Feb. 24, 1942. K. SINGER 2,274,505

CONTROLLED TRANSMISSION CIRCUIT

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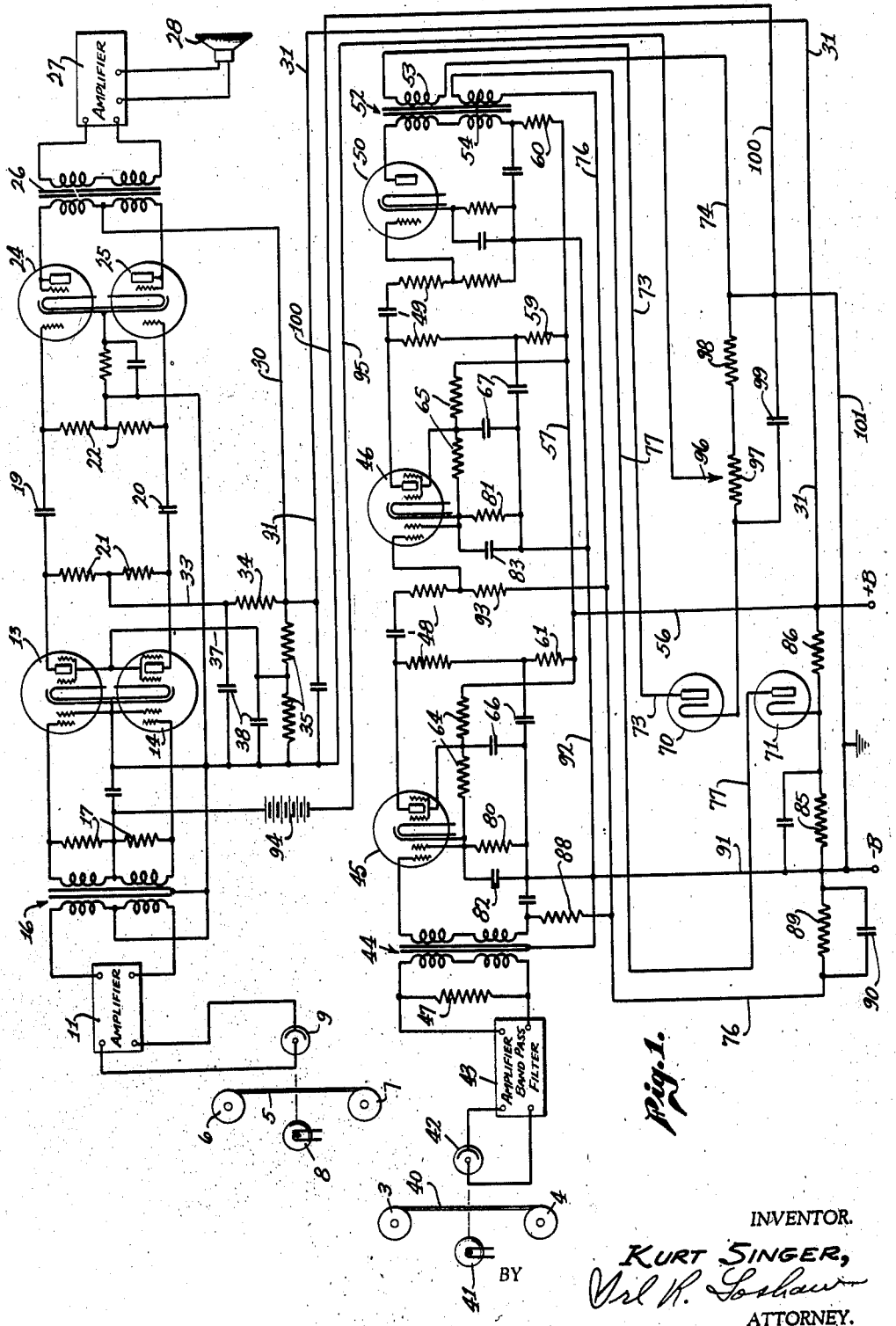


Fig. 1.

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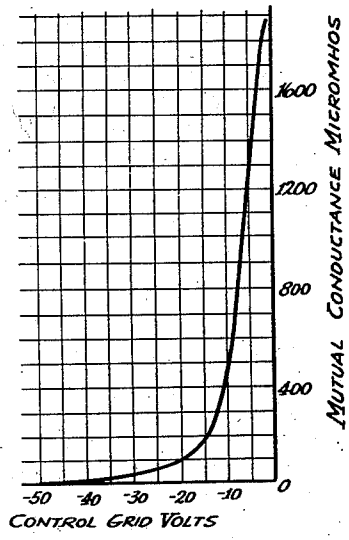


Fig. 2.

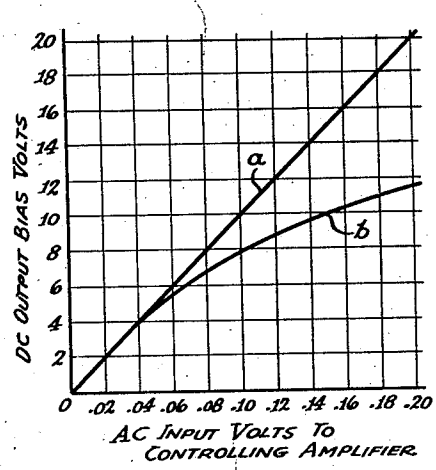


Fig. 3.

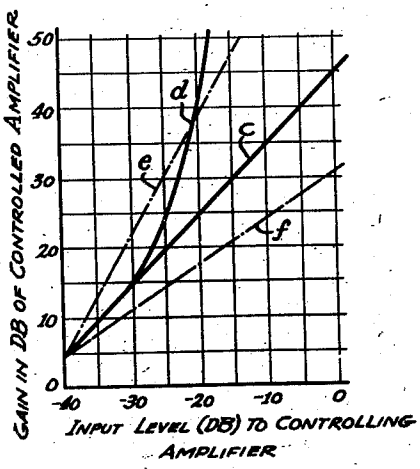


Fig. 4

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UNITED STATES PATENT OFFICE

2,274,505

CONTROLLED TRANSMISSION CIRCUIT

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6 Claims. (Cl. 179—100.3)

This invention relates to sound transmission circuits and particularly to a sound reproduction system wherein a primary signal is controlled by a secondary or control signal in a predetermined manner.

The transmission or gain of sound reproducing systems, in which the sound originates from sources such as film sound tracks, disc records and microphones, has been varied during operation in different manners, variations of certain types being known as compressions and expansions. It is well known in the art how to provide nonlinear gain characteristics for an amplifier, a linear characteristic being one wherein the amplitudes of the output signal vary in the same ratio as the amplitudes of the input signal. One common method of obtaining compression and expansion is to impress upon the grids of variable mu tubes a bias voltage which varies linearly with the transmitted signal amplitude, and, since the gain of the tubes is exponential with grid bias, the resulting characteristic between input and output is nonlinear. Although the amplifier gain is usually controlled by the signal being transmitted, it may also be controlled by an external or extraneous signal in a manner such as disclosed and claimed in Mueller Patent 1,888,467 of November 22, 1932. In the past, where a primary signal has been controlled by a secondary signal, the relationship between the two signals throughout their operating range has been relatively unimportant as long as the general overall result was accomplished.

The present invention is directed to a control system in which not only is the primary signal under control of a secondary signal, but a definite predetermined relationship is provided between the variations of one signal with respect to the other throughout their entire operating range in a novel manner. The relationship desired is that the variations in the signal being controlled be directly proportional to the variations of the control signal. This relationship is not obtainable by the normal application of the rectified control signal to the grid bias of the amplifier tube or tubes, inasmuch as the gain of the amplifier tube or tubes varies exponentially with respect to changes in biasing potential. In the present invention, therefore, not only is the gain of the primary amplifier varied by a portion of the rectified secondary or controlling signal, but the controlling signal also simultaneously varies the gain of its own amplifier. Thus, there is provided by the controlling amplifier circuit a correction which permits a biasing voltage to be applied to the primary amplifier in a manner such that the output of the primary amplifier varies in direct proportion to the variations in amplitude of the controlling signal throughout its entire range.

The principal object of the invention, therefore, is to improve the control of a variable gain amplifier.

Another object of the invention is to control the gain of an amplifier in a certain predetermined manner.

A further object of the invention is to obtain a predetermined characteristic of a variable gain amplifier with respect to the variations of a controlling signal.

A further object of the invention is to simultaneously control the gain of an amplifier of a controlling signal which is controlling the gain of an amplifier of a controlled signal.

A further object of the invention is to obtain a linear gain variation in an exponential amplifier.

A further object of the invention is to obtain a linear relationship between the variations in amplitude of a secondary signal source and the variations in amplitude of a primary signal source controlled by the secondary signal source.

Although the novel features which are believed to be characteritsic of this invention will be pointed out with particularity in the claims appended herewith, the invention itself, its objects and advantages, 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

Figure 1 is a schematic drawing of a sound reproducing system embodying the invention;

Figure 2 is a graph showing a characteristic curve of the amplifying tubes used in the invention;

Figure 3 is a graph showing the relationship between the input voltage to the controlling amplifier and the direct current biasing voltage output of the controlling amplifier-rectifier; and

Figure 4 is a graph showing the relationship between the input level to the controlling amplifier and the gain of the controlled amplifier.

Referring now to Fig. 1, one form of primary or controlled signal source is diagrammatically represented as a sound film 5 supplied from a reel 6 and taken up by a reel 7 and which is scanned by a light beam produced by a source of light 8 impinging upon a photoelectric cell 9,

the usual optical system and film drive being employed but not shown. The output of the photocell 9 is impressed upon a standard linear amplifier 11 and fed into a push-pull amplifier composed of tubes 13 and 14 of the exponential or variable mu type. The amplifier 11 is coupled to the tubes 13 and 14 by means of a push-pull transformer 16 having loading or compensating resistances 17 across the secondary thereof. Tubes 13 and 14 are connected by condensers 19 and 20 and resistances 21 and 22 to the input of a push-pull standard linear amplifier 24 and 25, the output of which is transmitted by a transformer 26 to a linear amplifier 27 which feeds a loudspeaker 28. Potential for the anodes of the tubes 24 and 25 is supplied over conductors 30 and 31 connected to the plus-B supply as shown. Potential for the anodes of tubes 13 and 14 is supplied over conductor 31 and conductor 33 through resistanec 34. Resistance 34 and resistances 35 form a potential divider from which is supplied the positive potential for the screen grids of tubes 13 and 14 over conductor 37. Bypass condensers 38 are used across resistances 34 and 35.

The controlling or secondary signal source may also be in the form of a sound track on a film 40 fed from a reel 3 to a reel 4 and reproduced through any well-known type of system employing a light source 41 and a photoelectric cell 42. The output of cell 42 is impressed upon a linear amplifier and bandpass filter unit 43. The bandpass filter is only necessary when the control signal is one of a plurality of frequencies recorded in the same track area with control signals of other frequencies. The output of unit 43 is impressed upon an exponential vacuum tube 45, similar to tubes 13 and 14, through an input transformer 44 which is loaded on the primary side by a resistance 47. The output circuit of the tube 45 is coupled through a condenser-resistance network 48 to a second exponential amplifier tube 46, the output circuit of this tube being also coupled through a condenser-resistance network 49 to a triode vacuum tube 50. The output of tube 50 is transmitted through a three-winding transformer 52 having secondary windings 53 and 54. The anode potential source for the tubes 45, 46 and 50 is the same as for the tubes in the primary amplifier, tubes 46 and 50 being connected to the plus-B terminal over conductors 56 and 57, through resistances 59 and 60, respectively, and tube 45 through resistance 61. The screen grids of tubes 45 and 46 are fed through potential divider resistances 64 and 65, respectively, having bypass condensers 66 and 67.

The output of the secondary or controlling amplifier just described is impressed upon two rectifiers 70 and 71, rectifier 71 controlling the gain of amplifier tubes 45 and 46, while rectifier 70 controls the gain of amplifier tubes 13 and 14. The output from tube 50 is impressed upon rectifier tube 70 over the secondary winding 53 of transformer 52 and conductors 73 and 74. The output of tube 50 is impressed upon rectifier 71 over the secondary winding 54 and conductors 76 and 77.

As mentioned above, the tubes 45 and 46 obtain their grid biasing potential, in addition to the bias obtained through self-biasing resistances 80 and 81 shunted by condensers 82 and 83, respectively, from rectifier 71 which is biased positively by resistances 85 and 86. The biasing circuit for tube 45 is from the grid of this tube through the secondary of transformer 44, filter resistance 88, conductor 76, control biasing resistance 89, shunted by bypass condenser 90, conductor 91, to the cathode of tube 45 through self-biasing resistance 80. The grid bias for tube 46 is obtained over a circuit from the grid of this tube through coupling resistance 93, over conductor 76, through resistance 89, over conductors 91 and 92, and self-biasing resistance 81. Thus, the output of tube 50 will vary the gain of tubes 45 and 46 in accordance with the output from the rectifier 71 over the above-traced circuits and, consequently, the voltage in secondary winding 53 feeding rectifier 70 will be varied in accordance with the characteristic of the control of the tubes 45 and 46.

The grid bias for tubes 13 and 14 in the primary amplifier is controlled by the output of rectifier 70 which opposes a fixed bias obtained from a potential source 94. The grid bias circuit for tubes 13 and 14 is from the grids of these tubes, through the secondary windings and loading resistances 17, through fixed bias potential source 94, conductor 95, to adjustable contact 96 on resistance 97, this resistance and rectifier biasing resistance 98 being shunted by bypass condenser 99. The remainder of this circuit is through the resistances 97 and 98, over conductor 100, to the cathodes of tubes 13 and 14. Conductor 100 is connected to the minus-B terminal and ground over conductor 101.

From the above, it will be noted that the amplifier circuit including tubes 13 and 14 is the finally controlled amplifier transmitting the primary signal from the film 5 for reproduction in loudspeaker 28. The amplifier circuit including tubes 45 and 46 is the controlling amplifier circuit transmitting the controlling signal from the film 40. The output of the controlling amplifier is divided, one portion being utilized to control the gain of the controlling amplifier, and the other portion being used to control the gain of the controlled amplifier. By this combination, a linear relationship between the amplitude variations of the controlling signal and the gain variations of the controlled amplifier is obtained.

To further explain the operation of this circuit, reference is made to Figs. 2, 3 and 4, in which Fig. 2 illustrates a characteristic curve for typical exponential tubes shown at 13, 14, 45 and 46. It will be noted from this characteristic that the curve is exponential, that is, as the control grid voltage increases in a positive direction, the mutual conductance of the tube, which represents its amplification or gain, increases as an exponential function. Thus, if the tubes 13 and 14 were impressed with a grid biasing potential varying linearly with the variations in the controlling signal, the resulting output of tubes 13 and 14 would not be linear with respect to the amplitudes of the controlling signal. An exponential system of this type is disclosed and claimed in Kreuzer Patent 2,006,052 of June 25, 1935.

By referring to Fig. 3, the relationship between the input voltage to the controlling amplifier and its direct current biasing voltage output is shown. If an uncontrolled amplifier were used for the controlling amplifier, that is, one having a fixed gain, then its bias voltage output would be linear as represented by the straight line *a*. By use of the invention, however, the direct current biasing voltage varies as shown by the drooping curve *b*. The drooping effect is, of course, the result of the exponential gain characteristic of tubes 45 and 46 shown in Fig. 2.

Now referring to Fig. 4, in which the relationship between the input level to the controlling amplifier with respect to the gain in db. of the controlled amplifier, represented by tubes 13 and 14, is shown, the characteristic *c* represents a linear relationship between these two variables. This characteristic is the one desired and is provided inasmuch as the grid biasing voltage output from rectifier 70 has a characteristic as shown by curve *b* in Fig. 3. If the linear relationship shown by the characteristic *a* of Fig. 3 existed between the controlling signal and the direct current biasing voltage provided thereby, which is the normal relationship, then the characteristic between the input controlling level and the gain of the controlled amplifier would be as shown by curve *d*.

In addition to the linear characteristic *c*, it is also possible with the invention to produce other types of linear characteristics having different amplification ratios such as shown by dotted lines *e* and *f*. Although the ordinate in Fig. 4 is gain in db. of the controlled amplifier, this ordinate may also represent the output of the controlled device, thus showing a linear relationship between the input voltage of the controlling signal and the output voltage of the controlled signal provided the input amplitude of the control signal is constant.

It is to be understood that although the specific arrangement described above provides for minimum gain of the controlled amplifier with minimum controlling signal, the invention also contemplates an arrangement providing maximum gain of the controlled amplifier with minimum amplitude of controlling signal. This is accomplished by reducing the fixed bias potential source 94 to a suitable lesser value and reversing the output of rectifier 70. It is also to be understood that rectifiers 70 and 71 may be full-wave rectifiers instead of half-wave, as shown.

What I claim as my invention is:

1. An electrical transmission circuit comprising a variable gain amplifier for transmitting a signal to be controlled, a second variable gain amplifier for transmitting a controlling signal, a plurality of rectifiers, means interconnecting the output of said second amplifier with one of said rectifiers for controlling the amplitude of the output of said second amplifier in accordance with the input amplitude to said second amplifier, and means for connecting the output of said second amplifier with another of said rectifiers for controlling the amplitude of the output of said first-mentioned amplifier in accordance with the controlled output of said second amplifier.

2. An electrical transmission circuit comprising a variable gain amplifier for transmitting a signal to be controlled, a second variable gain amplifier for transmitting a controlling signal for said first-mentioned amplifier, and a plurality of rectifiers having their inputs connected to the output of said second amplifier, the output of one of said rectifiers being connected to said first-mentioned amplifier, and the output of another of said rectifiers being connected to said second-mentioned amplifier.

3. An electrical transmission circuit comprising a variable gain amplifier for transmitting a signal to be controlled, a second variable gain amplifier for transmitting a controlling signal for said first-mentioned amplifier, and means interconnecting the output circuit of said second amplifier and the gain control circuit of said first-mentioned amplifier for producing a linear relationship between the variations in amplitude of said controlling signal and the variations in gain of said controlled amplifier.

4. An electrical transmission circuit comprising a variable gain amplifier for transmitting a signal to be controlled, a second variable gain amplifier for transmitting a controlling signal for said first-mentioned amplifier, and means interconnecting the output circuit of said second amplifier and the gain control circuit of said first-mentioned amplifier for producing a linear relationship between the variations in amplitude of said controlling signal and the variations in gain of said controlled amplifier, said last-mentioned means comprising a pair of rectifiers, one of which controls the gain of said first-mentioned amplifier, and the other of which controls the gain of said second-mentioned amplifier.

5. An electrical transmission circuit comprising an amplification circuit for a primary signal adapted to be controlled, an amplification circuit for a secondary signal adapted to vary in amplitude for controlling said primary signal, means for controlling the ratio of amplification of said secondary signal by said secondary signal, and means for controlling the ratio of amplification of said primary signal by the controlled secondary signal, the ratios of amplification providing a linear relationship between the variations in amplitude of said secondary signal and the variations in gain of said amplifier circuit for said primary signal.

6. A system of signal transmission control comprising a source of controlling signal currents varying in amplitude, a source of signal currents to be controlled, means for transmitting said controlled signal currents, said means including an amplifier having non-linear gain variations with respect to variations in biasing voltage, means for translating said controlling signal currents into a biasing voltage adapted to be impressed on said amplifier, and means included in said last-mentioned means for varying the translation of the variations in amplitude of said controlling signal to variations in biasing voltage in a ratio inversely proportional to the gain variation characteristic of the controlled amplifier.

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