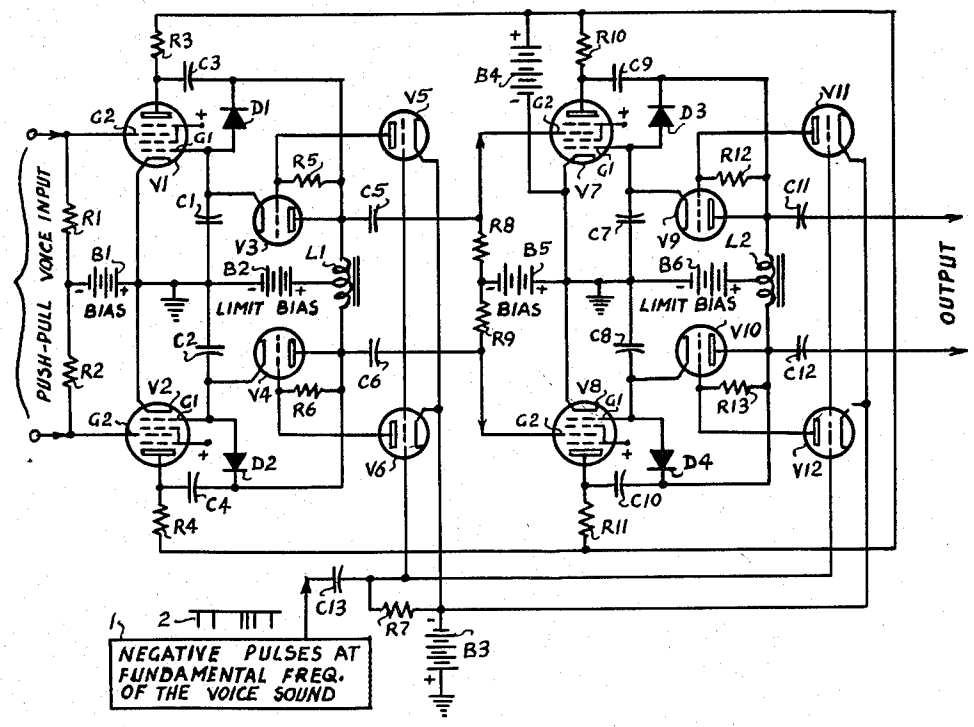
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AMPLITUDE EQUALIZER OF SPEECH SOUND WAVES

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AMPLITUDE EQUALIZER OF SPEECH SOUND WAVES

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1 Claim. (Cl. 330—144)

This invention relates to automatic amplitude control systems, and particularly to a system for normalizing the amplitude of propagated speech sound waves to a constant-peak amplitude level. Its main object is to compress and expand the amplitude of propagated speech sound waves stepwise at the fundamental frequencies of said sound waves, so that constant peak-amplitude may be obtained regardless of the speed of phonation. A further object is to provide amplitude equalization without resorting to loss of voice quality or intelligibility.

In various forms of speech sound wave production and reproduction, it is often desired that the wide variations of amplitude in speech sound waves, as originated in the vocal system, are synthetically compressed to a standard peak amplitude. Automatic volume control systems are used conventionally, for example, in radio circuitry. These systems, however, are useful only for slow amplitude variations, and if they are arranged to control fast amplitude variations of the speech sound waves, the voice quality is completely lost; although substantial amount of intelligibility may be preserved. Accordingly, the system disclosed herein is contemplated to provide complete equalization of the speech sound wave peaks, with negligible loss of voice quality, but without any loss of intelligibility. Such amplitude equalization without loss of voice quality may be obtained by shifting the amplitudes of sound wave patterns stepwise without distorting their waveforms; the condition of which I have shown to be true by actual tests. Briefly in accordance with the invention, the original speech sound waves are applied to a gain controllable amplifier. A gain-reducing feedback is first passed through a peak reference bias source, and stored in a capacitor, so as to reduce the gain of the amplifier in constant state. The fundamental frequencies of the speech sound waves (wave patterns) are selected, and narrow pulse signals are produced at the peaks of said wave patterns. These pulse signals are then utilized to modify the storage across said capacitor, so as to change the gain of said amplifier stepwise according to the amplitude of each of the incoming wave pattern of the speech sound wave. The nature of such a system will be apparent from the following specification, and in conjunction with the accompanying schematic arrangement of the figure.

Referring to the arrangement of the figure, the speech sound wave is applied to one of the control grids, for example, G2, of dual control vacuum tubes V1 and V2, from across resistors R1 and R2, which are connected to a normal bias battery B1. The tubes V1 and V2 are used as push-pull amplifiers of the sound waves, and the amplified waves are produced across their anode circuit resistors R3 and R4. The control grids G1 of tubes V1 and V2 are connected to cathode potential by way of capacitors C1 and C2, respectively. The amplified waves across R3 and R4 are coupled capacitively (by C3 and C4) in push-pull to an inductive load L1, the center tap of which is connected to the cathodes of tubes V1 and V2 in series with a positive potential, as

obtained from battery B2. From the two end terminals of inductor L1, there are connected diodes D1 and D2 to the control grids G1 of tubes V1 and V2, respectively. These diodes are so polarized that only negative signals developed across inductor L1 are admitted therethrough. The positive bias of battery B2, therefore, prevents admittance through diodes D1 and D2 until the negative signal across L1 exceeds the potential of B2, for charging either capacitor C1 or C2 in negative polarities. There are used two vacuum tubes, V3 and V4, in oppositely polarized parallel connections with the diodes D3 and D2, respectively. The oppositely polarized vacuum tubes V3 and V4 are used to charge the capacitors C1 and C2 positively during gain shifting pulse periods, and are normally rendered inoperative by high negative biases impressed upon their control grids. These negative biases are produced across resistors R5 and R6 by way of normal anode current draw through normally conducting tubes V5 and V6. In order to develop negative potentials across resistors R5 and R6, the anode elements of tubes V5 and V6 are arranged to receive near ground potential, and their cathodes to receive negative potential from battery B3, while the anode elements of tubes V1 and V2 receive positive potential from battery B4. The control grids of tubes V5 and V6 are connected to their cathodes through a common load resistor R7, so that these tubes are normally in conductive states.

In operation, the voice sound signals are generated across input resistors R1 and R2, and applied to the control grids G2 of gain controllable amplifier tubes V1 and V2. Due to the push-pull arrangement of these tubes, the amplified sound waves across anode circuit resistors R3 and R4 appear linearly. These amplified waves are coupled to the inductive load L1, the signals across which are fed back in push-pull to the control grids G1 of tubes V1 and V2, in series with diodes D1 and D2. Because of the positive bias of battery B2, the negatively developed signals across inductor L1 pass through the diodes D1 and D2 only when they rise above this bias level, and charge either capacitor C1 or C2 negatively. The negative charge across either one of these capacitors reduces the gain of its associate amplifier tube until the signal across inductor L1 equals the bias potential of battery B2, whereupon further charging of the capacitors stops. In normal speech sound waves the positive and negative peaks are not symmetric, and accordingly, the push-pull arrangement of amplifier tubes V1 and V2 facilitates amplitude equalization of both polarities. Thus when a high peak of the input voice signal arrives, the amplifier gain is reduced to a reference magnitude, and remains in such a state thereon, so that the amplifier functions linearly. The peak amplitude of a following wave pattern of the speech sound wave may have a lower amplitude than the preceding one, and accordingly, the gain of the amplifier must be readjusted at the arrival of the following peak.

As described in my U.S. Patent No. 2,872,517, February 3, 1959, the fundamental frequencies of speech sound waves are represented by the presence of trains of wave patterns, each terminating a high peaked wave. Thus by selecting these high peaked waves, the fundamental frequencies of speech sound waves may be represented, as described by way of a schematic arrangement in said patent. Accordingly, the block 1 in the figure represents a fundamental frequency selector, which is arranged to produce negative pulses at said high peaked waves, as indicated by the pulse waves 2 above block 1. These negative pulses are simultaneously applied upon the control grids of tubes V5 and V6 (through coupling capacitor C13), which momentarily become non-conductive, and remove the negative bias voltages across resistors R5 and R6. The tubes V3 and V4 in turn become con-

ductive, and because of their oppositely polarized connections in parallel with diodes D1 and D2, the capacitors C1 and C2 discharge during the short pulse period. This discharge may be more than necessary, but the diodes D1 and D2 will immediately readjust their charges to the required negative potentials. During such voltage adjustment, a high amplitude pulse may appear across the output resistors R3 and R4, but a small capacitor connected in parallel with the inductor L1 is found to suppress satisfactorily any pulse generated in L1 without interfering with the voice signals.

With the above given explanation, it is seen that the arrangement of the figure is capable of equalizing the varying amplitudes of speech sound waves stepwise, as proceeds wave pattern after wave pattern, without distorting their waveshapes. Such distortionless amplitude equalization will, accordingly, provide high quality and high intelligibility of the voice sounds, as I have shown by actual tests. Ideal conditions, however, are often difficult to attain, because of imperfect component parts that may be utilized. For example, the amplifier tubes V1 and V2 must provide high ratio of gain control with high linearity, the condition of which is very difficult to obtain, even though push-pull drive is utilized. Accordingly, two identical gain controlling stages will provide the requred gain control, with moderate drive to each stage, thereof. As the second stage is identical to the first stage, further description of same is not necessary. But for reference purposes, the component parts may be identified, as in the following:

The output voice signal across inductor L1 is coupled in push-pull to the control grids G2 of gain controllable amplifier tubes V7 and V8, through coupling capacitors C5, C6, and from across load resistors R8 and R9, which are further terminated common to ground in series with bias battery B5. The amplified sound waves across output resistors R10 and R11 are coupled to output load inductor L2 through coupling capacitors C9 and C10. The two end terminals of center tapped inductor L2 are coupled in push-pull to the control grids G1 of amplifier tubes V7 and V8, through polarized diodes D3 and D4, the anode terminals of which are further connected to storage capacitors C7 and C8, respectively, terminated common to ground. The center tap of inductor L2 is connected to ground in series with peak limiting positive bias of battery B6, so that the capacitors C7 and C8 are charged negatively through diodes D3 and D4 when the negative signal developed across L2 exceeds the limiting potential of battery B6; the latter of which may be the same as battery B2. The discharge of capacitors C7 and C8 is established by vacuum tubes V9 and V10, which are normally rendered inoperative by high negative bias potentials upon their control grids, developed across resistors R12 and R13. These negative bias potentials are developed by normally conductive tubes V11 and V12, the anode terminals of which are connected to the control grids of V9 and V10, respectively. Since the gain controlling storage capacitors C1, C2, and C7, C8 of both stages are discharged simultaneously during a pulse period, both the control grids and cathodes of V11 and V12 are connected in parallel with the grids and cathodes of tubes V5 and V6. The final amplitude equalized voice sound waves are then taken from across output inductor L2, either directly, or through the coupling capacitors C11 and C12.

In actual practice, the inductors L1 and L2 had been substituted by resistive elements. But due to the capacitive coupling, the voltage across said resistive elements varied erratically during discharge periods of the storage capacitors. Accordingly, the use of inductive elements is suggested more desirable; although resistive elements may also be used, if so desired. Each type has an advantage, for example, the use of resistive elements will deliver a wide band of frequencies with lesser cost, while the inductive element will eliminate some noise with higher cost; especially when high quality parts are used. If desired, the resistors R3, R4, R10, R11, coupling capacitors C3, C4, C9, C10 and inductors L1, L2 may be eliminated, and transformers substituted instead. This latter arrangement will provide higher quality signal output, but it becomes more complicated to adjust the timing of pulse periods during which the gain suppressing storage capacitors are discharged for the required stepwise gain adjustments of the two separate amplifier stages. It is, of course, obvious that transistors, for example, the types having dual base controls, may be utilized with the arrangement of the figure.

With the above given specification of the arrangement of the figure, it is readily suggested that various substitutions, modifications and adaptations are possible, without deparating from the true spirit and scope of the invention.

What I claim is:

In complex waves having random variations in amplitude peaks, a system of equalizing the amplitudes of said peaks, comprising means for producing said complex waves; means for producing pulse signals at said peaks; first and second gain controllable amplifier means, each comprising an electric discharge device having an emitter, first and second gain controlling electrodes, and a collector electrode, respectively; means for applying said produced complex waves to the gain controlling first electrodes of said first and second amplifier means in oppositely poled directions for amplification of same in their respective collector electrodes; an inductive impedance means having first and second terminals and a center tap; means for coupling said amplified complex waves in said collector electrodes of the first and second amplifier means to the first and second terminals of said impedance means, respectively; a peak limiting bias voltage source, and means for connecting same from said center tap to the emitter electrodes of said first and second electric discharge devices; first and second rectifier means and first and second storage means; means for coupling the first rectifier means and the first storage means in series with the first terminal of said impedance means and the second electrode of said first amplifier means in gain reducing direction, so that said storage means is charged in substantially a steady state for gain reduction when the peak of said amplified complex wave is higher than said peak limiting bias source; means for coupling the second rectifier means and the second storage means in series with the second terminal of said impedance means and the second electrode of said second amplifier means in gain reducing direction, so that said storage means is charged in substantially a steady state for gain reduction when the peak of said amplified complex wave is higher than said peak limiting bias source; third and fourth electric discharge devices, each having an emitter, an admittance control electrode and a collector; means for coupling said third and fourth devices oppositely polarized across said first and second rectifier means, resepctively, for discharging the steady state charges of said first and second storage devices; a normal admittance blocking bias source upon the electrodes of said third and fourth electric discharge devices; and means for applying said pulse signals to last said electrodes for cancelling said blocking bias, whereby to modify said steady state storages, and thereby obtaining said stepwise amplitude equalization across said impedance means in oppositely polarized directions.

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