphic signals, voice or music signals, or any other electrical impulses of this general type.

It is to be understood also that the compensating amplifier need not be directly connected to the normally distorting amplifier, but intermediate stages could be employed between such amplifiers if desired. Further than this, it is obvious that the compensating amplifier could follow an amplifier which produced distortion and due to the manner in which the compensating amplifier is made, as heretofore described, it is obvious that it would correct for the distortion previously produced in the signal system.

Although this invention has been described in considerable detail, it is to be understood that such description is intended as illustrative rather than limiting, as the invention may be variously embodied and is to be interpreted as claimed.

I claim:

1. In a signal amplifying system, the combination of a compensating amplifier, said compensating amplifier having electrically symmetrically arranged amplifier units, a second stage driven by said compensating amplifier, said compensating amplifier having a portion of its

characteristic curve rising and said second stage having a portion of its characteristic curve drooping, whereby the relation of input voltage for said amplifier and output voltage delivered by said second stage is linear.

2. In a device of the class described, the combination of two signal amplifying stages, one of said stages being driven by the other of said stages, one of said stages having a drooping characteristic and the other of said stages having a rising characteristic, the stage with said rising characteristic having vacuum tubes arranged in a symmetrical system, whereby substantial distortionless amplification is obtained.

3. In a device of the class described, input means, a pair of vacuum tubes having grids, cathodes and anodes, said grids being connected to said input means, means for biasing said grids to a predetermined negative potential, a second pair of vacuum tubes having grids, cathodes and anodes, the grids of said second pair of vacuum tubes being biased more negatively than the grids of said first pair, means independent of the grids of said first pair of vacuum tubes for operatively connecting the grids of said second pair of vacuum tubes to said input means, said input means impressing a lesser signal voltage upon the grids of said second pair of vacuum tubes than on the grids of said first pair of vacuum tubes, said first and second pair of vacuum tubes being each arranged in push-pull relation, output means including an output transformer having a center tapped primary, the opposite ends of said primary being connected to an anode of one of said first mentioned vacuum tubes and to an anode of one of said second mentioned vacuum tubes.

4. In a device of the class described, a compensating amplifier having a first pair and a second pair of vacuum tubes, each having a grid, a cathode and an anode, input means for controlling said grids, means for independently biasing the grids of said first and second pairs of tubes at different potentials, said input means impressing a lower signal voltage on the grids of the more highly biased tubes, condenser means interposed between the grids of said second pair of vacuum tubes and said input means, the anodes of said tubes being connected in pairs and each pair including an anode of one of said first mentioned tubes and an anode of one of said second mentioned tubes, and output means reversely connected to said pairs of anodes.

5. In a device of the class described, a compensating amplifier having a first pair and a second pair of vacuum tubes, each having a grid, a cathode and an anode, input means for controlling said grids, means for independently biasing the grids of said first and second pairs of tubes at different potentials, condenser means interposed between the grids of said second pair of vacuum tubes and said input means, said input means impressing a lower signal voltage on the grids of the more highly biased tubes, the anodes of said tubes being connected in pairs and each pair including an anode of one of said first mentioned tubes and an anode of one of said second mentioned tubes, output means reversely connected to said pairs of anodes, and means for varying the effect of said input means on the grids of at least one pair of said vacuum tubes.

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