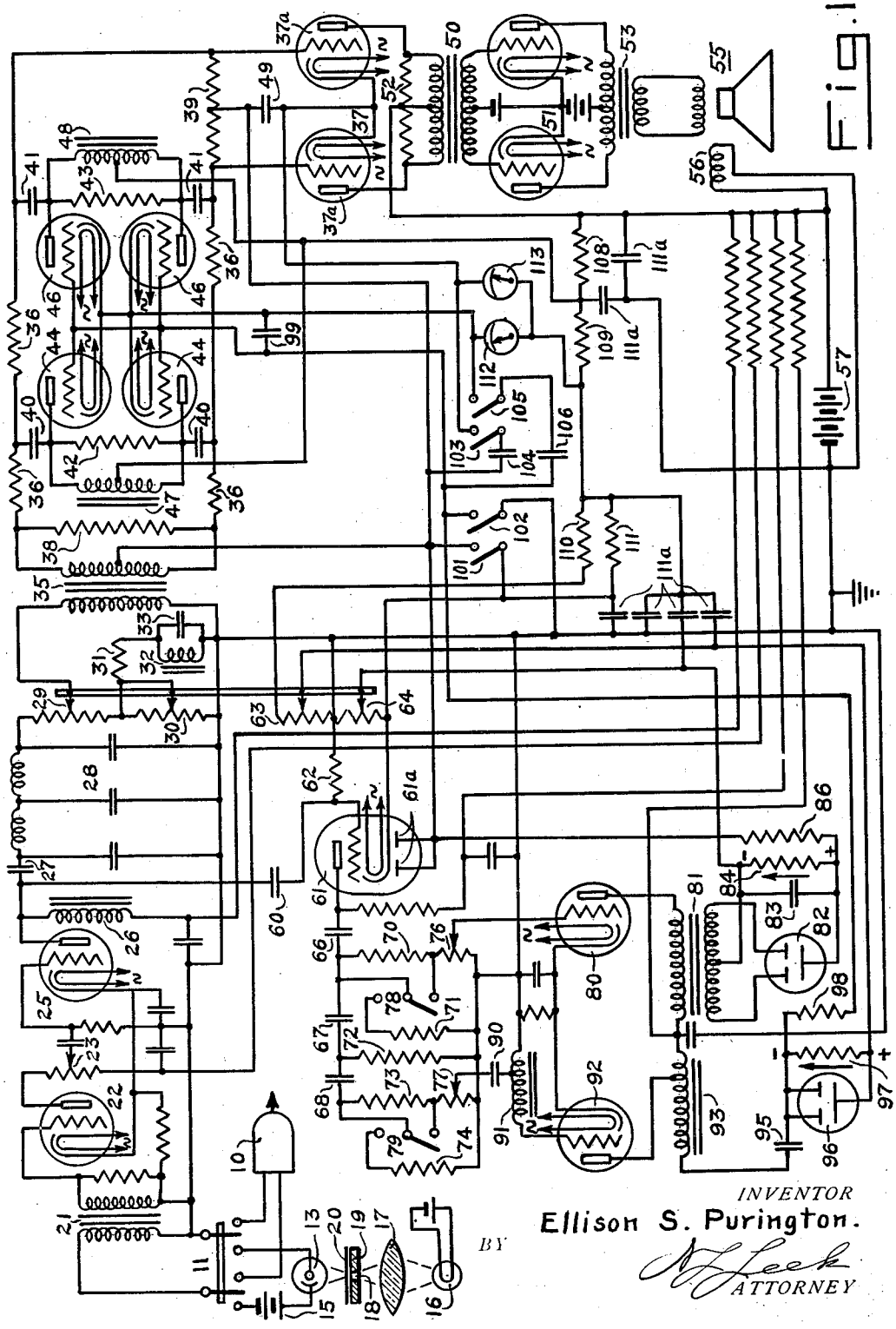
Oct. 26, 1937. E. S. PURINGTON 2,096,757

SOUND REPRODUCTION SYSTEM

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Fig. 1.



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Fig. 2.

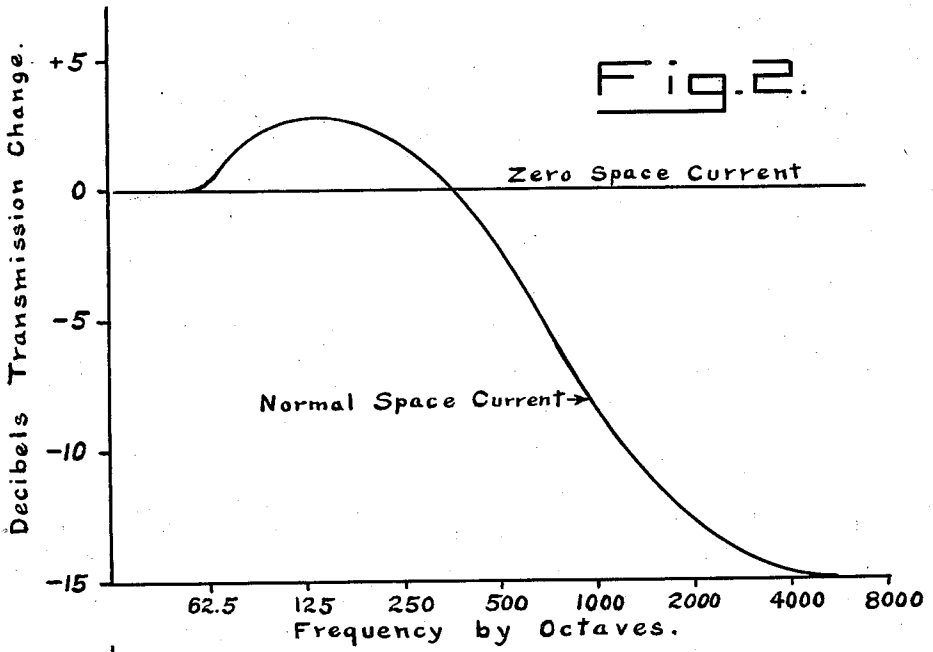
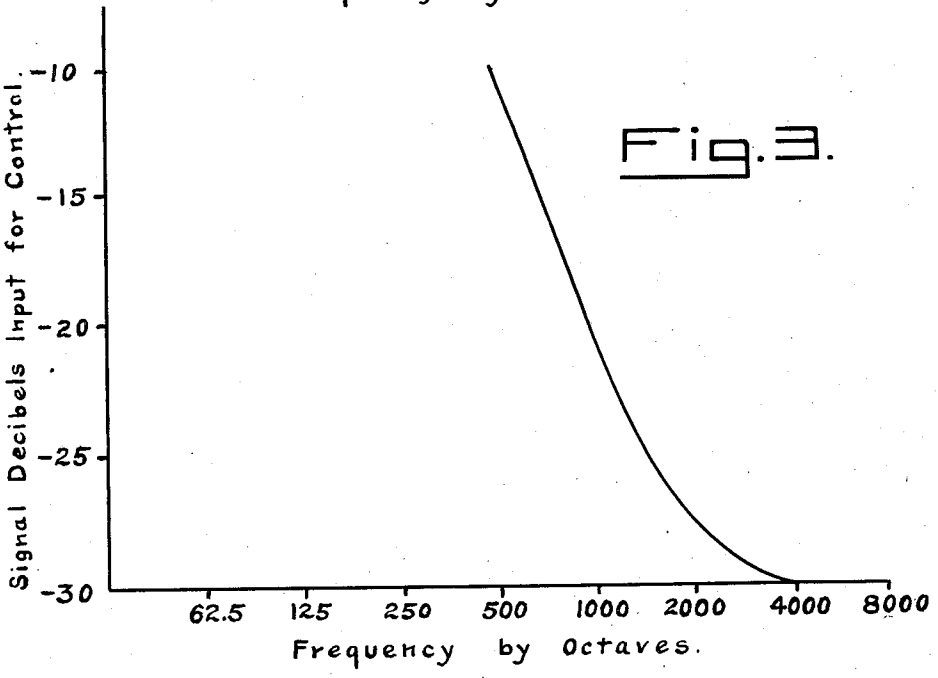


Fig. 3.



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SOUND REPRODUCTION SYSTEM

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Application July 22, 1935, Serial No. 32,684

16 Claims. (Cl. 179—100.4)

This invention relates to sound amplifying systems and more particularly to a system of the above type having volume expansion and scratch elimination characteristics.

An object of the invention is to provide a novel and improved system of the type above indicated.

A feature of the invention consists in the provision of a scratch filter comprising a capacity resistance network having means to vary the effectiveness of the capacity so as to control the frequency discrimination characteristics of the filter. In the form shown this is accomplished by means of a space discharge device having its space current path connected in series with the capacity elements of the filter so that the effectiveness of the capacity varies in accordance with the impedance of the device. For scratch elimination purposes, it is usually desirable to provide a filter which discriminates against the higher frequencies. The capacities and space discharge devices are, accordingly, disposed in series in the shunt leg of the filter so that, when the space discharge devices are of low impedance, the filter discriminates more against the high frequencies than when the devices are of high impedance. The invention provides for controlling the impedance of the space discharge devices in accordance with the strength of the input signal or in accordance with the high frequency component of the input signal. In this way, the filter is caused to prevent passage of scratch frequencies except when they are accompanied by signals sufficient in intensity to mask the same.

Another feature of the invention consists in the provision of a filter of the above type containing only capacity and resistance elements so that, when the capacity elements are ineffective, the filter does not appreciably affect the frequency transmission characteristics of the system.

Another feature consists in the arrangement of the shunt capacities and space discharge devices in push-pull relationship so that distortion and uneven operation is avoided.

Another feature consists in the provision of means to supply a comparatively high fixed bias potential to the space discharge devices when desired so as to cause them to have a sufficiently high impedance to render the capacity elements substantially ineffective for filter purposes.

Another feature consists in the combination of the scratch filter with an amplifier having volume expansion characteristics and the provision of means to reduce the effectiveness of the scratch filter and to reduce the expansion characteristics of the amplifier when low signal volumes are being transmitted. In the form shown, this is accomplished by the use of a manual volume control which is connected to control the initial bias of the space discharge devices in the filter and in the amplifier in accordance with the setting thereof.

Another feature consists in the provision of a resistance attenuation network for varying the effectiveness of the control circuit without appreciably changing the frequency transmission characteristics thereof. In the form shown, this is accomplished by a shunt potentiometer from which the control potential is taken. A series and shunt resistance are adapted to be connected in circuit with this potentiometer so as to reduce the control potential which is derived therefrom.

Other features consist in the various new and original details of construction and combinations of parts hereinafter more fully set forth.

Although the novel features which are believed to be characteristic of this invention will be particularly pointed out in the claims appended hereto, the invention itself, as to its objects and advantages, the mode of its operation and the manner of its organization may be better understood by referring to the following description taken in connection with the accompanying drawings forming a part thereof, in which

Figure 1 illustrates diagrammatically the system as applied to the reproduction of sound from the sound record of a talking moving picture projector and phonograph;

Figure 2 depicts a curve showing the effect of various frequencies on the control of the filter circuit; and

Figure 3 depicts a curve showing the relative transmission characteristics of the filter circuit for various values of space currents in the controlling elements.

In the following description and in the claims, parts will be identified by specific names for convenience, but they are intended to be as generic in their application to similar parts as the art will permit.

Referring to the accompanying drawings, and more particularly to Figure 1, a phonograph pick-up 10 is shown which is connected to two contacts of a double pole double throw switch 11, the other contacts of which are connected to the circuit of a photoelectric cell 13 including battery 15. Light from a lamp 16 is focused by means of a lens 17 through an aperture 18 in an aperture plate 19 upon the sound record of a moving photographic film 20. The light which passes

through this film then impinges upon the photoelectric cell 13.

The blades of the switch 11 are connected through a transformer 21 to the input circuit of a space discharge amplifier 22. The output circuit of this amplifier is connected through a potentiometer 23 to the input circuit of a second space discharge amplifier 25. The output circuit of the amplifier 25 includes a choke coil 26, a blocking condenser 27, a filter network 28 and two potentiometers 29 and 30. Connected across the potentiometer 30 is a tone compensation circuit including a resistor 31, a choke 32, and a condenser 33.

The contact of the potentiometer 29 is connected to the primary of a transformer 35, the secondary of which is connected through resistors 36 to the input circuit of a push-pull amplifier 37 comprising tubes 37a. Between the secondary of the transformer 35 and the input circuit of the amplifier 37 is a balanced type filtering network substantially of the resistance-condenser type which includes resistors 38 and 39. The bridging arms of this filter include condensers 40 and 41, resistors 42 and 43, the tube impedances of vacuum tubes 44 and 46, and choke coils 47 and 48. If found desirable resistors may be substituted for the choke coils 47 and 48 or choke coils may be substituted for the resistors 36. A condenser 49 is connected between the mid-point of the resistor 39 and the cathodes of the push-pull amplifier 37.

The output circuit of the push-pull amplifier 37 is connected through a transformer 50 to the input circuit of a power push-pull amplifier 51. A resistor 52 is connected across the primary of the transformer 50 to maintain the frequency characteristics substantially independent of the gain ratio characteristics.

The output circuit of the power amplifier 51 is connected through a transformer 53 to the moving coil of a loud speaker 55, the field coil 56 of which is connected across a battery 57 which is also used as a source of plate supply for the various space discharge devices.

The output circuit of the amplifier 25 is also connected through a second stoppage condenser 60 to the input circuit of a space discharge amplifier-limiter tube 61, of the duplex-diode triode type, and through a resistor 62 to the mid point of two potentiometers 63 and 64 and to ground. The potentiometers 63 and 64 are operated in unison with the potentiometers 29 and 30.

The output circuit of the amplifier 61 includes condensers 66, 67, and 68, resistors 70, 71, 72, 73, and 74, and potentiometers 76 and 77, and two single pole double throw switches 78 and 79 for either short circuiting the resistors 70 and 73, respectively, or for connecting the resistor 71 in parallel with the resistor 70 and the potentiometer 76 and for connecting the resistor 74 in parallel with the resistor 73 and the potentiometer 77.

The movable contact of the potentiometer 76 is connected in the input circuit of a space discharge amplifier 80, the output circuit of which is connected to the primary of a transformer 81. The secondary of the transformer 81 is connected to a rectifier circuit including a rectifier tube 82, a condenser 83, and a resistor 84. The positive side of the resistor 84 is connected through a resistor 86 to the center tap of the secondary of the transformer 35, to the center tap of the resistance 39 and to the diodes 61a of the tube 61. The negative side of the resistor 84 is connected to the movable contact of the potentiometer 64.

The movable contact of the potentiometer 77 is connected through a condenser 90 and autotransformer 91 to the input circuit of a space discharge amplifier 92. The output circuit of this amplifier is connected through a second autotransformer 93 to a rectifier circuit which includes a condenser 95, a rectifier tube 96, and a resistor 97. The positive side of the resistor 97 is connected to the movable contact of the potentiometer 63. The negative side of this resistor 97 is connected through a resistor 98 to the grids of the tubes 44 and 46. Between the cathodes and grids of these tubes 44 and 46 is connected a condenser 99.

A bleeder system including resistors 108, 109, 110, 111 and potentiometers 63 and 64 is bridged across the plate supply battery 57 to supply various operating potentials for the electrodes of the tubes. The bleeder net-work is suitably bypassed by condensers 111a to minimize signal currents in the bleeder resistors. The cathodes of the tubes 44 and 46 are connected together and to the positive side of a meter 112. The cathodes of the tubes 37a are connected together and to the positive side of a meter 113. The negative sides of the meters 112 and 113 are connected together and to the junction of the resistors 109, 110 and 111. The space currents of the tubes 44, 46 and 37a pass through the meters 112 and 113, and, combined with the bleeder currents, pass to ground through the resistors 110 and 111 and potentiometers 63 and 64.

A switch 101 is provided for establishing, when desired, a suitable fixed bias on the tubes 37a by connecting the mid-point of the resistor 39 to the negative side of the resistor 111, which is also connected to the cathode of the amplifier-limiter tube 61. A switch 102 is provided for grounding the grids of the tubes 44 and 46, when desired, thereby establishing a relatively high bias on these tubes. These switches 101 and 102 render the rectifiers inoperative and cause normal functioning of the system by causing the push-pull amplifier 37 to operate as a normal amplifier and by rendering the tubes 44 and 46 non-conductive.

In the operation of the embodiment of the invention shown in the accompanying figure, the energy received by the transformer 21 passes to the amplifier 22 where it is amplified and fed through the potentiometer 23 to the second amplifier 25, where it is further amplified and the major portion is fed through the blocking condenser 27 and filter circuit 28 to the volume control potentiometers 29 and 30. The filter circuit 28 provides means for suppressing the very high frequencies.

When the movable contact of the potentiometer 30 is in its lowest or minimum volume position, the tone circuit 31—33 is short circuited and is inoperative. As the volume control is actuated to obtain a higher volume, the tone circuit becomes effective and operates as a shunt on a portion of the resistance 50. The tone circuit is designed to produce more effect on the high and low frequencies than on the intermediate frequencies so that the energy distribution between the various frequencies is varied in such a way as to maintain the apparent quality substantially constant and independent of the volume level. In this way the circuit is caused to

compensate for the different response characteristics of the human ear to different frequencies. The ear, for example, is more sensitive to intermediate frequencies in the audible range than to the high and low frequencies. This discrimination is greatest at low volumes and is less evident as the higher volumes are reached. The tone control circuit is accordingly designed to compensate for this characteristic so that the volume can be altered without changing the apparent quality of the selection.

Energy is fed from the potentiometer 29 to the input circuit of the push-pull amplifier 37, the amount available for this purpose being determined by the setting of the potentiometer 29. This energy is amplified by the amplifier 37 and is fed through the transformer 50 to the push-pull power amplifier 51 where it is further amplified. The output of the power amplifier 51 is then fed through the transformer 53 to the loud speaker 55 where it is reproduced as speech or music in a well known manner.

For controlling the operation of the amplifier circuits above mentioned, some of the energy from the amplifier 25 passes through the stoppage condenser 60 to the tube 61. The condenser 69 and resistor 62 are so chosen that only a small amount of the total output energy from the amplifier 25 is diverted for control purposes. The constants of these elements are further chosen so that suitable discrimination against very low tones will be made as determined by the acoustical effect produced and are selected so as to prevent the lower tones, by reason of their greater energy content, from exercising undue control. Energy produced by amplification by the tube 61 is transmitted to condensers 66, 67, and 68, resistors 70, 71, 72, 73, and 74 and potentiometers 76 and 77. These condensers and resistors are so chosen as to discriminate against low and intermediate frequency tones with the exception of condenser 66 which will pass these tones to a considerable degree.

Energy for controlling the potential across condenser 49 for dynamic multiplier purposes is derived from potentiometer 76, while energy for producing voltage across condenser 99 for automatic scratch filter purposes is obtained from potentiometer 77. Switches 78 and 79 are provided so that the energy available for the potentiometers 76 and 77 may be made large or small without substantial change of the transmission characteristics of the filtering network.

Energy for dynamic multiplication control purposes is derived from potentiometer 76 and is amplified by tube 80. The amplified energy from this tube is delivered through the transformer 81 to the rectifier circuit which includes the rectifier tube 82, condenser 83 and resistor 84. The rectified current in this circuit passes through the resistor 84 in the direction of the arrow and produces a potential difference across this resistor which is proportional to the strength of the input signal substantially throughout the entire audio band.

This potential is applied through the resistor 86 to the input circuit of the amplifier 37, thus opposing the negative bias which is normally imposed upon the grids of the tubes 37*a*. In this way the gain ratio of the amplifier 37 is made to increase in accordance with an increase of input signal strength.

The potential drop across the resistor 84 is limited by the action of the diodes 61*a* of the tube 61, which prevents this potential from increasing beyond a predetermined value, so that the strongest signals will reduce the bias on the tubes of the amplifier 37 only to a suitable value when used for maximum possible output power.

Energy for automatic scratch filter purposes is obtained from the potentiometer 77 and passes through the condenser 90 and auto-transformer 91 to the amplifier tube 92. The energy after being amplified by the tube 92 is transmitted through the auto-transformer 93 and condenser 95 to the rectifier circuit, which includes rectifier tube 96 and resistor 97. The condensers 90 and 95 and the auto-transformers 91 and 93 are so chosen as to discriminate against low and intermediate audio frequencies. The rectified current in this circuit passes through the resistor 97 in the direction of the arrow and produces an average potential difference across this resistance which is determined by the strength of the higher frequency portion of the input signal.

When high frequency currents are not present in the input signal there is a small negative bias on the grids of the tubes 44 and 46 determined by the position of the potentiometer 63. Under these conditions the impedances of these tubes 44 and 46 are low so that the filter network operates to prevent the passage of high frequencies, such as scratch and ground noise, to the amplifier 37, these frequencies being by-passed through the condensers 40 and 41 and the tubes 44 and 46.

When high frequencies are present in the input signal however, rectified current will flow through the resistor 97, as already described, thus causing an increase of negative potential to be produced at the upper end of this resistor as viewed in the figure. This negative potential is applied through the resistor 98 to the grids of the tubes 44 and 46, thereby increasing their impedance and allowing the high frequencies to pass to the amplifier 37, as under these conditions the resistors 42 and 43 will be the controlling factors in preventing the by-passing of the high frequencies through the filter network.

Resistors 42 and 43 are several times the impedance of tubes 44 and 46 and are used to determine the upper possible limit of resistance bridged across chokes 47 and 48, and serve to permit serious resonance effects of condenser 40 and choke 47 and condensers 41 and choke 48 when the tubes 44 and 46 pass no current.

It is thus seen that as the amount and frequency of the high frequencies impressed upon transformer 21 increase, the impedances of the tubes 44 and 46 will also increase, thus allowing the filter network to pass the high frequencies in accordance with their intensity in the input signal.

No limiting device is necessary for the automatic scratch filter, as an increase of high frequency signals causes the plate currents of the tubes to be reduced to the minimum possible value of zero.

The potentiometers 29, 30, 63 and 64 may be operated in unison, so that with manual increase of signal volume the negative potentials across condensers 99 and 49 will be decreased and increased respectively. This will produce less dynamic multiplication and less automatic scratch elimination when the circuit is operated at lower volume level. The voltages across the potentiometers 63 and 64 are derived from the source of plate power 57 through the use of bleeder resistors 108, 109, 110, and 111, and the potentiometers may be suitably chosen to control the plate currents of the tubes between any de-

sired values, as for example from approximately zero to the normal operating value.

The meters 112 and 113 are provided to indicate the operation of the circuit as to filtering and dynamic action.

The switches 101 and 102 are provided for eliminating either the dynamic multiplier action or the automatic scratch filter action. When the switch 101 is closed a suitable bias for normal operation of the push-pull amplifier 37 will be applied to the grids of the tubes of the amplifier 37 as determined by the potential of the negative side of the resistor 111. When the switch 102 is closed the maximum possible bias from the negative end of the source of plate power 57 will be applied to the grids of the tubes 44 and 46.

The timing of the control circuits is adjusted by the constants of the rectifier output systems including condensers 49 and 99 and may be suitable for reasonably fast operation as determined by the characteristics of the output circuit. In general, the operation should be such that the control is not noticeable to the ear. If it is desired to delay the operation slightly the switches 103 and 105 are closed, thus throwing the condensers 104 and 106 in parallel with the condensers 49 and 99.

Condensers 60, 66, resistors 62, 70, 76 and transformer 81 are adapted to make the electrical energy impressed upon rectifier 82 correspond to the acoustical value of the output of amplifier 25, by discriminating against lower frequency tones. The filter network comprising condensers 67, 68 and 80; resistors 71, 72, 73 and 74; the autotransformer 91; the output circuit and autotransformer 93 and condenser 95 are selected to discriminate against the lower and intermediate frequency tones. Consequently rectifier 82 is energized especially by intermediate frequency tones in accordance with the acoustical volume corresponding to electrical currents in the output of tube 25, but rectifier 83 is energized by higher frequency tones in accordance with the currents in the output of tube 25 in the scratch frequency range. It is evident therefore that energy throughout the entire audio band derived from the sound source is available for operating the dynamic multiplier control circuits while only the high frequencies which are in the same range as the background noise of the sound record are used for operating the automatic scratch filter circuits. The constants of all the circuits including elements 60 to 93 and condenser 95 may be so proportioned as to give the desired frequency and energy characteristics for operating the two rectifier systems for these purposes.

Although one particular type of rectifier system is shown in the accompanying drawings, it will be understood that any suitable types of rectifier systems could be used to produce voltages across condensers 49 and 99 suitable for the desired purpose, in accordance with the energy and frequency characteristics.

The entire system therefore, involves an automatic scratch filter circuit controlled by the impedance of vacuum tube devices and a dynamic multiplier circuit, the gain ratio of which is controlled by the potentials on the control electrodes. Low and intermediate frequency tones do not effectively operate the scratch filter circuit, but do control the dynamic multiplier circuit. High frequency tones, however, operate both the scratch filter and the dynamic multiplier control. This gives a normal amount of expansion of volume range for the low and intermediate tones and an increased expansion for the highest tones.

This system provides, through control of potential across condenser 49, dynamic multiplication or volume expansion on substantially all frequencies, and also provides, through control of potential across condenser 99, further dynamic multiplication on a group of selected frequencies in accordance with their energy content in the input signal. The transmission properties of the system may be proportioned in any manner desirable, as for example by choice of transformers and filter elements in the main amplifying channel, to give substantially uniform transmission characteristics under conditions of maximum input signal. The use of a low pass filter 28 to cut off signals higher than about 5000 cycles, while desirable for disc records, may be omitted when film records are used.

Figure 2 depicts the effect of change of potential across the condenser 99 upon the change of transmission of signals through the entire amplifier, in an illustrated case. Abscissae represent frequency of signals impressed upon the system, ordinates represent transmission change. The value of transmission with negative potential across the condenser 99 to produce zero space current of the tubes 44 and 46 is taken arbitrarily as zero decibels for all frequencies and is represented by the straight line.

The curved line shows the filtering effect when normal space current passes through the tubes 44 and 46, as occurs in the absence of any appreciable signal, thus indicating discrimination against the high frequency portions of the signal. When signals are impressed of suitable characteristics to reduce the plate currents to zero, the transmission of the system is altered by the change of the automatic filter network in such a manner as to increase the transmission on all frequencies above 360 cycles and very greatly on all frequencies above 1000 cycles. The transmission on frequencies between 60 and 350 cycles is at the same time diminished due to the series-resonance effect of the chokes and condensers in the shunt arms of the filter network.

For intermediate values of potentials and space currents the transmission curve would lie between the two curves depicted. It is therefore seen that any change in the signal which increases the negative potential across the condenser 99 increases the contrast of the high and low frequency portions of energy present in the signal.

In Figure 3 is depicted the relative effects of signals of different frequencies in causing the change of transmission shown in Figure 2, indicating that higher frequencies of a given intensity exercise control much more readily than low frequencies of the same intensity and that very low frequencies produce practically no control whatsoever.

Although only a few of the various forms in which this invention may be embodied have been shown herein, it is to be understood that the invention is not limited to any specific construction, but might be embodied in various forms without departing from the spirit of the invention or the scope of the appended claims.

What I claim is:—

1. In a system for reproducing sound from a sound record, a volume control device for manually controlling the input signal strength, a variable filter having variable impedance devices adapted to control the frequency transmission characteristics of said system, means responsive

to a characteristic of the input signal for controlling said variable impedance devices, and means associated with said volume control device for altering the control of said variable impedance devices in proportion to the setting of said volume control device.

2. In a system for reproducing sound from a sound record, a main transmission channel having a volume control device, a filter adapted normally to suppress the high frequency components, and an amplifier, a control channel actuated in accordance with the input signal, said control channel having means responsive to substantially the entire audio frequency range of said signal for varying the gain ratio of said amplifier in accordance with the average intensity of said signal, means responsive to the high frequency components of said signal for causing said filter to pass said components when they are present in excess of a predetermined strength, and means to selectively render said filter and said control circuit inoperative.

3. In an electrical transmission channel, a variable filter including a space discharge device connected to control the transmission characteristics thereof and having a control electrode, means responsive to the signal strength to impress a variable biasing potential on said control electrode whereby the transmission characteristics of said filter vary according to signal strength and means to selectively impress a fixed biasing potential on said control electrode to cause the filter characteristics to remain constant.

4. In an electrical transmission channel, a variable filter having shunt condensers and space discharge devices having their space current paths connected in series with said condensers to control by their impedance the transmission characteristics of said filter and having control electrodes, means responsive to the signal strength to impress a variable biasing potential on said control electrodes whereby the transmission characteristics of said filter vary according to signal strength and means to selectively impress a fixed biasing potential on said control electrodes to cause the filter characteristics to remain constant.

5. In an electrical transmission channel, a space discharge amplifier having control electrodes, a variable filter including space discharge devices connected to control the transmission characteristics thereof and having control electrodes, means responsive to the signal strength to impress a variable biasing potential on the control electrodes of said amplifier and said filter so as to vary the amplification factor of said amplifier and the transmission characteristics of said filter in accordance with signal strength and means to selectively impress a fixed biasing potential on said control electrodes to cause the amplifier to operate with a constant amplification factor and to cause the filter characteristics to remain constant.

6. In an electrical transmission channel, a space discharge amplifier having control electrodes, a variable filter having shunt condensers and space discharge devices having their space current paths connected in series with said condensers to control by their impedance the transmission characteristics of said filter and having control electrodes, means responsive to the signal strength to impress a variable biasing potential on the control electrodes of said amplifier and said filter so as to vary the amplification factor of said amplifier and the transmission characteristics of said filter in accordance with signal strength and means to selectively impress a fixed biasing potential on said control electrodes to cause the amplifier to operate with a fixed amplification factor and the filter characteristics to remain constant.

7. In an electrical transmission channel, a space discharge amplifier having control electrodes, a variable filter normally adapted to discriminate against high frequencies, a space discharge device connected to control the discrimination characteristics of said filter and having a control electrode, means responsive to the signal strength to impress a variable biasing potential on the control electrodes of said amplifier so as to cause the amplification factor of said amplifier to vary in accordance with signal volume and means responsive to the high frequency component of the signal to impress a variable biasing potential on the control electrode of said filter so as to control the discrimination characteristics thereof in accordance with the strength of said high frequency components and means to selectively impress a fixed biasing potential on all of said control electrodes to cause the amplifier to operate with a fixed amplification factor and the filter characteristics to remain constant.

8. In an electrical transmission channel, a variable filter having shunt condensers, space discharge devices having their space current paths connected in series with said condensers to control by their impedance the transmission characteristics of said filter and a high resistance connected in parallel to said space discharge devices to prevent resonance effects in said condensers when said space discharge devices operate at a high impedance.

9. In an electrical transmission channel, a variable filter comprising a capacity resistance network having series resistances and shunt capacities, space discharge devices having their space current paths connected in series with said capacities to vary by their impedance the effectiveness thereof, whereby the said network constitutes a low pass filter when the internal impedance of said space discharge devices is low and constitutes an attenuation network without appreciable discrimination when said impedance is high.

10. In an electrical transmission channel, a filter network including impedances connected in the shunt leg thereof and a pair of space discharge devices connected in push-pull relationship in series with said impedances and adapted to control by their internal impedance the effectiveness of said first impedances.

11. In an electrical transmission channel, a filter network including condensers connected in the shunt leg thereof, a pair of space discharge devices connected in push-pull in series with said condensers and adapted to control by their impedance the effectiveness thereof.

12. In an electrical transmission channel, a filter network comprising a series impedance and a shunt leg on each side of said impedance, each of said shunt legs including a pair of condensers and a pair of space discharge devices connected in push-pull relationship with their space current paths in series with said condensers and means controlling the impedance of said space discharge devices to vary thereby the effectiveness of said condensers.

13. In an electrical transmission channel, a filter network comprising a series impedance and a shunt leg on each side of said impedance, each

of said shunt legs including a pair of condensers and a pair of space discharge devices connected in push-pull relationship with their space current paths in series with said condensers, means controlling the impedance of said space discharge devices to vary thereby the effectiveness of said condensers and means to apply a high fixed biasing potential to said space discharge devices to substantially block the same whereby said condensers are rendered ineffective.

14. In an electrical transmission channel, a filter network comprising a series impedance and a shunt leg on each side of said impedance, each of said shunt legs including a pair of condensers and a pair of space discharge devices connected in push-pull relationship with their space current paths in series with said condensers, means controlling the impedance of said space discharge devices to vary thereby the effectiveness of said condensers, means to apply a high fixed biasing potential to said space discharge devices to substantially block the same whereby said condensers are rendered ineffective and a high resistance connected in parallel with said space discharge devices to limit the maximum impedance of said shunt leg.

15. In an electrical transmission channel, a resistance attenuation network including a shunt potentiometer, means deriving a control voltage from said potentiometer and means to introduce a series and a shunt resistance in said network to decrease said control voltage without introducing substantial change in the transmission characteristics of said network.

16. In a system for reproducing sound from a sound record, a space discharge amplifier having control electrodes, a variable filter including space discharge devices connected to control the transmission characteristics thereof and having control electrodes, means responsive to the signal strength to impress a variable biasing potential on the control electrodes of said amplifier and said filter so as to vary the amplification factor of said amplifier and the transmission characteristics of said filter in accordance with signal strength, volume control means for adjusting the volume of the reproduced sound and means actuated in unison with said volume control, means to adjust the initial biasing potential of said space discharge devices so that variations in signal strength produce less control effect when the volume control is set for a lower volume.

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