Sept. 8, 1942. B. KREUZER 2,295,410

SOUND RECORDING AMPLIFIER CIRCUITS

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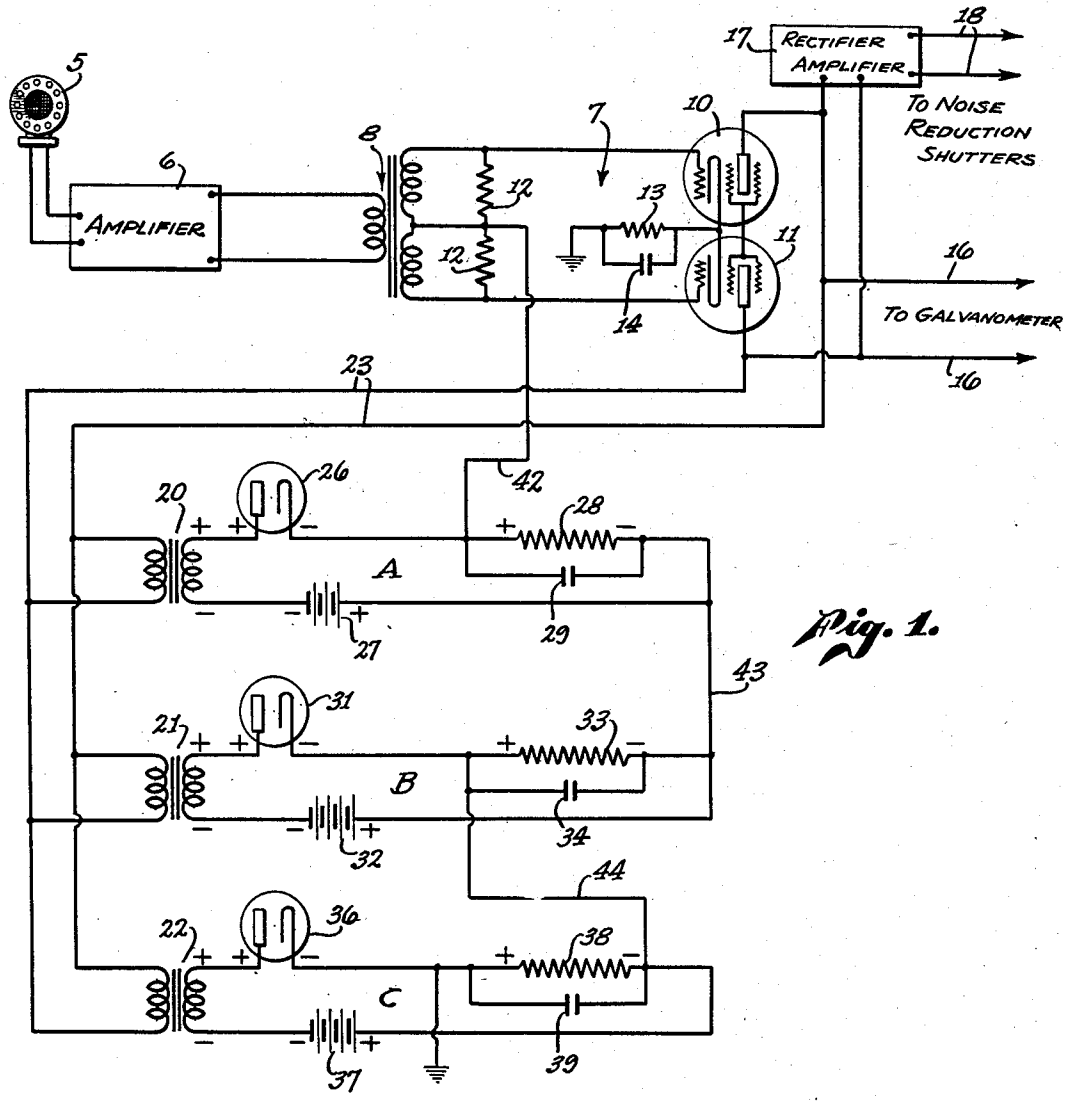


Fig. 1.

Fig. 4.

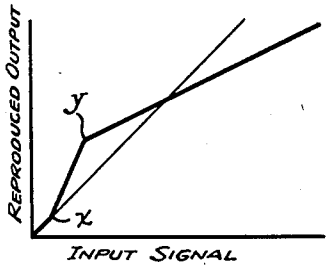


Fig. 2.

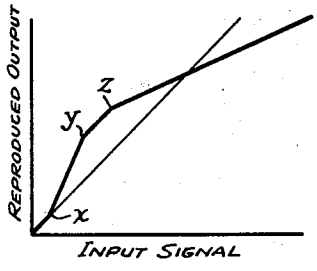
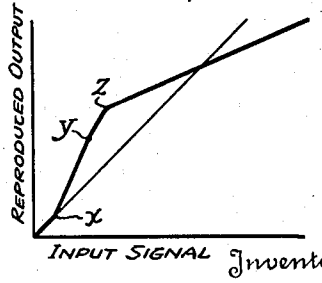


Fig. 3.



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SOUND RECORDING AMPLIFIER CIRCUITS

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Application December 1, 1939, Serial No. 307,129

1 Claim. (Cl. 179—171)

This invention relates to sound recording circuits and particularly to automatic gain control amplifiers therefor wherein different rates of gain or amplification are obtained over selected portions of the signal amplitude range being recorded.

In the art of sound recording, it has been found desirable to record different portions of a signal range at different ratios of amplification. One reason why this is desirable is because of the limited range of the film track area compared with the range of certain signals being recorded, such as those from a large orchestra. In this instance, the upper amplitude range is reduced by introducing compression, while the lower levels may be expanded for noise-reduction elimination. However, it is not desirable to expand the extremely low levels, since their expansion would increase the acoustic or "set" noises which are always present. Furthermore, for certain types of recording wherein dialogue composes the major portion of the recording, the dialogue may be recorded linearly; that is, directly proportional to the variations in change of the signal, while higher level sounds may be compressed. However, where certain dramatic effects are introduced, producing high momentary peaks, it is necessary that these peaks be reduced to prevent listener annoyance in theatres where the reproduced level is 15 to 20 db. higher than normal. The invention also lends itself to the automatic introduction of certain types of dramatic effects.

Ordinarily, a mixer, by manual control and after a rehearsal to acquaint himself with the type and trend of the sound being recorded, controls the amplifier to not only bring the signal within the film range, but also to produce expansion over certain amplitude ranges, a linear relationship between signal and film impression over other ranges, and a compression effect over the higher ranges. The present invention, however, contemplates accomplishing these results automatically for a definite type of signal. For instance, one automatic characteristic may be such that at extremely small levels, normal amplification occurs, then, above a certain threshold value, expansion may occur up to another amplitude level, then linear recording is again introduced up to another predetermined level above which compression at a certain ratio may occur. This automatic control is effected by a plurality of parallel-connected rectifiers whose outputs are connected in series for controlling the bias of an amplifier between the source of signals and the recording equipment.

The principal object of the invention, therefore, is to improve the recording characteristics of a recording system.

Another object of the invention is to automatically control the transmission ratio of signals being recorded.

A further object of the invention is to automatically vary the gain of an amplifier at different signal input levels.

A further object of the invention is to provide a plurality of selective control circuits for controlling the gain of an amplifier, the control circuits having their inputs and outputs connected to the amplifier.

Although the novel features which are believed to be characteristic of this invention are pointed out with particularity in the claims appended herewith, the manner of its organization and the mode of its operation will be better understood by referring to the following description read in conjunction with the accompanying drawing forming a part thereof in which

Figure 1 is a diagrammatic arrangement of the amplifier portion of a sound recording system; and

Figures 2, 3 and 4 are graphs showing different transmission or amplification characteristics obtainable with the circuit of Fig. 1.

Referring now to Fig. 1, signals may be detected by different types of pickup devices, one of which may be a microphone such as shown at 5. The detected signals are amplified by an amplifier 6 and fed to a controlled amplifier 7 through a transformer 8. The amplifier 7 is composed of a pair of push-pull variable mu tubes 10 and 11 having grid circuits including the secondary of transformer 8 and loading resistances 12. A biasing resistance 13 and bypass condenser 14 are shown in the grid cathode circuit. It is to be understood that, although a push-pull amplifier is shown, a single tube amplifier may also be employed. The output of tubes 10 and 11 is divided and fed to a sound-recording galvanometer (not shown) over conductors 16 and to a rectifier amplifier 17, the output of which is fed to noise-reduction shutters (not shown) over conductors 18. The usual sources of potential for the anodes and screen grids and heating source for the cathodes are employed but have not been shown for the purposes of explanation. This general type of sound recording system is disclosed in detail in Patents 2,102,776, 2,102,777, and 2,102,778.

The output of tubes 10 and 11 is further divided and fed into three parallel-connected rectifier circuits A, B and C, through respective trans-

formers 20, 21 and 22 fed from conductors 23. Circuit A contains a rectifier 26, a biasing source of potential 27 and a resistor 28 shunted by a bypass condenser 29. Rectifier circuit B contains a rectifier 31, a biasing source of potential 32, and a resistance 33 shunted by a bypass condenser 34, while rectifier circuit C is composed of a rectifier 36, a biasing source of potential 37, and a resistance 38 shunted by a bypass condenser 39. It will be noted that the biasing circuit for the tubes 10 and 11 is from the grids of tubes 10 and 11, through resistances 12, over conductor 42, through resistance 28, over conductor 43, resistance 33, conductor 44, resistance 38 and through ground to resistance 13 and the cathodes of the tubes 10 and 11. In the rectifier circuits A, B and C, the polarities of the various circuit elements have been placed thereon for the purpose of explanation.

Although the three rectifier circuits are similar, the biasing potential 27 in circuit A is small compared with the biasing sources 32 and 37 in circuits B and C, the latter two of which may or may not be equal, as will be explained hereinafter. Also, the biasing potential 27 is such that, before current flows through the resistance 28, a certain amplitude or threshold level from tubes 10 and 11 must be reached. When this threshold value is reached, current will flow through the resistance 28, creating a voltage in a direction indicated by the polarity marks. This voltage variation reduces the normal negative bias on the tubes 10 and 11, and increases their gain or amplification constant. As the signal level continues to increase, the threshold level of rectifier unit B will be reached, causing current to flow through resistance 33 with the corresponding voltage variation across this resistance as indicated. This resistance, however, is connected so that the voltage produced across it is in opposition to the voltage across resistance 28, and will thus either neutralize or at least reduce the biasing effect of the resistance 28 according to the value of these resistances.

As the signal continues to increase, the threshold value of rectifier unit C is reached, and resistance 38 becomes effective to either neutralize or to actually negatively increase the bias on tubes 10 and 11. Thus, it is obvious that by adjustment of the biasing sources 27, 32 and 37, and resistances 28, 33 and 38, various degrees of expansion and compression or linear amplification may be obtained from the tubes 10 and 11, and the signal being impressed upon the film will vary accordingly.

To further illustrate the characteristics obtainable with the invention, reference is made to Figs. 2, 3 and 4, in which the relationship between the input signal and the reproduced output from the film is shown, the 45° reference curve representing linear transmission or amplification. In Fig. 2, normal amplification occurs from zero to point "*x*," and thus certain "set" noises and other inherent acoustic noises are maintained at a low level and do not become annoying. The point "*x*" is, therefore, the threshold amplitude limit for rectifier circuit A, and is the point at which current begins to flow through resistance 28 to reduce the negative bias on tubes 10 and 11, and increase their gain. Expansion thus begins at point "*x*" and, although the "set" noises are also expanded, they are masked by the signal at the level of point "*x*." This condition exists for increases in amplitude up to point "*y*," which is the threshold value for rectifier unit B and also the threshold value for rectifier unit C, because potential sources 32 and 37 have been made equal. At the level of point "*y*," therefore, current flows through both resistances 33 and 38, and their voltage variations are additive to overcome the normal reduction in bias introduced by resistance 28 and to make the bias go negative. Thus, for amplitude levels above point "*y*," compression is introduced in the signal, as shown by the remainder of the curve, and the high peaks are thus brought within the film range as well as obtaining the other advantages of compression.

Referring now to Fig. 3, the threshold value for rectifier unit A is made the same as in Fig. 2, so for very low signals such as set noises, background noises, etc., normal amplification is provided. Similar to Fig. 2, expansion begins at point "*x*," since the current flowing in resistance 28 will reduce the bias on tubes 10 and 11 as in Fig. 2. At the point "*y*" level, however, bias 32 on rectifier B has been adjusted to send sufficient current through resistance 33 to just neutralize the effect of resistance 28 so that, between the level at point "*y*" and the level at a point "*z*," the amplifier 10—11 is again linear. By adjustment of bias 37, point "*z*" is the threshold amplitude limit for rectifier unit C and, when it becomes effective, it increases the negative bias and introduces compression, as shown by the remainder of the curve.

Referring to Fig. 4, the threshold value of rectifier A is shown at point "*x*," and the threshold value of rectifier unit B is shown at point "*y*," similar to Figs. 2 and 3. However, in this case, the value of resistance 33 is such as not to fully neutralize the effect of resistance 28, so that there still remains some expansion of the signal between the point "*y*" and the point "*z*." At point "*z*," however, the rectifier unit C becomes effective, fully overcoming the effect of resistance 28 and introducing compression in the circuit, as shown by the remainder of the curve. It is to be understood that the points "*x*," "*y*" and "*z*" may be positioned at any predetermined amplitude depending on the values of the rectifier biasing potentials, while the ratio of amplification may be controlled by the values of the biasing resistances.

Thus, in the above type of circuit, a simple and flexible control arrangement is provided for obtaining a plurality of transmission and amplification characteristics suitable for any particular signal. By the use of simple noninductive resistances in the biasing circuit and linear amplifiers, the characteristic may be accurately predetermined by the setting of the biasing potentials 27, 32 and 37 and the values of the resistances 28, 33 and 38. Thus, the recording operator or mixer is relieved of all adjustments after the initial ones have been made according to the type of signal being recorded. The inputs to rectifiers 26, 31 and 36 may also be provided with voltage controls to shift the breakaway points and the rate of gain of the amplifier 7, it being understood that the input circuits may have a series relationship. The start and release times of the expansion and compression occurring in the system are functions of the internal resistances of rectifiers 26, 31 and 36, the values of resistances 28, 33 and 38 and the values of bypass condensers 29, 34 and 39.

What I claim as my invention is:

A sound recording amplifier circuit comprising a push-pull variable gain amplifier, a plurality

of parallel-arranged rectifiers having their inputs connected in parallel, means for separately biasing each of said rectifiers to provide different operating points, one of said rectifiers operating over a certain range of signal levels, two of said rectifiers operating over another range of signal levels and all of said rectifiers operating over a third range of signal levels, means for connecting the output circuits of said rectifiers in series, said means including a resistance in each of the output circuits of said rectifiers, said resistances having different values, means individual to each resistance for controlling the timing characteristic of each of said rectifier output circuits, and means for connecting said rectifiers to said variable gain amplifier for controlling the gain of said amplifier, the different biases on said rectifiers controlling the amplitude level at which changes in gain variations occur and the different values of resistances controlling the rate of gain variation over the level ranges determined by said different biases.

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