Nov. 19, 1940. G. L. DIMMICK 2,222,172

ENVELOPE CURRENT SYSTEM

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FIG. 1.

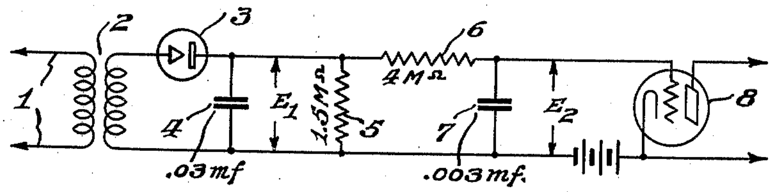


FIG. 2.

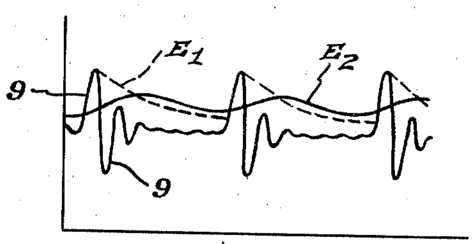


FIG. 3.

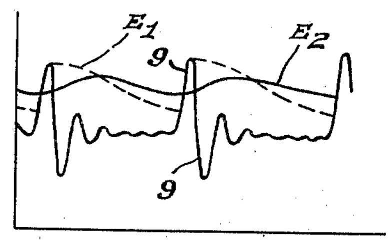


FIG. 4.

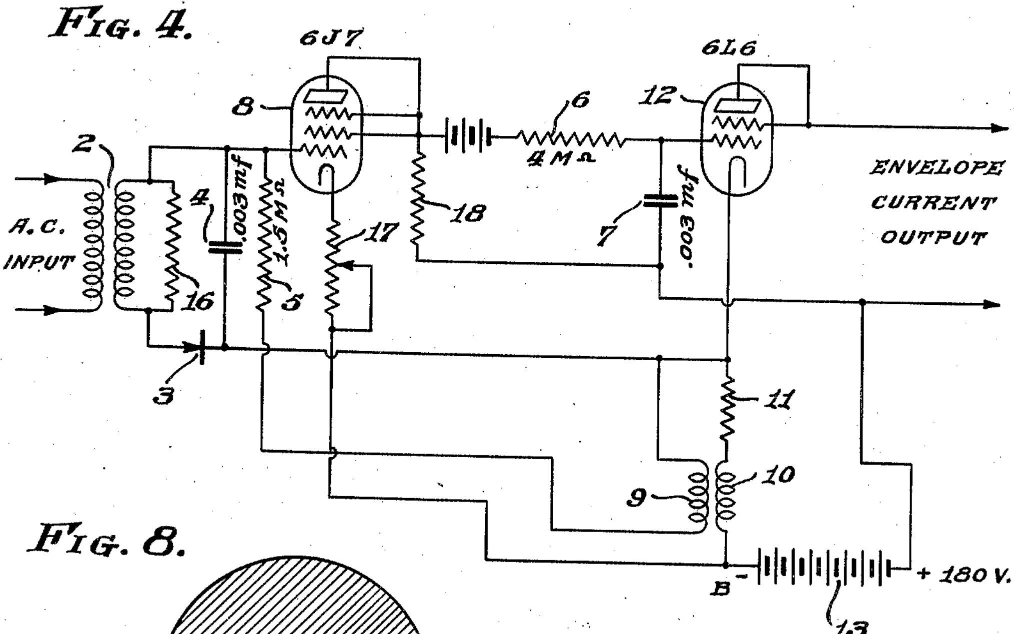
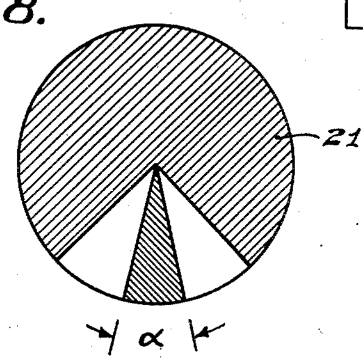


FIG. 8.



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ENVELOPE CURRENT SYSTEM

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FIG. 5.

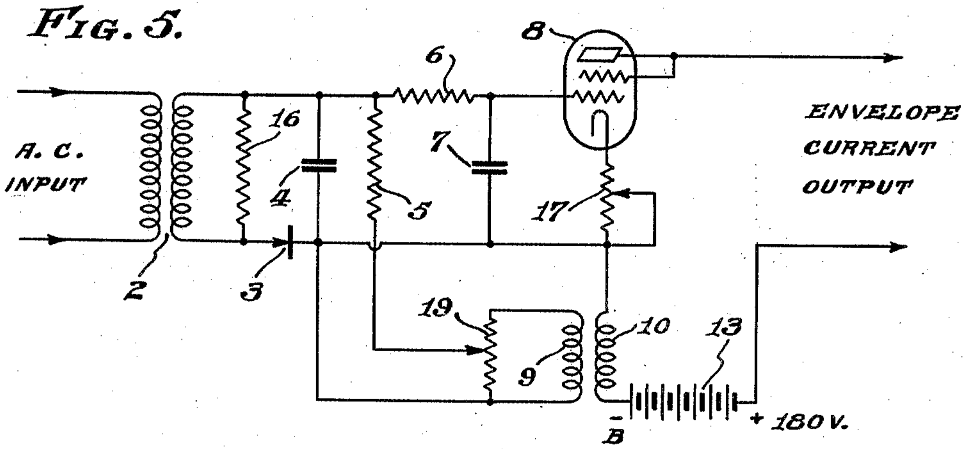
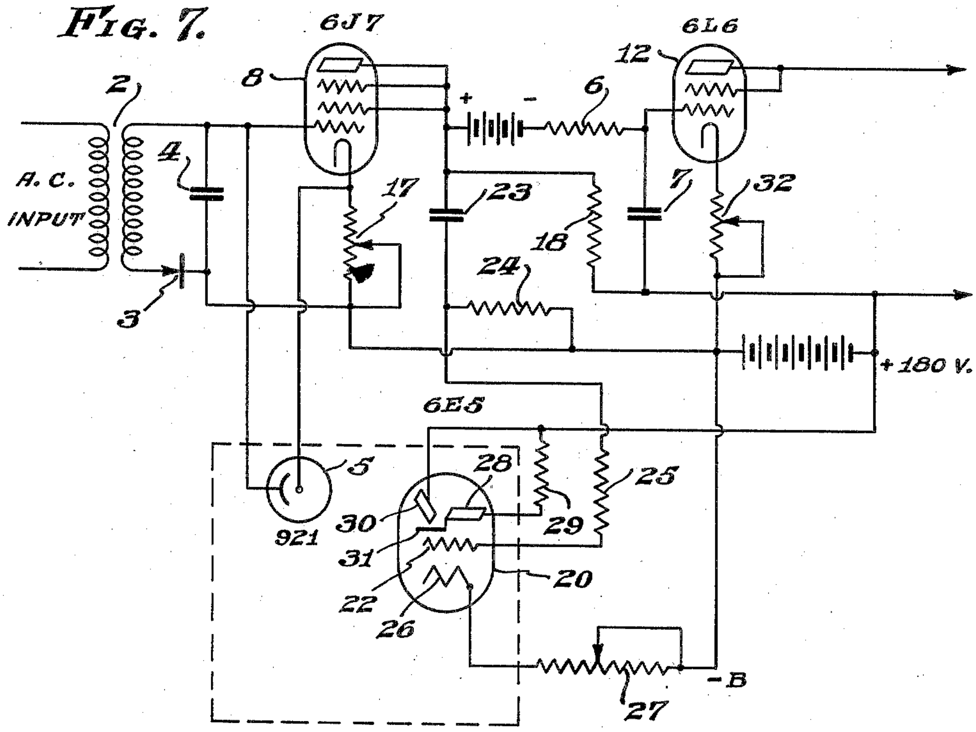


FIG. 7.



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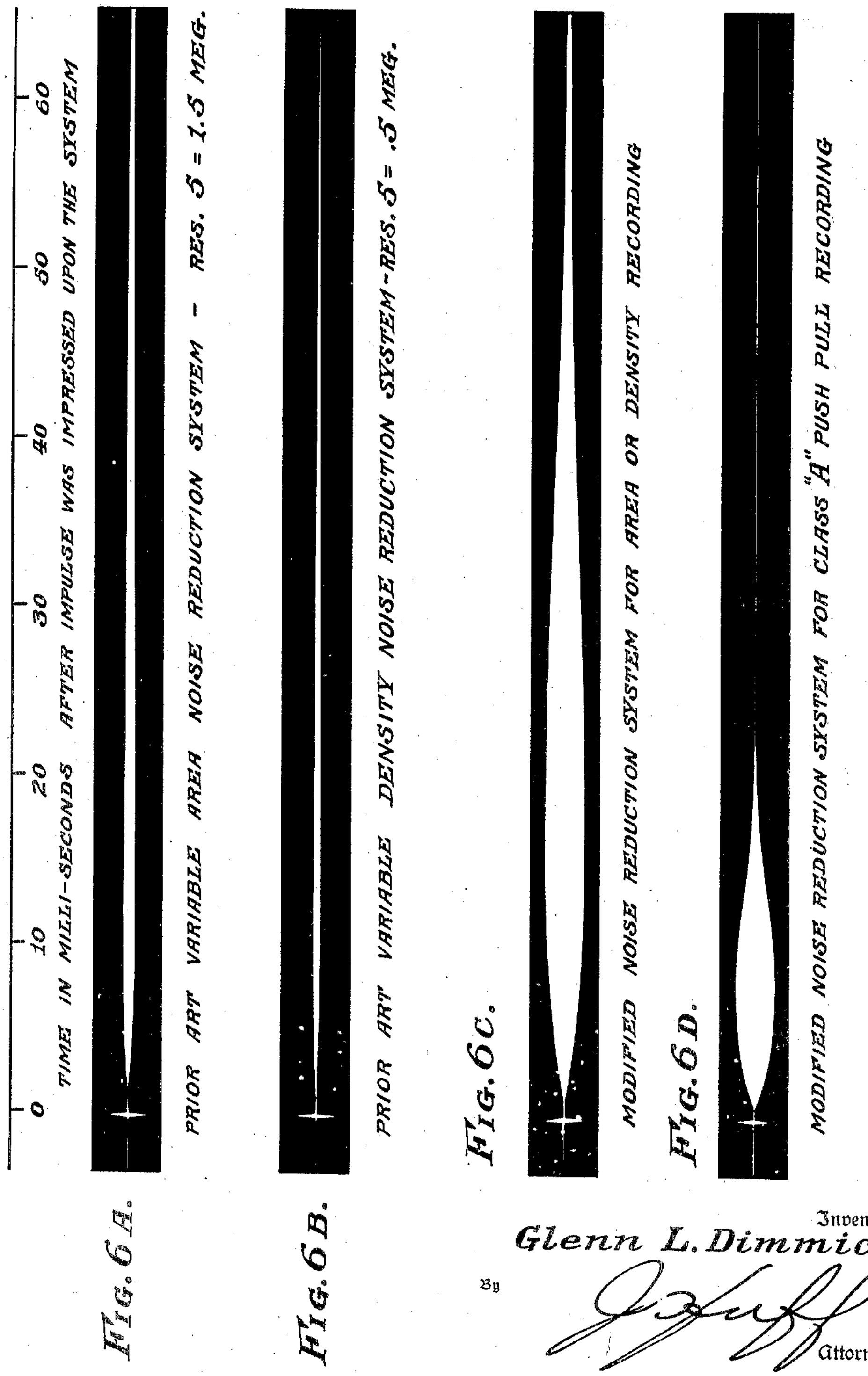

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UNITED STATES PATENT OFFICE

2,222,172

ENVELOPE CURRENT SYSTEM

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Application May 19, 1939, Serial No. 274,524

7 Claims. (Cl. 179—100.3)

This invention relates to systems for producing a current having a wave form similar to the envelope of the peaks of an alternating current such as audio frequency current, which contains components of many different frequencies and varies rapidly in amplitude, and has for its principal object the provision of an improved apparatus and method of operation whereby the envelope current potential is made to follow the alternating voltage peak values more closely than has been heretofore possible.

Various alternating current peak reading or envelope current producing systems are well known, have been used extensively, particularly in connection with the recording of sound pictures, and are disclosed by prior art patents such as Robinson 1,854,159, Hanna 1,888,724, McDowell 1,855,197, Kreuzer 1,999,700 and others. As hereinafter explained, these various prior art systems have left something to be desired with respect to their ability to produce an output or direct current bias which follows closely the peaks of the alternating current input, and with respect to facility in the timing of the increase and decrease in such output or bias current. In a copending application of Kellogg, Serial No. 237,603, filed October 29, 1938 (RCV Docket 5526), and assigned to the same assignee as the present application, are disclosed various alternating current peak reading or envelope current systems which minimize the aforesaid difficulty by periodically increasing the resistance of a condenser discharge path or by subjecting the condenser to successive charges. The present invention is an improvement on that of the aforesaid Kellogg application and differs therefrom with respect to the means provided for controlling the discharge rate of the timing condenser.

The invention will be better understood from the following description considered in connection with the accompanying drawings, and its scope is indicated by the appended claims.

Referring to the drawings,

Figure 1 is a wiring diagram of a prior art system on which the improvement of the present invention is based,

Figures 2 and 3 are explanatory curves relating to the operation of the system of Fig. 1,

Figure 4 is a wiring diagram of a preferred form of the present invention,

Figure 5 is a wiring diagram of a modification of the system of Fig. 4,

Figures 6A, 6B, 6C and 6D are explanatory diagrams relating to the operation of the systems of Figs. 1 and 4,

Figure 7 is a wiring diagram of a system which operates somewhat differently from the systems of Figs. 4 and 5, and

Figure 8 illustrates a detail of the system of Fig. 7.

Fig. 1 shows, in elementary form, a circuit arrangement which is in wide use for providing a current proportional to the envelope of an audio frequency current. After suitable amplification, the audio frequency current is applied to terminals 1—1 of transformer 2. A rectifier 3 permits current to pass in one direction only, and condenser 4 becomes charged by the rectified current. Since the resistance of the rectifier 3 to reversed current or to the discharge of condenser 4 is very high, condenser 4 would remain for a long period of time charged to a voltage corresponding to the highest voltage impressed across the rectifier. In order that the charge on condenser 4 may be reduced when the audio frequency amplitude becomes less, a discharge resistance 5 must be provided. The magnitude of this resistance is so chosen relative to the capacity of condenser 4 that the decrease in voltage E_1 across condenser 4, when the audio frequency voltage falls, will be at the desired rate. Obviously, if condenser 4 is permitted to discharge very rapidly through resistance 5, the voltage E_1 which should represent an envelope, will attempt to follow individual waves of the audio frequency and this is not desirable. On the other hand, if resistance 5 is made very high, E_1 will follow very slowly when the audio frequency amplitude drops, and this may in part defeat the purpose of the device for which the envelope wave is wanted. A desirable value of resistance 5 is therefore chosen which will cause E_1 to follow decreases at a suitable rate. It is, in general, desirable to make the resistance of the rectifier 3 and of the input circuit as reflected through the transformer 2, so low in relation to the capacity of condenser 4 that an audio frequency peak of very short duration will suffice to build up the voltage E_1 to a value substantially equal to this peak voltage. The impedance of the rectifier and input circuit must also be low compared with resistance 5, so that the latter will not constitute an appreciable drain on the rectifier during charging.

The circuit so far described will provide a voltage which comes as near to following the true peak envelope as it is practically possible to provide. Such an envelope voltage, however, is found to contain in greater or less magnitude, numerous fluctuations which are in the audio frequency range, and it is practically almost always necessary to subject the envelope voltage or current to low pass filtering in order that it shall not introduce sounds in the system. This gives a voltage E_2 which rises and falls with E_1 but does not have the small rapid fluctuations which are present in E_1. The simplest type of low pass filter employed for this purpose consists in a resistance 6 and a condenser 7.

The RC product of this stage of filtering must be sufficient to practically eliminate the audio components. In general, condenser 7 is of much smaller capacity than condenser 4 (for example, one-tenth) and resistance 6 is correspondingly high. With this arrangement, the current through resistance 6 is too small to greatly affect the voltage E_1. The filtered voltage E_2 may be applied to the grid of a thermionic amplifier tube 8, from the plate circuit of which is derived the necessary power for control or for ground noise reduction purposes. In some arrangements, a low pass filter involving inductance and capacity is employed instead of resistance and capacity. This gives a sharper cut-off characteristic which may be desirable under certain conditions.

An arrangement similar to that shown in Fig. 1 for obtaining an envelope voltage is already in wide use and is satisfactory, providing a sufficiently slow discharge of condenser 4 is not objectionable. When attempt is made, by reducing the value of resistance 5 in Fig. 1, to produce an envelope voltage or current, which follows the decreases in the audio frequency voltage more rapidly, it is found that the system no longer gives an envelope voltage equal to that of peak voltages of short duration in the audio frequency system, but tends to give a voltage more nearly corresponding to the average or to the R. M. S. audio frequency voltage. This is true regardless of the fact that resistances 5 and 6 do not appreciably load the rectifier 3 during the instant of charging.

Fig. 2 illustrates what happens when there is a brief audio frequency peak followed by an interval of inverse or low audio voltage, comparable in length to the time constant of resistance 6 and condenser 7. Curve 9 represents an assumed audio frequency voltage wave. Curve E_1 represents the voltage across condenser 4 of Fig. 1, assuming that the input impedance is very low, permitting development of the substantially full peak voltage across condenser 4. Curve E_2 represents the filtered voltage. It is obvious that this will never reach the peak value of E_1 because condenser 4 will have discharged to a lower voltage before condenser 7 has had time to become charged.

If some means may be provided which will maintain condenser 4 at its maximum voltage for a period of time comparable with the time constant of resistance 6 and condenser 7 and then permit condenser 4 to discharge, we should have the conditions indicated in Fig. 3, where it is seen that the voltage E_2 rises to a value much more closely approaching that of the peaks of the audio waves.

It is the purpose of the present invention to provide improved means for maintaining the peak voltage on condenser 4 for a longer period of time than the actual duration of the maximum voltage in the audio frequency wave. This may be accomplished either by delaying the discharge of condenser 4 or by supplying additional charging current which reaches condenser 4 subsequent to the initial charging wave. It is well recognized that the employment of a full wave rectifier will in some cases assist in maintaining the voltage on such a condenser, but only a small and doubtful advantage is obtained in this manner. In many cases, it is desired to obtain an envelope of the peaks of one polarity only, and not of the other. For this purpose, the full wave rectifier is obviously not appropriate. In the second place, in spite of all of the filtering applied, there is a residuum of components of audible frequency. If this residuum is of the same frequency as the audio waves, it is not objectionable in quality. If it is of double frequency, such as is produced by a full wave rectifier, it may be much more objectionable in sound, even though smaller in magnitude.

The expression "peak reading ability of the circuit" is utilized throughout this specification to indicate the ratio of noise reduction wave amplitude to the recorded impulse amplitude.

It will, of course, be understood that the alternating current peak reading or envelope current producing systems herein described are particularly useful for the purpose of reducing the background noise otherwise incident to the recording of sound motion pictures, and that these systems or control circuits (1) are normally supplied from the same audio frequency source as the main sound recording channel, and (2) supply a direct current which varies in accordance with the volume or envelope of the recorded audio frequency impulses and is utilized to bias the operation of a noiseless recording element such as a shutter, a galvanometer or other member such as those disclosed by the patents identified above.

The control or alternating current peak envelope current producing system of Fig. 4 differs from the prior art circuit of Fig. 1 in that (1) the capacitor 4 and its discharge resistor 5 are separated from the resistor 6 and capacitor 7 by the amplifier 8, and (2) the resistor 5 is connected in series with a transformer secondary winding 9 which is inductively associated with a primary winding 10 connected through a resistor 11 to the cathode of an amplifier 12, and through a plate supply source 13 to the plate or anode of the amplifier 12. Also a resistor 16 is connected in shunt to the secondary winding of the control circuit input transformer 2, an adjustable resistor 17 is provided in the cathode lead of the amplifier 8, and a coupling resistor 18 is common to the output circuit of the amplifier 8 and the input of the amplifier 12. Because of the leakage from the grid to filament, it is impractical to employ resistors higher than approximately 4 megohms. This circuit makes it possible to decrease the capacitance of capacitor 4 from .03 mf. to .003 mf., thus decreasing the charging current of the capacitor and improving the peak reading ability of the circuit, without the necessity of employing resistances higher than 4 megohms (MΩ).

By including the secondary winding 9 in the discharge path of the capacitor 4, the circuit is made to have a 100% peak reading ability throughout the whole audio frequency range, and to have output or envelope current increase and decrease rates which may be substantially equal or have any other desired relation. Thus the transformer 9—10 is so connected that while the plate current of the amplifier 12 is increasing, the secondary voltage opposes discharge of the capacitor 4. Whether or not current flows from the secondary winding 9 to the capacitor 4 depends, of course, on the ratio of the transformer. The voltage across the secondary **9** is a maximum when the envelope current starts to increase, and decreases as this current increases, until it reaches zero, when the envelope current attains a steady value.

If it is desired to have the charge of the capacitor **4** the same at the beginning and end of the increase in envelope current, there is selected a transformer ratio which causes current to flow from the secondary **9** to the capacitor **4** during the first part of the envelope current increase, and current to flow out of the capacitor **4** during the last part of this increase.

Before the secondary voltage reaches zero and the capacitor **4** begins to discharge through the resistor **17**, the envelope current starts to decrease, thus causing the secondary voltage to reverse and accelerate discharge of the capacitor **4**. This helps to shorten the closing time. If the resistor **17** is small and the capacitor **4** is discharged quickly, the envelope current increase and decrease times may be made substantially equal, both of these times being dependent on the values of the resistor **6** and the capacitor **7**.

It will be observed that the resistor **11** and the primary winding **10** are connected in the cathode return lead of the amplifier **12**. The resultant voltage of the resistor **11** and primary **12** is in opposition to the voltage across the capacitor **4**, thus producing inverse feedback. As can be readily determined by calculation, the primary voltage has a fixed 180° phase relation with the voltage across the capacitor **4** when $L_{10}=R_{10}R_6C_7$.

The usefulness of this method of increasing the peak reading ability is not limited to the variable density noise reduction circuit of Fig. 4, but is equally applicable to variable area types of noise reduction circuit. Such an application is illustrated by Fig. 5.

In this modification of the invention, the transformer primary **10** is connected in the plate circuit of the amplifier **8** and the resistor **5** is connected across the capacitor **4** in series with an adjustable part of a resistor **19** through which any desired part of the secondary voltage may be included in the discharge path of the capacitor. It is necessary that the secondary winding **9** be reversed, due to the fact that only one stage of amplification is involved and an increase in the voltage of the capacitor **4** results in a decrease in the plate current of the amplifier.

As previously indicated, this circuit would not be fully peak reading even if the resistance **5** were infinite during the increase in the level or volume of the alternating current impulse input. This necessarily follows, for the reason that the capacitor **4** is large, requires several high frequency cycles to charge it, and must supply the charge of the capacitor **7**, thus reducing the volume responsive or envelope current voltage in the ratio of the capacities in these two capacitors. To make this circuit peak reading, it is necessary that the secondary voltage during the increase in the volume of the input impulses be high enough to supply the necessary additional charge to the capacitor **4**. This is readily accomplished by providing a proper transformer ratio. It is even possible to make the system make the circuit more than 100% peak reading. Thus the amplifier may be adjusted to have zero margin under steady static conditions and to have a finite margin for transients. The peak reading ability of the circuit is, of course, determined by adjustment of the potentiometer **19**.

The results obtained from operation of the prior art circuit of Fig. 1 are shown by Figs. 6A and 6B, and the results obtained from operation of the improved circuits of Figs. 4 and 5 are shown by Figs. 6C and 6D. As indicated by the legends of these figures, which are enlargements of actual recorded sound tracks, Fig. 6A shows the performance of the prior art variable area noise reduction system; Fig. 6B shows the performance of the prior art variable density noise reduction system; Fig. 6C shows the performance of the improved noise reduction systems of Figs. 4 and 5; and Fig. 6D shows the performance of the systems of Figs. 4 and 5 as applied to class A push-pull recording.

In each of the figures, a single impulse is recorded under the *o* indication and the variation in the envelope current or voltage is recorded on the adjacent record track. It will be noted that only in the case of the improved system is the recorded envelope amplitude comparable with the amplitude of the recorded impulse.

During the operation of these systems, the bias coil of a recording galvanometer was connected to the noise reduction circuit under test, the galvanometer modulation coil was connected to the output of the main recording channel, the system was adjusted for zero margin at 4,000 cycles, and individual 4,000 cycle waves were impressed on the system at the rate of about one per second while a sound track was being recorded. The ratio of the amplitude of the noise reduction wave to the amplitude of the individual 4,000 cycle waves was taken as the peak reading ability of the system.

The noise reduction circuit of Fig. 7 is similar to that of Fig. 4 in a number of respects, but differs therefrom in that (1) the discharge path of the capacitor **4** includes a photocell **5** (Type 921 for example) and the cathode return lead resistor **17**, and (2) the transformer **9—10** is replaced by an electron ray tube **20** of the "Magic Eye" type, such as the RCA 6E5. In this circuit arrangement, the tubes **5** and **20** are enclosed in a light tight container and the capacitor **4** is discharged only when illuminated from the tube **20**, which may be of the type disclosed by U. S. Patents 2,051,189 and 2,094,684.

As indicated by Fig. 8, the top of the tube **20** is provided with an opaque mask **21**. The shadow angle α of the ray control electrode increases from zero to 90 degrees when the voltage of the grid **22** (Fig. 7) is changed from —3.5 volts to zero volts. As a result, the light applied to the photocell **5** decreases as the grid **22** becomes less negative and is entirely interrupted at zero grid voltage when the shadow angle α is equal to the opening in the mask **21**.

A capacitor **23**, which has the same value as the capacitor **7**, and a resistor **24**, which has the same value as the resistor **6**, are connected between the "—B" terminal and the plate of the amplifier **8**; the grid **22** is connected through a resistor **25** to the junction between the capacitor **23** and the resistor **24**; a cathode **26** is connected through a resistor **27** to the "—B" terminal; an anode **28** is connected to the "+180V" terminal through a resistor **29**; and a fluorescent electrode **30** is connected directly to the "+180V" terminal. The anode extension **31**, of course, functions as the control electrode of the visual indicating portion of the tube and determines the pattern on the target or fluorescent anode **30**.

When the volume of the A. C. input suddenly increases, the grid of the amplifier 8 becomes more negative, the current of the resistor 18 increases, the capacitor 23 is charged in a positive direction, the grid 22 becomes less negative, and the light reaching the photocell 5 is interrupted. The peak charge on the capacitor 4 is therefore "trapped" and this capacitor cannot discharge until the voltage of the resistor 24 decreases to a point where the light is permitted to pass. But since the voltages across the resistors 6 and 24 are the same, light will be applied to the photocell only when the capacitor 7 has been fully charged, when the capacitor 4 will be discharged through the photocell 5 at a rate depending on the photocell resistance and the capacity of the capacitor.

If the rate of discharge through the photocell is faster than the rate at which the capacitor 7 discharges through resistor 6, capacitor 7 and resistor 6 control the rates of increase and decrease in the envelope current output. If the rate of discharge through the photocell is slower than the rate of discharge of the capacitor 7, the photocell determines the rate at which the envelope current decreases.

The voltage required to interrupt the light is preferably made small as compared to the maximum voltage of the resistor 24, so that the peak reading ability of the control circuit is independent of rates of increase and decrease in the values of the envelope current which activates the shutter or other background noise control member of the recording system. If desired, these rates may be made equal and quite fast for push-pull recording. The ability of the control circuit to respond to the full peak value of the first quarter wave is tremendously improved, for the reason that the capacitor 4 may be made much smaller than in the case of the prior art system of Fig. 1. For steady static conditions, the voltages of the resistors 6 and 24 are zero, thus allowing the normal amount of light to reach the photocell. The resistor 27 is utilized to adjust the bias of the tube 20 and the resistors 17 and 32 may be utilized to adjust the envelope current output value without affecting the operation of the tube 20.

I claim as my invention:

1. In a system for deriving an envelope voltage proportional to the peak values of an alternating current voltage, the combination of means for rectifying said alternating voltage, a capacitor arranged to be charged by said rectified voltage, means for amplifying said envelope voltage, and means responsive to said amplified voltage for regulating the charge on said capacitor.

2. In a system for deriving an envelope voltage proportional to the peak values of an alternating current voltage, the combination of means for rectifying said alternating voltage, a capacitor arranged to be charged by said rectified voltage, means for amplifying said envelope voltage, and means including a coupling transformer interposed between the output circuit of said amplifying means and the discharge circuit of said capacitor for regulating the charge on said capacitor.

3. In a system for deriving an envelope voltage proportional to the peak values of an alternating current voltage, the combination of means for rectifying said alternating voltage, a capacitor arranged to be charged by said rectified voltage, means for amplifying said envelope voltage, and means including a photocell interposed in the discharge path of said capacitor and light source means responsive to the output of said amplifier and arranged to control the illumination of said photocell for delaying the discharge of said capacitor.

4. In a system for deriving an envelope voltage proportional to the peak values of an alternating current voltage, the combination of means for rectifying said alternating voltage, a capacitor arranged to be charged by said rectified voltage, amplifying means provided with an input circuit subjected to said envelope voltage and with an output circuit from which the amplified envelope voltage is applied, a transformer provided with a primary circuit connected in said output circuit and with a secondary circuit, and a discharge path for said capacitor including said secondary circuit.

5. In a system for deriving an envelope voltage proportional to the peak values of an alternating current voltage, the combination of means for rectifying said alternating voltage, a capacitor arranged to be charged by said rectified voltage, amplifying means provided with an input circuit subjected to said envelope voltage and with an output circuit from which the amplified envelope voltage is applied, a transformer provided with a primary circuit connected in said output circuit and with a secondary circuit, a resistor, and a capacitor discharge path including said resistor and said secondary circuit.

6. In a system for deriving an envelope voltage proportional to the peak values of an alternating current voltage, the combination of means for rectifying said alternating voltage, a capacitor arranged to be charged by said rectified voltage, successive amplifier stages each provided with an input and an output circuit, means for subjecting one of said input circuits to said envelope voltage, a filter network connected between another of said input circuits and one of said output circuits, and means coupling another of said output circuits to the discharge path of said capacitor for regulating the charge on said capacitor.

7. In a system for deriving an envelope voltage proportional to the peak values of an alternating current voltage, the combination of means for rectifying said alternating voltage, a capacitor arranged to be charged by said rectified voltage, amplifying means provided with an input and an output circuit, a resistance-capacity network connected between said capacitor and said input circuit, and means responsive to the current of said output circuit for regulating the charge on said capacitor.

GLENN L. DIMMICK.