

Dec. 17, 1940.

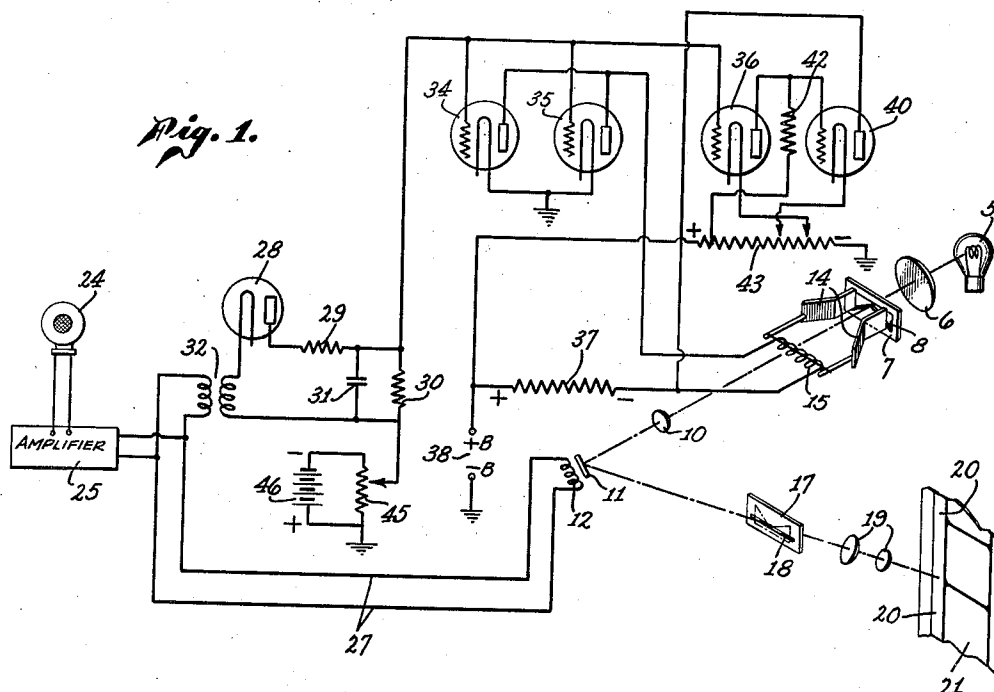
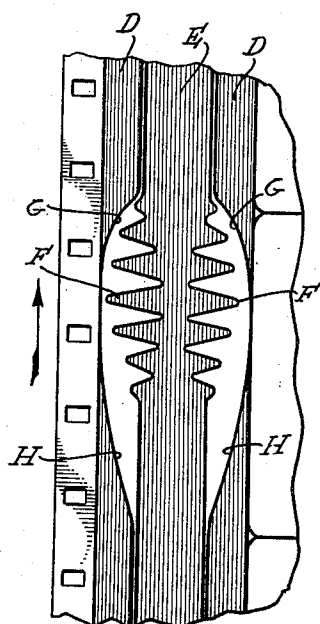
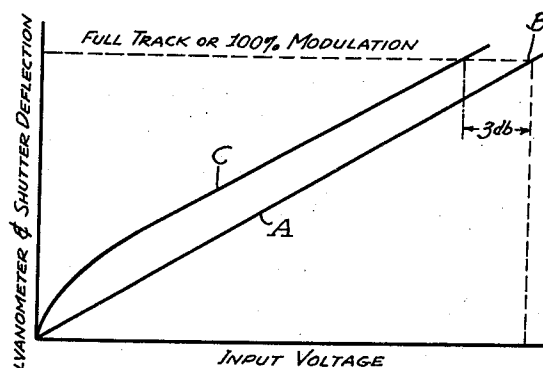
B. KREUZER

2,224,914

NOISE REDUCTION CIRCUIT FOR SOUND RECORDING

Filed April 29, 1939

2 Sheets-Sheet 1



Inventor
BARTON KREUZER,

By *Carl R. Loshaw*

Attorney

Dec. 17, 1940.

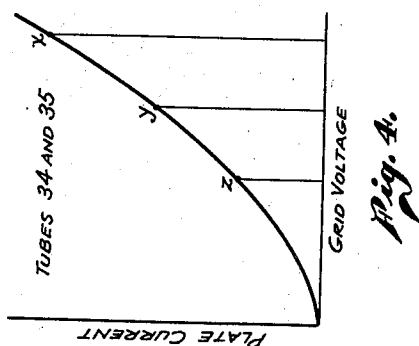
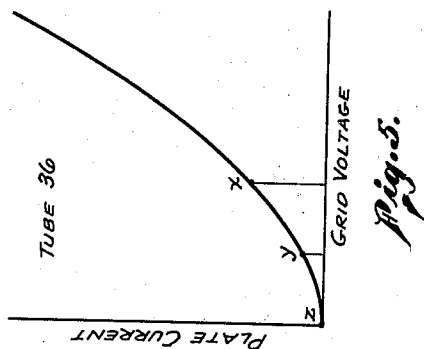
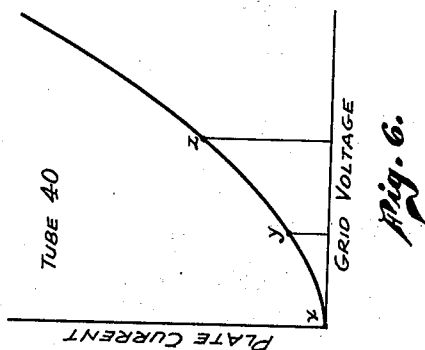
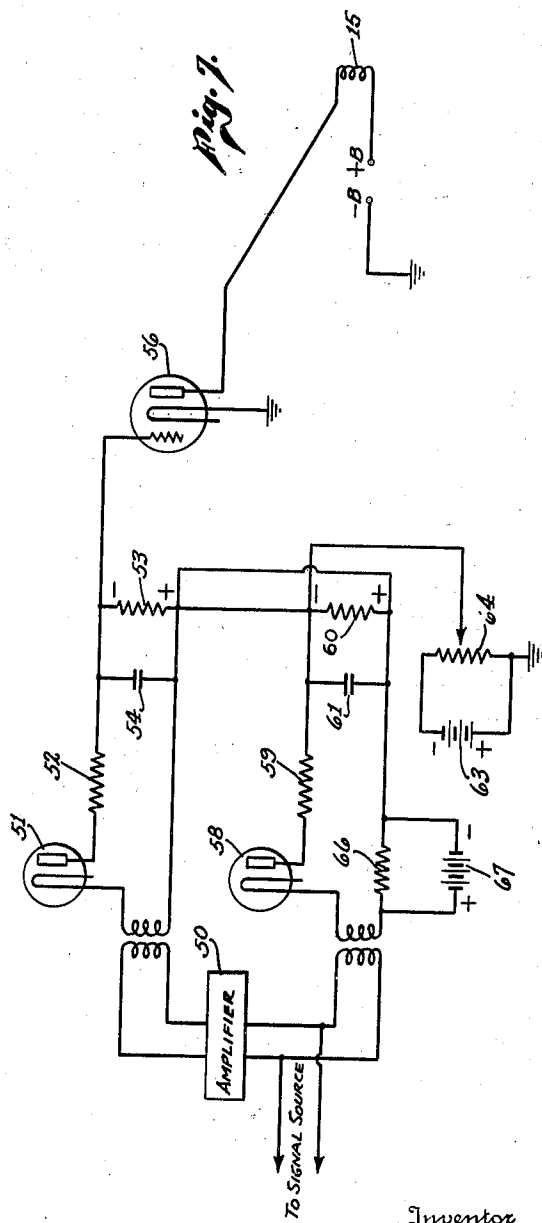
B. KREUZER

2,224,914

NOISE REDUCTION CIRCUIT FOR SOUND RECORDING

Filed April 29, 1939

2 Sheets-Sheet 2



Inventor

BARTON KREUZER,

Wm R. Goshaw

Attorney

UNITED STATES PATENT OFFICE

2,224,914

NOISE REDUCTION CIRCUIT FOR SOUND RECORDING

Barton Kreuzer, Los Angeles, Calif., assignor to
Radio Corporation of America, a corporation of
Delaware

Application April 29, 1939, Serial No. 270,876

11 Claims. (Cl. 179—100.3)

This invention relates to sound recording systems and particularly to sound recording systems wherein noise reduction is applied during the recording.

5 Sound recording systems of the variable area and variable density types are well known in the art. In the area type of system the film is light-impressed with a beam varying transversely of the sound track portion of the film, while in the
10 density type, the film is light-impressed with a beam of constant length and width, but of varying intensity. The application of noise reduction to both types of systems is also well known wherein all or substantially all of the unmodulated track area is caused to be opaque in the
15 final print produced by area recording, or the modulation of the variable intensity beam is such that the density of the final print varies between a point at one end of the characteristic curve and
20 a point higher up on this curve at the higher modulations.

The present invention is particularly directed to an optimum practical method of and apparatus for applying the noise reduction action. Referring specifically to the sound recording type
25 of system which produces a variable area duplex track, two narrow, transparent traces are found in the final print at times of no signal, the outer portions being under control of noise reduction
30 shutters and the central portion being under control of the movements of the galvanometer mirror. The narrow traces could be eliminated but are provided to prevent film breathing. In this type of system, the noise reduction shutters are
35 actuated with direct current obtained from rectifying a portion of the signal being impressed on the galvanometer. Thus, actuation of the shutters occurs substantially simultaneously with the actuation of the galvanometer. Therefore,
40 and particularly when sounds which increase rapidly in amplitude are impressed on the galvanometer, the shutters may fail to clear the track area sufficiently to accommodate the peaks of the modulations, and so-called clipping of the
45 peaks occurs.

On the other hand, if the shutters were actuated with sufficient rapidity to clear the track area for all types of applied sounds, the trace or traces made by the shutters would introduce audible sounds commonly known as "plops" or
50 "swishes." However, if the traces referred to above are wide enough initially to accommodate sounds within a certain amplitude range, then the transparent areas at times of no signal would
55 introduce ground-noise which is undesirable.

Thus, the present invention is a noise reduction system having an action which will reduce both ground noise at times of no signal and peak-clipping to a practical minimum.

An object of the invention, therefore, is to improve the noise reduction action of the noise reduction portion of a sound recording system.

Another object of the invention is to control the noise reduction portion of the apparatus to produce a sound record in which the light transmission therethrough is at an optimum minimum
10 during times of no signal.

A further object of the invention is to actuate the noise reduction portion of the system at different speeds depending upon the amplitude of
15 the signal being recorded.

A further object of the invention is to automatically actuate the noise reduction shutters at different rates according to the amplitude of the
20 signal.

A further object of the invention is to vary the rate of application of noise reduction in accordance with the amplitude of the signal.

A further object of the invention is to produce an anti-ground noise sound record in which the
25 average transparency varies with amplitude of the modulations thereon.

Although the novel features which are believed to be characteristic of this invention are pointed out with particularity in the claims appended
30 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 drawings forming a part thereof, in which
35

Fig. 1 is a diagrammatic representation of a variable area type of sound recording system with a schematic circuit embodying the invention;

Fig. 2 is a graph illustrating the operation of the system shown in Fig. 1;
40

Fig. 3 is a sound track record resulting from the operation of the system of Fig. 1;

Figs. 4, 5 and 6 are characteristic curves of the various tubes employed in Fig. 1; and

Fig. 7 is a schematic diagram of another embodiment of the invention.
45

Referring now to Fig. 1, the right-hand portion of the drawing diagrammatically represents a variable area recording system of the standard duplex record type such as that disclosed by U. S.
50 Patents 2,102,776; 2,102,777 and 2,102,778. Light from a light source 5 is collected by a lens 6 projected through an aperture plate 7 with an appropriate aperture 8 therein, from which it is projected through lens 10 to a mirror 11 of a 55

galvanometer having an actuating coil 12. A pair of shutters 14 operated by a coil 15 control the amount of light passing through the ends of the aperture 8. Reflected light from the galvanometer mirror 11 is projected to a slit mask 17 having a slit 18 therein, from which it is collected by objective lenses 19 and impressed upon the sound track portion 20 of a film 21. The above-described apparatus is the usual recording system for producing standard variable area duplex tracks.

The sound to be recorded is detected by a microphone 24 and translated into electrical currents which are amplified by an amplifier 25 and then impressed upon the coil 12 of the galvanometer over conductors 27. The impression of these currents on the galvanometer causes the mirror 11 to follow the instantaneous values of the amplitude and frequencies of the signal to vibrate the light beam normal to the slit 18. A portion of the current output of amplifier 25 is impressed through a transformer 32 upon a rectifier 23 having a time filter circuit consisting of a series resistance 29, a shunt resistance 30 and a shunt capacitance 31. This timing filter circuit is disclosed and claimed in my Patent 1,999,700, issued April 30, 1935.

The rectified output of rectifier 23, after passing through the filter, is impressed directly upon the grids of three triode vacuum tubes 34, 35 and 36, tubes 34 and 35 having their outputs connected in parallel to feed the actuating winding 15 of shutters 14 through a resistance 37 and potential supply 38. The plate of tube 36 is directly coupled to the grid of tube 40, plate potential for the tube 36 and grid bias potential for the tube 40 being obtained over a common resistance 42 which is large compared with the plate resistance of tube 36. The resistance 42 is connected near the positive end of a potentiometer resistance 43 supplied from the potential source 33. The grid bias on tube 36 is made different from that on the grid of tube 40 by connecting the respective filaments of the tubes 36 and 40 to different points on common potentiometer 43, the points of connection being made variable to permit adjustment of the bias. The plate of tube 40 is connected to the negative end of resistance 37, this resistance being large with respect to the plate resistance of tube 40. Grid bias for tubes 34 and 35 is obtained from a potentiometer 45 connected across a potential source 46. The bias on the grid of tube 36 is made different from that on the grids of tubes 34 and 35 by the connecting of the cathode of tube 36 to potentiometer 43, while the cathodes of tubes 34 and 35 are connected to ground.

The above noise reduction circuit just described may produce different actions of the shutters 14, one preferred action being illustrated in the graph of Fig. 2, wherein the input voltage, for instance, to amplifier 25 is plotted against galvanometer and shutter deflections. The curve A represents the galvanometer deflection for a certain range of input voltages, this curve showing a linear relationship between these two factors, maximum input voltage corresponding to full-track or 100% modulation being shown at point B. The curve C of Fig. 2 represents the shutter deflection for substantially the same range of input voltages, it being observed that in the lower range of input voltages, the shutters separate very rapidly as the voltage increases, while this speed of shutter deflection becomes much less rapid with further increases in the in-

put voltage until the shutter action becomes substantially the same as that of the galvanometer. As shown on the graph, the shutters lead the galvanometer with respect to the track area so that the shutters completely clear the track area at a level of 3 db. below the amplitude required for 100% modulation of the track. This type of action provides a rapidity of shutter action necessary to prevent undue clipping of the sound modulations at the beginning of the sounds and prevents introducing deleterious audible sounds by the traces formed by the shutters. At the same time, the optimum amount of noise reduction may be applied at times of no signal.

An illustrative sound record resulting from this operation is shown in Fig. 3, wherein the opaque areas D are produced by the noise reduction shutters, and the opaque area E, by the position of the light beam on the slit 18 of the mask 17. As the galvanometer mirror is actuated, the opaque area E is varied in accordance with the instantaneous values of the sound, and a sound track is produced as shown by the traces F, the film being advanced during the original recording in the direction of the arrow. This illustrative sound record also shows the action of the shutters during the impression of the signal on the galvanometer, and it will be observed that the separation speed of the shutters in the lower range of amplitude is more rapid than at the higher amplitudes to produce the curved noise reduction shutter traces G. The closing time, however, is slower than the opening time, as shown by the noise reduction traces H. This timing relation is caused by the action of filter 29, 30 and 31, as explained in my Patent 1,999,700, issued April 30, 1935, referred to above.

The present invention is particularly directed to the operation of the circuit consisting of elements from 34 to 46, particularly tubes 34, 35, 36 and 40. The shutters 14 are maintained at their minimum distance of separation by an initial current flow from the tubes 34 and 35 through winding 15 and resistance 37, the amount of this current flow being determined by the bias on the grids of tubes 34 and 35 in accordance with the setting of the potentiometer 45. This adjustment is made such that the narrow zero traces between opaque areas D and E, shown in Fig. 3, are produced by very narrow light beams passing to the film at times of no signal. The initial adjustment of the grid bias of tubes 36 and 40 is such that no output current flows from the tube 40 through the resistance 37 at times of no signal.

To more clearly illustrate this condition, reference is made to Figs. 4, 5 and 6, the points x on the curves representing the static bias or no signal adjustment of the different tubes. For tubes 34 and 35, the point x is well up on the curve, thus providing the current required for maintaining the shutters 14 at their minimum separation. Tube 36 has a larger bias (see Fig. 5), while tube 40 has a bias which substantially prevents any output current from flowing through resistance 37 (see Fig. 6).

Now, as the signal is rectified, the bias on tubes 34, 35 and 36 is increased by the increase in rectified current, and the output current from tubes 34 and 35 flowing through the winding 15 and resistance 37 decreases as shown by point y in Fig. 4. This causes a certain amount of separation of the shutters 14. Simultaneously, however, the bias voltage is reduced on the grid of tube 36, as shown by point y in Fig. 5, which

decreases the plate current from tube 36 and thus raises its plate voltage. Since this plate voltage is also the grid bias voltage for tube 40, the grid voltage for tube 40 has now been made more positive, causing tube 40 to draw current through resistance 37 (see point *y* in Fig. 6). This current, through the resistance 37, produces a voltage drop in this resistance which decreases the plate current from tubes 34 and 35 and thus also reduces the current in the coil 15. Therefore, as the rectifier 28 begins to function with signal input, there are two factors which reduce the current in coil 15, one being the normal reduction in the plate current of tubes 34 and 35 caused by the increase in the grid bias thereof, and the other, the reduction in the plate current of these tubes by the reduction of their plate voltage caused by the output current from tube 40. The result of the action just described produces the steep portion of the curve C in Fig. 2 and the steep portion of the traces G in Fig. 3.

Now, as the output of rectifier 28 continues to increase in accordance with the signal input, the current from tubes 34, 35 and 36 continues to decrease as their grid biases increase, as shown by Figs. 4 and 5. When this bias has reached point *z*, it will be observed that tube 36 has reached cutoff, and any further increase in its bias does not alter its plate current. Thus, the output current from tube 40 becomes substantially constant at point *z* in Fig. 6, and further increases in output of rectifier 28 do not affect the plate current of tube 40 or the plate voltage of tubes 34 and 35 and, consequently, have no effect on the separation of shutters 14. Because of the curvature of the toe of characteristics of tubes 36 and 40, the transition point where the cumulative action ceases is gradual, thus producing the curved traces G in Fig. 3. After the tubes 36 and 40 cease to function, only the decrease in bias on tubes 34 and 35 has any effect upon decreasing the current in coil 15, and consequently the shutters separate more or less linearly with respect to input voltage. This action is shown in Fig. 2 by the straight portion of curve C.

Thus, by the action of the circuit arrangement shown, including tubes 34, 35, 36 and 40, a very rapid movement of the shutters occurs over the low amplitude range of the signal, and a more linear relationship between input and shutter deflection is obtained after a certain amplitude is reached. It is to be realized that although two tubes 34 and 35 are shown in parallel, a single tube may also be used; and, also, instead of triode tubes 34, 35, 36 and 40, exponential or variable μ tubes are suitable. Furthermore, an oppositely phased action is obtainable by using an intermediate tube to obtain a decrease in bias on tube 36 with an increase in signal amplitude which will decrease the output current of tube 40 from a certain initial value.

This type of circuit shown in Fig. 1 thus provides a very flexible method of obtaining certain types of characteristic shutter openings with respect to certain types of signal, such as dialogue and different musical compositions. That is, some signals may be of substantially uniform amplitude throughout, while others are made up of periodic sequences of high amplitudes, and different bias settings for the tubes may be quickly made to provide the optimum shutter action for the particular type of signal being recorded.

Referring now to Fig. 7, there is shown a circuit modification of the noise reduction rectifier

and amplifier circuit of Fig. 1. In the operation of this circuit, the cumulative action between two rectifiers is in phase opposition over the upper range of signal amplitudes to produce a shutter action similar to curve C of Fig. 2. The input to this circuit may be from the amplifier 25 of Fig. 1, the output of which is divided, one portion being impressed upon an amplifier 50. The output of amplifier 50 is impressed upon a rectifier 51, in the output of which is a timing filter circuit including a series resistance 52, a shunt resistance 53 and a condenser 54. This timing circuit is connected to the input of a direct current amplifier 56, the output of which feeds the noise reduction winding 15 of Fig. 1.

The other portion of the output of amplifier 25 is impressed directly upon a rectifier 58 having a timing filter circuit 59, 60 and 61 in its output circuit. A source of grid bias for amplifier tube 56 is shown as a potential source 63 shunted by potentiometer 64. A biasing circuit for rectifier 58 is also employed, this biasing circuit comprising a resistance 66 shunted by a potential source 67. The essential differences, therefore, between the two parallel rectifier branches feeding the direct current amplifier 56 is that a pre-amplifier is in the input of rectifier 51, while a bias is applied to the rectifier 58. These differences produce a shutter action similar to curve C of Fig. 2, as mentioned above, as follows:

The input circuit of rectifier 51 is impressed with a signal potential depending upon the gain of amplifier 50 which produces an increase in the grid bias of tube 56, as explained in connection with Fig. 1. This increase in bias decreases the current through winding 15 and allows the shutters to open rapidly with respect to galvanometer deflection. The gain of amplifier 50 and the setting of the timing filter circuit 52, 53, and 54 controls the speed of this action. However, the same signal is impressed upon rectifier 58, but at a lower level because no similar amplifier to amplifier 50 is used in its input circuit. Also, there is a static bias applied to the rectifier 58 at 66 so that it will not draw current until a certain amplitude of input signal is reached. The adjustment of this rectifier bias determines the position of the bend in curve C of Fig. 2, since the output from rectifier 58, when it functions, produces a voltage across resistance 60 which opposes or bucks the voltage across resistance 53 caused by the output of rectifier 51. (See polarities of resistances 53 and 60 and connections thereof.) Thus, the rapid shutter action caused by rectifier 51 alone is slowed down at the higher amplitudes of the signal, the resulting action being dependent upon the differential voltage across 53 and 60, which is substantially proportional to the gain of amplifier 50. The linear portion of curve C is thus produced. This parallel rectifier arrangement, therefore, will provide the shutters 14 of Fig. 1 with a deflection similar to that shown in Fig. 2 by curve C.

Although the invention has been described above embodied in a variable area duplex recording system, it is also applicable to the single shutter type of noise reduction system as well as the type of system which does not employ shutters, but biases the galvanometer or other light modulating means directly as shown in U. S. Patents 1,854,159 and 1,888,724. It will also be understood that the circuit may be used to vary the modulation point of a light beam so that the variable density print is substantially opaque at times of no signal and the modulation point varies

ies between a point at one end of the characteristic and a point higher up on the characteristic at higher modulations.

I claim:

- 5 1. A circuit comprising means for generating alternating currents, means for rectifying a portion of said currents, means for utilizing a portion of said alternating currents in direct proportion to the variations in amplitude of said alternating currents, means for utilizing said rectified portion of said alternating currents, and means interposed between said last-mentioned means and said rectifying means, said last-mentioned means including a plurality of electronic elements selectively operable with the variations in amplitude of said alternating currents to vary the proportionality between the amplitude variations of said alternating currents as impressed on said rectifying means and the amplitude variations of said rectified currents as impressed on said rectified current utilizing means.
- 10 2. A circuit comprising a source of alternating currents varying in amplitude, means for directly utilizing a portion of said alternating currents, means for rectifying another portion of said alternating currents, means for utilizing said rectified currents, and a plurality of electronic means selectively operative with amplitude for varying the reaction produced by said rectified currents with respect to the reaction produced by said alternating currents.
- 15 3. A circuit comprising a source of alternating currents varying in amplitude, means for directly utilizing a portion of said alternating currents, means for rectifying another portion of said alternating currents, means for utilizing said rectified currents, and means for varying the reaction produced by said rectified currents with respect to the reaction produced by said alternating currents, said last-mentioned means comprising a plurality of vacuum tubes, all of which are effective over a certain range of amplitudes of said alternating currents and only certain others of which are effective over another range of amplitudes of said alternating currents.
- 20 4. A circuit comprising a source of alternating currents, a rectifier for said currents, a direct current amplifier for said rectified currents, a load in the plate circuit of said direct current amplifier, and a second direct current amplifier having an initial bias different from said first direct current amplifier, said second direct current amplifier and said first direct current amplifier cumulatively effecting said load over the lower range of amplitudes of said alternating currents and only said first direct current amplifier operating over the higher range of amplitudes of said alternating currents.
- 25 5. A sound recording system comprising a source of alternating currents to be recorded, a light beam, means for directly modulating said beam with a portion of said alternating currents, and means for modulating said light beam with the average value of said currents, said last-mentioned means comprising a rectifier and a plurality of direct current amplifiers interposed between said source of alternating currents and said second-mentioned modulating means, all of
- 30
- 35
- 40
- 45
- 50
- 55
- 60
- 65

said direct current amplifiers operating cumulatively on said second-mentioned modulating means over a certain range of amplitudes of said alternating currents, while only certain others of said direct current amplifiers operate on said second-mentioned modulating means over another range of amplitudes of said alternating currents.

6. A direct current amplifier circuit comprising a plurality of vacuum tubes, a common input circuit for said tubes, a pair of output circuits for said tubes, means for impressing variations in voltages on said input circuit to produce variations in current in said output circuits, one of said output circuits comprising an inductance and resistance connected in series and the other of said output circuits comprising said resistance, and means for differently biasing said vacuum tubes, the plate voltage on one of said amplifiers being the grid bias on another of said amplifiers.

7. A rectifier circuit comprising a source of alternating current, a pair of rectifiers, means for impressing a portion of said alternating currents directly on one of said rectifiers, means for amplifying another portion of said alternating currents, means for impressing said amplified alternating currents on another of said rectifiers, means for connecting the outputs of said rectifiers in phase opposition, a direct current amplifier, and means for impressing the differential output of said rectifiers upon said direct current amplifier.

8. A rectifier circuit in accordance with claim 7 in which said first-mentioned rectifier is provided with a predetermined bias.

9. A rectifier system comprising a source of alternating currents, a pair of rectifiers for said currents having a common input circuit, means for impressing said alternating currents on said input circuit, a common output circuit for said rectifiers, means for varying the time of operation of one of said rectifiers with respect to the other of the rectifiers, and means for combining the output of said rectifiers.

10. A direct current amplifier circuit comprising a plurality of vacuum tubes, a common input circuit for said tubes, a pair of output circuits for said tubes, means for impressing variations in voltages on said input circuit to produce variations in current in said output circuits, one of said output circuits including a load circuit and an impedance connected in series and the other of said output circuits including said impedance, and means for differently biasing said vacuum tubes for selective operation in accordance with the amplitude of said input voltages.

11. A rectifier circuit comprising a source of alternating current, a pair of rectifiers, means for impressing a portion of said alternating currents directly on one of said rectifiers, means for amplifying another portion of said alternating currents, means for impressing said amplified alternating currents on another of said rectifiers, and means for connecting the outputs of said rectifiers in phase opposition.

BARTON KREUZER.