

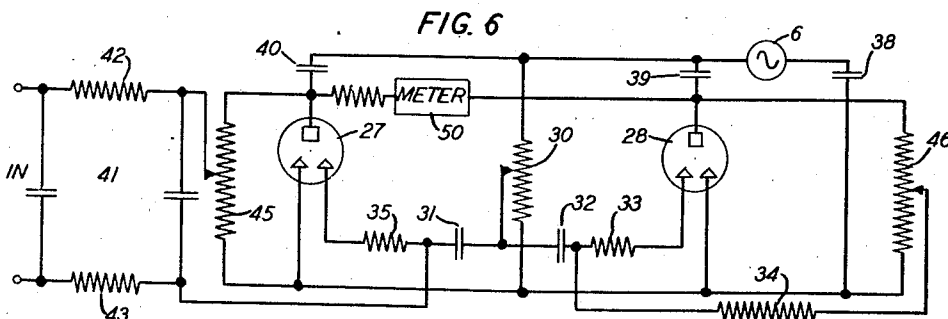
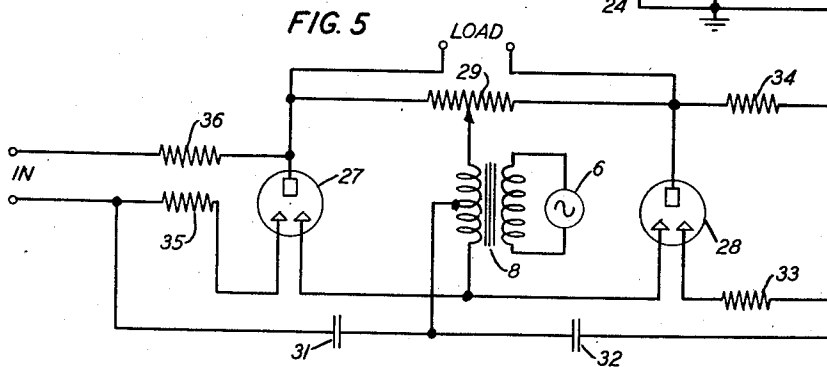
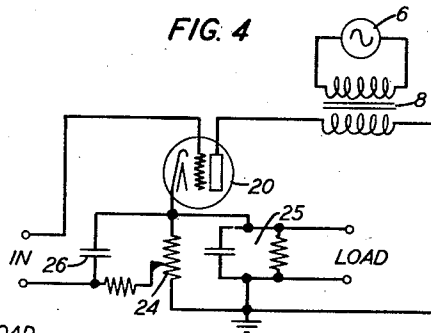
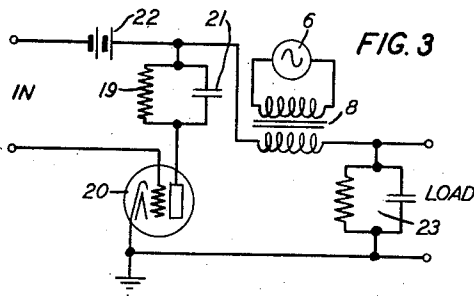
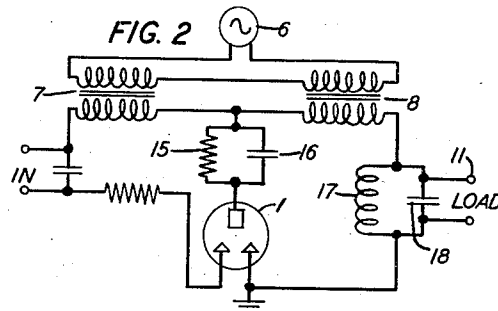
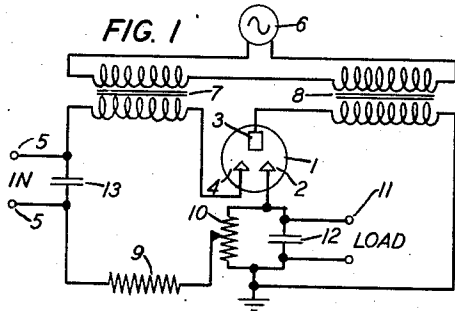
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2,293,570

AMPLIFIER USING GAS-FILLED TUBE

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AMPLIFIER USING GAS-FILLED TUBE

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2 Claims. (Cl. 179—171)

The present invention relates to space discharge device circuits and especially to circuits using gas-filled tubes for amplification of applied waves or voltages.

An object of the invention is to obtain a large degree of amplification with a high degree of linearity.

In the operation of gas-filled tubes as amplifiers, an alternating or intermittent voltage of higher frequency than the wave to be amplified is applied to the discharge electrodes and the instant of breakdown is controlled by the voltage that is to be amplified. The discharge is extinguished by the alternating or interrupted high frequency voltage applied across the discharge electrodes, and the phase in the high frequency cycle at which the discharge is extinguished is ordinarily constant, the exact value depending on the tube design, including the kind of gas used. By controlling the phase in the cycle at which the discharge begins, the fraction of the cycle during which current flows is controlled and this in turn determines the useful load current. Filtering means is used to keep the high frequency current out of the load circuit.

It has been suggested that the high frequency voltage wave be shaped to reduce distortion. This involves use of shaping devices that are likely to be cumbersome and costly.

In accordance with the present invention distortion is reduced by feeding back a portion of the output wave or voltage to advance or retard the phase in the cycle at which breakdown occurs, and by making the effect of the fed back wave or voltage opposite to that of the original input wave or voltage whereby the over-all amplification is reduced as compared to the case of no feedback. Since the gain obtainable with a gas-filled tube is very large, large reduction in gain can be produced by the feedback action and this means that large increase in linearity is effected. The circuit connections for producing the feedback action are simple in comparison with wave shaping circuits that have been suggested heretofore.

The nature of the invention and its various objects and features will appear more fully from the following detailed description of illustrative embodiments shown in the accompanying drawing.

In the drawing:

Fig. 1 is a schematic circuit diagram of one form of circuit using negative feedback in accordance with this invention;

Figs. 2, 3 and 4 are similar diagrams of alternative circuits; and

Figs. 5 and 6 are similar diagrams showing the use of two tubes differentially coupled to a common load.

In Figs. 1, 2, 5 and 6 cold cathode gas-filled tubes are shown, although in all of these circuits hot-cathode tubes could be used if desired.

In Fig. 1, the gas-filled tube 1 has main discharge gap 2, 3 and a starting gap 2, 4. Electrodes 2 and 4 may be alike and are located relatively close to each other. Electrode 3 is physically distinct and is always the anode. In Fig. 1 the input is connected across 2 and 4 so that the discharge is initiated across the gap 2, 4 supplying ions to set off the main gap 2, 3.

The signal applied across terminals 5 may consist of varying direct current, or impulses, speech or other suitable type. The source of alternating current 6 is of higher frequency than the signal and may be as high as desired within the limitation that the time required to restore the tube to unionized condition must be small compared with a half period of the high frequency wave. This wave is applied through transformers 7 and 8 to both the input circuit and the output circuit.

The input circuit is connected to the cathode by way of series resistor 9 and the slider on resistor 10 across which the load terminals 11 are connected, shunted by by-pass condenser 12 for the high frequency wave from 6. Similarly the input terminals are shunted by by-pass condenser 13 for the high frequency wave.

The resistance 10 is in part common to the output circuit and input circuit and provides negative feedback as will be described.

In the absence of any signal voltage at terminals 5, 5 there will be rectified high frequency current across the resistance 10 and across the load terminals but the condenser 12 will by-pass the high frequency component. More complete filtering may be used as desired at this point. The high frequency wave drives electrodes 3 and 4 both positive at the same time and both negative a half cycle later. In the positive half cycle current flows for a certain fraction of the time depending upon adjustments. In the negative half cycle the discharge is extinguished in both the starting gap and the main gap.

A signal which makes the starter electrode 4 more positive advances the time in the high frequency cycle at which the discharge begins. Once the tube has broken down the starting electrode loses control and the tube is restored at a given point in the high frequency cycle which for a

given tube and circuit remains substantially constant. A signal which makes the starter electrode 4 more negative delays the breakdown until a later time in the high frequency cycle. Thus, during a positive swing of the signal voltage a succession of current impulses is produced in the output circuit of greater than normal duration and during a negative swing of the signal voltage the output high frequency impulses are shorter than normal. The cumulative effect is a charge on condenser 12, hence across the load, which varies in accordance with the signal variations.

Since only a relatively small input voltage is required to control a large energy flow in the output circuit, a large factor of amplification is possible with this type of circuit. With a high frequency wave of sinusoidal shape or any shape in which the phase angle at which breakdown occurs is not strictly proportional to the peak input voltage, a considerable distortion is produced in the amplified output signal or indication. For example, assuming a sine wave form for the high frequency voltage, the effective amplification increases markedly with input peak signal voltage and may be many times as great for a high amplitude signal as for a low amplitude signal.

In accordance with the invention this distortion is reduced by applying to the starter electrode some of the output signal voltage in opposite phase to the incoming signal, and in Fig. 1 this feedback voltage is obtained from the resistance 10, the amount depending upon the position of the slider along the resistance. This fed back voltage represents the amplified signal distorted to some extent. If the distortion at any portion of the signal swing is of such nature that the current is flowing for too large a part of the high frequency cycle, the fed back voltage tends to delay the breakdown point in the high frequency cycle so that the discharge impulse is shortened, and if the impulse is disproportionately short the fed back voltage advances the breakdown phase to lengthen the impulse. This action comes about automatically from the fact that the fed back voltage is substantially opposite in phase to the incoming signal voltage. Preferably the feedback voltage ratio is relatively large in order to secure a correspondingly great reduction in gain and improvement in distortion. The use of negative feedback for reduction of distortion is broadly claimed in H. S. Black Patent 2,102,671, patented December 21, 1937.

The circuit of Fig. 2 is similar to that of Fig. 1 except that in Fig. 2 separate impedances are used for the feedback impedance 15 and for the load impedance 17. These are shunted respectively by by-pass condensers 16 and 18 for the high frequency. The operation is otherwise the same.

In Fig. 3, since a hot cathode tube 20 is used, it is unnecessary to extinguish the discharge between the control electrode and cathode, and transformer 7 can thus be dispensed with. The circuit is of the plate feedback type, meaning that the feedback impedance 19 is next to the plate. Bias battery 22 is used to apply a negative bias to the control electrode relative to the anode. Condenser 21 by-passes the high frequency and the load impedance is shown at 23 comprising a resistor and shunting condenser. In the absence of a signal voltage discharge impulses of slightly less than half a cycle duration are produced. During the negative signal swing

these impulses are shortened and during the positive signal swing they are lengthened. The negative feedback effects a corrective phase displacement in such direction as to reduce the output and at the same time and in corresponding amount reduce the distortion.

Fig. 4 is, in general, similar to Fig. 3 but uses a cathode feedback, meaning that the feedback impedance is next to the cathode. It comprises resistor 24. The load coupling impedance 25 is in shunt with the resistor 24. The two condensers shown are by-pass condensers for the high frequency wave from source 6. Condenser 26 also serves as a grid bias capacity in conjunction with resistance 24.

In some cases, such as in measuring circuits, it is desirable to make the circuit immune to fluctuations in the peak voltage of the high frequency source 6. This is done in Figs. 5 and 6 in which two tubes 27 and 28 are used to cancel out the effects of such voltage changes.

In the absence of a signal or voltage to be indicated or measured applied to the "in" terminals, the adjustments are such that both tubes break down at the same instant and produce the same potential at both terminals of the load or meter so that for a constant or varying value of peak voltage of the source 6 there is no difference of potential across the load terminals. The sliders on resistances 29 and 30 may be adjusted to correspond to this balanced condition.

If, now, in Fig. 5 a signal or other voltage is applied to the input, the phase in the high frequency cycle at which tube 27 breaks down is varied while it remains fixed in the case of tube 28. The current in the two portions of resistance 29 becomes unbalanced and this causes current to flow into the load. The voltage in either half of resistor 29 also produces feedback to the corresponding grid through the corresponding condenser 31 or 32, and the size of the fed back voltage is determined by the ratio of the two resistances 33 and 34 for tube 28 and resistances 35 and 36 (including the resistance across the input terminals) for tube 27. Condensers 31 and 32 also provide a path for applying negative restoring voltages to the starter electrodes.

The operation of Fig. 6 is similar to that of Fig. 5, the main difference being that the high frequency voltage is in Fig. 6 applied to the starter electrodes through condensers 38, 39, 40 instead of through a transformer. The high frequency voltage applied to the grids is varied by the slider on resistor 30. A filter 41 is shown in the input circuit for purifying the wave to be measured.

In the absence of an input voltage both tubes break down as above described, producing no meter current, since equal currents flow through equal resistances 45 and 46. A voltage across the input terminals varies the starting time of the impulses in tube 27 but not in tube 28, and this causes an equalizing current to flow through the meter 50. On the negative high frequency cycle, restoring voltage is applied through condensers 39 and 40 for restoring the main gaps and through condensers 31 and 32 for restoring the starter gaps. Negative feedback is produced by applying voltage from across each resistor 45, 46 to the corresponding starter electrode, this voltage being momentarily stored in the corresponding condenser 31 or 32. In the case of tube 27 the voltage is applied through the resistors 42 and 43 and the input terminals and thence through

resistor 35. In the case of tube 28 the voltage is applied through series resistors 34 and 33.

The circuits that have been disclosed are to be taken as illustrative rather than limiting. The scope of the invention is defined in the claims.

What is claimed is:

1. In combination, a circuit comprising a pair of gas-filled tubes, a load differentially coupled to the discharge space electrodes of said tubes, a source of intermittent voltage for supplying the discharge spaces of said tubes in parallel, an input circuit for voltages to be amplified coupled to the control elements of one only of said tubes, and means for feeding back from the output sides of said tubes to the control electrodes of said tubes a portion of the output voltage in such phase as to tend to oppose the initiation of current flow in said devices and in sufficient amount

to improve the linearity of amplification of the circuit.

2. In an amplifier circuit, a pair of gas-filled tubes each having discharge electrodes and a starter electrode, means to apply a voltage to be amplified to the starter electrode of only one of said tubes, a source of alternating voltage, connected to the discharge electrodes of said tubes, of a frequency high in comparison to the frequency of said voltage to be amplified, a load circuit differentially coupled to the discharge electrodes of both tubes, means to apply a portion of said alternating voltage to said starter electrodes in like phase, and means to feed back a portion of the load voltage to the starter electrode of said one tube in phase opposition to the voltage that is to be amplified.

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