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2,332,536

ELECTRICAL CIRCUIT CONTROL DEVICE

Filed April 23, 1941

FIG. 1.

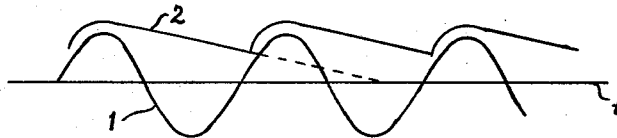


FIG. 2.

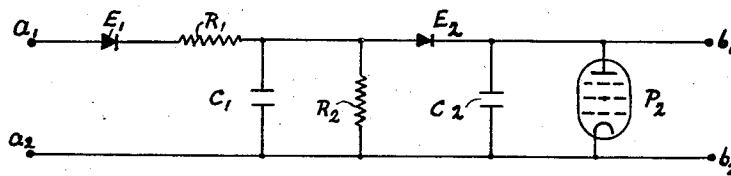


FIG. 3.

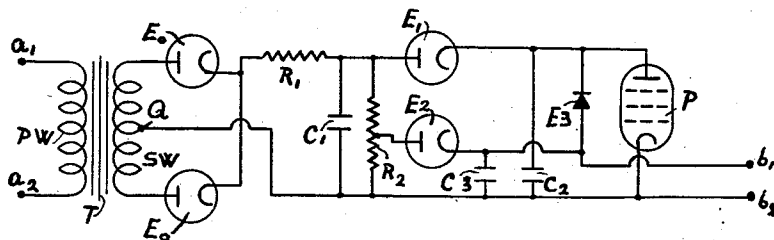


FIG. 4.

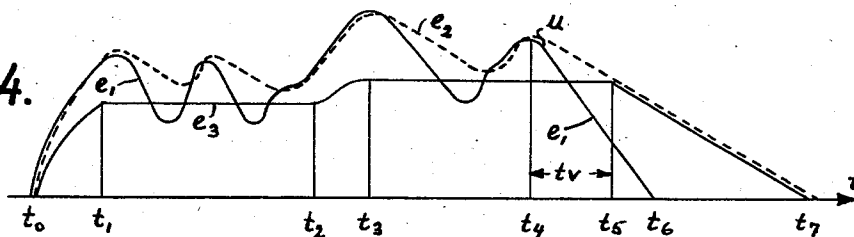


FIG. 5.

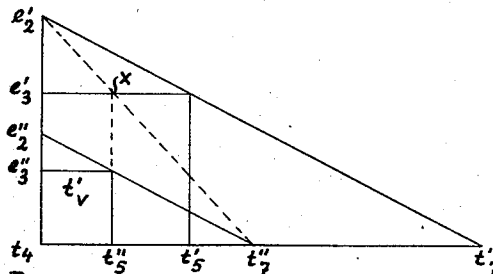
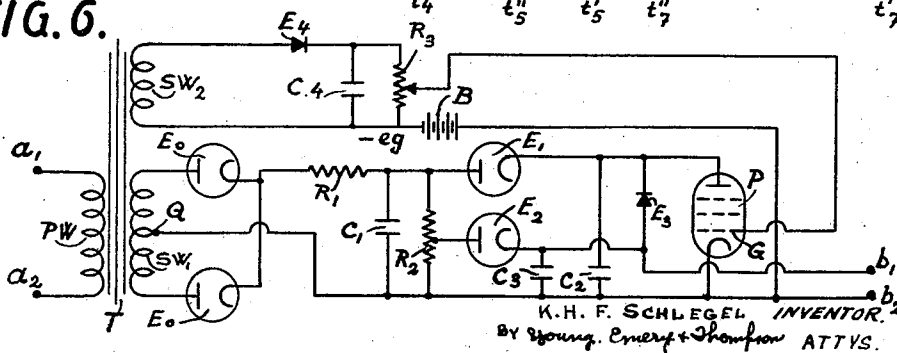


FIG. 6.



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UNITED STATES PATENT OFFICE

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ELECTRICAL CIRCUIT CONTROL DEVICE

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11 Claims. (Cl. 179-1)

This invention relates to electrical circuit control devices and more particularly to control circuits for automatically controlling the gain of electronic amplifiers in sound translating systems.

An object of the invention is to provide an improved method of controlling the volume range in electro-acoustical translators.

Another object is to provide means for demodulating a control voltage used for automatic volume control so as to prevent sound frequencies from reaching the gain control member of the sound translating system.

Various other objects and advantages will become apparent to those skilled in the art as the nature of the invention is more fully disclosed.

In automatic volume control circuits in which the gain of an electronic amplifier is controlled by means of a control voltage derived from the input or output circuits of the sound translating channel, it is desirable that the control voltage should vary in accordance with the sound energy, and not, as is generally the case in the existing control circuits for automatic volume control, according to the peak amplitudes which occur in the signals.

The fact that in the volume control devices so far applied to automatic volume control the control voltage produced by rectification of the sound responsive electric oscillations varies as the envelope of the rectified amplitudes involves the drawback that occasional peak amplitudes occurring in a sound selection will have a predominant effect on the control voltage. Thus, for instance, in the case of volume compression during the recording of sounds the peak amplitudes will cause a sudden decrease of the gain of the amplifier, whereby the values of the subsequent amplitudes of the sound selection are reduced below the correct level, and the dynamic quality of the programme is thereby minimized. A substantial improvement in the dynamic quality would be achieved, if the control voltage could be caused to vary according to the sound energy instead of following the envelope of the rectified currents, as the effect of the peak amplitudes would thereby be less pronounced.

In electrical filter circuits comprising a rectifier, a parallel condenser, a series resistance and a load resistance, the control voltage across the condenser may be caused to vary proportionally with the mean value of the rectified amplitudes, provided that the charge time which is essentially determined by the series resistance and the discharge time constant determined by the load

resistance are substantially of the same order. If the rectifier has a square law characteristic or if the input signal has beforehand undergone a deformation according to a logarithmic law, the D. C. control voltage derived from a circuit of this kind will vary according to the mean value of the squares of the amplitudes, i. e., in accordance with the energy of the sound responsive electric oscillations or, in other words, according to the sound energy.

However, the energy responsive control voltage derived from such a circuit will contain audio-frequency fluctuations, and it is therefore necessary to provide means for demodulating the control voltage before it can be applied to the gain control member.

A feature of the invention consists in the use of separate circuits for producing an energy responsive control voltage and for demodulating the said control voltage.

In one embodiment of the invention the control voltage is derived from the first mentioned control circuit, wherein the voltage across the condenser is caused to vary in accordance with the sound energy, and the demodulation is effected by suitable choice of the discharge time constant of a parallel condenser included in the second circuit.

In another embodiment of the invention the demodulation of the control voltage is effected by providing means in the second circuit for maintaining the control voltage derived from the first mentioned circuit at a constant level during a predetermined time interval after the cessation of the sound amplitudes.

For a better understanding of the invention reference is made to the accompanying drawing in which

Fig. 1 illustrates the curves of the signal current and the variations of a control current obtained by rectification of said signal current.

Fig. 2 illustrates a circuit for producing a control voltage proportional to the volume and free from audible modulation.

Fig. 3 is a modified circuit of the same kind.

Fig. 4 illustrates a voltage-time curve of the condensers shown in the circuits in Figs. 2 and 3.

Fig. 5 is a diagram of the discharge time for two different values of the control voltage according to the circuit shown in Fig. 3, and

Fig. 6 is a modification of the circuit shown in Fig. 3.

Referring to the accompanying drawing, in Fig. 1, curve 1 shows the variation of a signal voltage, i. e., sound responsive electric oscillations during

a time interval, whereas curve 2 shows the resulting variation after rectification and passage through a filter condenser. Provided that the frequency represented by curve 1 is the normally lowest frequency, for example 30 cycles, it will be seen that if the discharge time of the filter condenser is a relatively short one, for example of the same order as the charging time, the voltage across the condenser will start to fall immediately after the passing of one rectified current impulse. Curve 2 will thus follow the shape of curve 1 and will, therefore, have a definite modulation.

Fig. 2 shows an embodiment of a circuit arrangement according to the invention in which the energy responsive control voltage is produced by feeding a portion of the sound responsive electric oscillations to a circuit comprising input terminals a_1 and a_2 , the rectifier E_1 , a series resistance R_1 , a parallel condenser C_1 and a load resistance R_2 . The characteristic of rectifier E_1 and the value of the resistances R_1 and R_2 which determine the charge and discharge times of condenser C_1 respectively are matched in such a way that the voltage variations across the condenser C_1 are proportional to the volume of the signals, or, in other words, vary in accordance with the sound energy. Connected in series with the first mentioned circuit is the second circuit comprising a blocking rectifier E_2 , a parallel condenser C_2 and a load resistance comprising the space discharge path of an electron discharge tube, preferably a pentode P. The output terminals of the second circuit b_1 and b_2 are connected with the anode and cathode respectively of the said pentode. The demodulation of the energy responsive control voltage produced across the condenser C_1 is effected by means of the last mentioned filter circuit including the condenser C_2 , the discharge time constant of which may be chosen sufficiently long as to remove audible modulation from the control voltage. By loading the condenser C_2 with the circuit of the pentode P the result is achieved that the control voltage across the condenser C_2 decreases proportionally with the time after cessation of the sound responsive oscillations. It will be realised that instead of using the pentode P any equivalent load resistance such as a resistance in conjunction with a self-inductance may be applied. The embodiment shown in Fig. 2 may be used in such cases where conditions permit of a long discharge time of the control voltage, as for instance when the reverberation of a room has to be corrected.

In many cases, however, for instance in electro-acoustical sound transmission using logarithmic compression, such a long discharge time as that of a circuit as shown in Fig. 2 will result in distortion. In such cases therefore, it is necessary to take special precautions to render the control voltage free from modulation. A modified circuit adapted to this purpose is shown in Fig. 3 in which the arrangement of the condenser discharge circuit supplying the control voltage is such that the discharge of the condenser is delayed during a suitable time interval so as to maintain the control voltage at a constant value during the said time interval, whereupon the condenser is rapidly discharged.

The operation of this circuit arrangement is as follows:

A portion of the sound responsive electric oscillations is impressed on the input terminals a_1 and a_2 of the primary winding PW in a transformer T, the secondary winding SW of which is con-

nected with the anodes of two iodide rectifiers E_0 connected in push-pull. The cathodes of the said rectifiers E_0 are connected through a series resistance R_1 with one terminal of a filter condenser C_1 , the charge time of which is essentially determined by the value of resistance R_1 , whereas the discharge time of the said condenser is determined by the value of the load resistance R_2 . The other terminal of condenser C_1 is connected with the midpoint tap Q of the secondary winding SW. The values of the resistances R_1 and R_2 are so chosen that the charge time and discharge time of condenser C_1 are approximately of the same order, for example 3 milliseconds and 10 milliseconds. Assuming that the rectifiers E_0 have a square law characteristic or that the sound responsive electric oscillations have undergone a logarithmic deformation, the voltage across the condenser C_1 will consequently vary according to the sound energy. However, this voltage will be heavily modulated having superimposed on the D. C. component an A. C. component as shown in curve 2 of Fig. 1. The amplitudes of this A. C. component—an indication of the amount of modulation—depend partly on the frequency of the original sound responsive oscillations and partly on the discharge time of the condenser C_1 , the modulation increasing the lower the frequency and the shorter the discharge time.

Parallel with the condenser C_1 there is a blocking condenser C_2 which is being charged at the same time through a diode rectifier E_1 . Now this blocking condenser C_2 , the function of which will be described in the following, is discharged considerably slower than condenser C_1 , namely, with a discharge time of the order of 100 milliseconds which is caused by the load resistance of the blocking condenser. As in the embodiment shown in Fig. 2, the load resistance of condenser C_2 is an electron discharge tube, preferably a pentode P, providing for a constant discharge current, whereby the voltage of the blocking condenser decreases proportionally with the time.

Referring again to Fig. 3 it will be seen that parallel with a part of the load resistance R_2 is a third condenser C_3 which is being charged through rectifier E_2 with a voltage slightly lower than that across condensers C_1 and C_2 , and which is connected to the anode of the pentode P through a blocking rectifier E_3 .

As long as the voltage across the blocking condenser C_2 is higher than the voltage across condenser C_3 , the latter will have an infinite discharge time owing to the blocking rectifier E_2 which will prevent discharge through the resistance R_2 . The voltage across the condenser C_3 will therefore remain constant during a certain time interval, until the voltage across the blocking condenser C_2 has decreased by discharge through the pentode P below the value of the voltage across condenser C_3 . At that moment, however, the last mentioned condenser will be discharged through the blocking rectifier E_3 and the pentode P.

The voltage variations across condensers C_1 , C_2 and C_3 is illustrated in Fig. 4, wherein the corresponding voltages are indicated at e_1 , e_2 and e_3 . The starting time of all the three voltages is indicated by the time interval t_0 — t_1 , the voltage e_1 (varying as already mentioned in accordance with the sound energy) is heavily modulated owing to the short discharge time constant of condenser C_1 and therefore cannot be used directly as a control voltage. The voltage e_2 across the

blocking condenser C_2 of Fig. 3 follows mainly the variations of voltage e_1 . Since, however, the condenser C_2 has a larger discharge time constant the audible modulation will be much less. When conditions are arranged so as to provide for a long discharge time, as represented in Fig. 4 by the straight line $u-t_7$ which represents the discharge time of condensers C_2 and C_3 , it may be possible to obtain a sufficiently low degree of modulation of the voltage e_2 so as to permit this voltage to be used directly as a control voltage, as assumed in the embodiment shown in Fig. 2.

The curve e_3 in Fig. 4 represents the voltage variations across the condenser C_3 in Fig. 3. Owing to the function of the blocking condenser C_2 in conjunction with the blocking rectifier E_3 the control voltage e_3 will remain constant within certain time intervals t_1-t_2 and t_3-t_5 and will consequently be free from audible modulation. The discharge time interval of condenser C_1 is represented by t_4-t_6 whereas t_4-t_7 represents the discharge time of condenser C_2 .

As is shown from the above, the value of the control voltage is given by the energy as distinct from the peak value of the sound responsive electric oscillations passing through the rectifiers E_0 to condenser C_1 .

The relation between the values of the control voltage e_3 , Fig. 4, and the time interval during which the control voltage remains constant after cessation of the sound is illustrated in Fig. 5.

E'_3 and E''_3 are two different values of the control voltage across condenser C_3 at the time t_4 when the sounds disappear. e'_2 and e''_2 are the corresponding values of the voltage across the blocking condenser C_2 . $t_4-t'_7$ and $t_4-t''_7$ are the corresponding discharge times of the latter condenser, whereas $t'_5-t'_7$ and $t'_5-t''_7$ are the discharge times of condenser C_3 corresponding to the control voltages $e'_3-e''_3$ respectively. It will be seen that the constant voltage interval $t'_v(=t_4-t'_5)$ is considerably larger than the corresponding interval $t''_v(=t_4-t''_5)$ so that the bigger the control voltage e_3 the longer the constant voltage interval t_v .

Owing to the fact, that, in a musical programme the low notes which are of particular importance with regard to the quality of the sounds generally occur with a large acoustical energy as compared with the high notes, the low notes will, in general, give rise to relatively large control voltages. Consequently, the constant voltage time interval will normally be larger at lower than at higher frequencies of the sound responsive electric oscillations.

Since, on the other hand, the audible modulation is more pronounced in the control voltage derived from low notes the increased constant voltage time interval will normally provide for a satisfactory demodulation.

In special cases, however, such as in broadcasting of grammophone recording, the low frequencies are often suppressed such that the lower notes do not occur with a relatively large acoustical energy. In such cases there is no reason for having different constant voltage time intervals at different control voltages, and it may, therefore, be desirable to provide means for keeping the constant voltage time interval independent of the value of the control voltage.

In a further embodiment of the invention which is illustrated in Fig. 6 this result is achieved by providing means for increasing the discharge time of the control voltage condenser C_3 so that the discharge current increases with

increasing amplitudes. The discharge of the condenser C_3 is in this case represented by the dotted line $e'_2-t''_7$ in Fig. 5. It will be seen that the constant voltage interval e'_3-x corresponding to voltage e'_3 is now equal to the constant voltage time interval t''_v corresponding to voltage e''_3 .

The modified circuit arrangement shown in Fig. 6 is similar to that of Fig. 3, there has been added, however, a rectifier circuit comprising an auxiliary winding SW_2 on transformer T , a rectifier E_4 , a parallel condenser C_4 and an adjustable load resistance R_3 the movable contact of which is connected to the control grid G of the pentode P . A battery B supplying a negative bias e_g to one terminal of the said load resistance or potentiometer R_3 is inserted in series with one of the output terminals b_2 of the control circuit.

The operation of this circuit arrangement is as follows:

Sound responsive electric oscillations induced in secondary SW_2 are rectified by rectifier E_4 and the rectified pulses charge condenser C_4 . The voltage across this condenser increases proportionally with the amplitudes of the input oscillations and opposes the negative bias on the control grid G so that the discharge current through the pentode P will increase proportionally with the increase of the input amplitudes. The rate of increase may be arbitrarily adjusted by the setting of the slidable contact of resistance R_3 .

I claim:

1. In a sound translating and amplifying system, a control device for variably controlling the gain of amplification comprising a rectifier and a primary filter circuit adapted to produce a control voltage proportional to the mean value of the rectified pulses, a secondary filter circuit coupled to the said primary filter circuit, and blocking means inserted between the primary and secondary circuit for rendering the releasing time of the said secondary circuit independent of the time constants of the said primary circuit.

2. In a sound translating and amplifying system, a control device for variably controlling the gain of amplification comprising a rectifier and a primary filter circuit adapted to produce a control voltage proportional to the mean value of the rectified pulses, a secondary filter circuit coupled to the said primary filter circuit and adapted to remove audible modulation from the said control voltage, and a blocking circuit for preventing the release of the said secondary circuit during a predetermined time interval so as to maintain the said control voltage at a constant value during the said time interval.

3. In a sound translating and amplifying system, a control device for variably controlling the gain of amplification comprising a rectifier and a primary filter circuit adapted to produce a control voltage proportional to the mean value of the rectified pulses, a secondary filter circuit coupled to the said primary filter circuit and adapted to remove audible modulation from the said control voltage, a blocking circuit for preventing the release of the said secondary circuit during a predetermined time interval so as to maintain the said control voltage at a constant value during the said time interval and unidirectional means inserted between the said primary circuit and the said secondary and blocking circuits for rendering the discharge of the last mentioned circuits independent of the first mentioned circuit.

4. In a sound translating and amplifying system, a control device for variably controlling the gain of amplification comprising a rectifier and a filter circuit adapted to produce a control voltage proportional to the mean value of the rectified pulses, a second filter circuit and a blocking circuit means for impressing a fraction of the said control voltage on the said second filter circuit, means for impressing a greater fraction of the said control voltage on the said blocking circuit, and uni-directional means inserted between the blocking circuit and the second filter circuit so as to prevent the release of the second filter circuit during a predetermined interval.

5. In a sound translating and amplifying system, a control device for variably controlling the gain of amplification comprising a rectifier and a primary filter circuit adapted to produce a control voltage proportional to the mean value of the rectified pulses, a secondary filter circuit coupled to the said primary filter circuit and adapted to remove audible modulation from the said control voltage, and a blocking circuit for delaying the release of the said secondary circuit, said secondary circuit and said blocking circuit having separate condensers and a common discharge path, means for charging the condenser of the blocking circuit to a higher potential than the condenser of the secondary circuit, and uni-directional means inserted between the last mentioned condenser and the said discharge path so as to prevent the release of the secondary circuit during a predetermined interval.

6. In a sound translating and amplifying system, a control device for variably controlling the gain of amplification comprising a rectifier and a primary filter circuit adapted to produce a control voltage proportional to the mean value of the rectified pulses and including a condenser and a parallel resistance, a secondary filter circuit coupled to a part of said resistance and a blocking circuit coupled to a greater part of said resistance, said secondary circuit and said blocking circuit having separate condensers and a common discharge path, and uni-directional means inserted between the condenser of the secondary circuit and the said discharge path so as to delay the release of the secondary circuit during a predetermined interval.

7. In a sound translating and amplifying system, a control device for variably controlling the gain of amplification comprising an input transformer, a rectifier and a primary filter circuit adapted to produce a control voltage proportional to the mean value of the rectified pulses and including a condenser and a parallel resistance, a secondary filter circuit coupled to a part of said resistance and a blocking circuit coupled to a greater part of said resistance, said secondary circuit and said blocking circuit having separate condensers and a common discharge path, a pentode having its anode-cathode resistance inserted in the said discharge path and uni-directional means inserted between the condenser of the said secondary circuit and the anode circuit of the said pentode so as to prevent the release of the secondary circuit during a predetermined time interval.

8. In a sound translating and amplifying system as defined in claim 7 the addition of a rectifier circuit including an auxiliary secondary winding on the said input transformer, a rectifier, a parallel condenser adapted to be charged through the said rectifier, an adjustable load resistance connected across the said condenser, a

movable contact on the said load resistance, and means connecting the said movable contact with a control grid of the said electron discharge tube and adapted to impress a variable negative bias on the said control grid so as to increase the discharge current through the said electron discharge tube proportionally with the increase of the signal current.

9. In a sound translating and amplifying system, a control channel, means applying a portion of the signal energy to the said control channel, an input transformer having its secondary winding inserted in the said control channel, a pair of diode rectifiers connected in push-pull in the said control channel and adapted to rectify the control energy, a parallel condenser adapted to be charged through the said rectifier and having charge and discharge time constants of substantially the same order so as to produce a control voltage proportional to the variation of the signal energy, means impressing the said control voltage on a filter circuit comprising a blocking rectifier, a secondary filter condenser, an electron discharge tube having its anode connected to one terminal and its cathode connected to the other terminal of the said filter condenser, and means impressing the said control voltage on the amplification of the said sound translating and amplifying system.

10. In a sound translating and amplifying system, a control device for variably controlling the gain of said amplifier, a primary rectifying and filtering circuit including a square law rectifier, a parallel condenser and a load resistance and having operating and releasing times of substantially the same order, a secondary filter circuit coupled to the said primary circuit through a tapping on the said load resistance and including a filter condenser and a rectifier inserted between one terminal of the last mentioned condenser and the said tapping, a blocking circuit including a blocking condenser connected in parallel with the said load resistance of the said primary circuit, a rectifier inserted between one terminal of said blocking condenser and said load resistance, an electronic discharge tube having its anode connected with one terminal and its cathode connected with the other terminal of said blocking condenser, and a blocking rectifier inserted between the anode of the said electron discharge tube and one terminal of the filter condenser of the said secondary circuit.

11. In a sound translating and amplifying system, a control channel, means applying a portion of the signal energy to the said control channel, an input transformer having its secondary winding inserted in the said control channel, a pair of diode rectifiers connected in push-pull in the said control channel and adapted to rectify the control energy, a parallel condenser adapted to be charged through the said rectifier and having charge and discharge time constants of substantially the same order so as to produce a control voltage proportional to the variation of the signal energy, means impressing the said control voltage on a filter circuit comprising a blocking rectifier, a secondary filter condenser, an electron discharge tube having its anode connected to one terminal and its cathode connected to the other terminal of the said filter condenser, and means impressing the said control voltage on the sound translating and amplifying system to influence the amplification.

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