Oct. 15, 1940. C. J. LE BEL 2,218,400

EQUALIZER

Filed Nov. 5, 1937

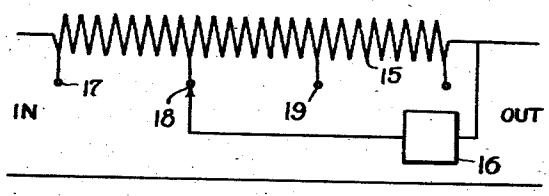


FIG. 1

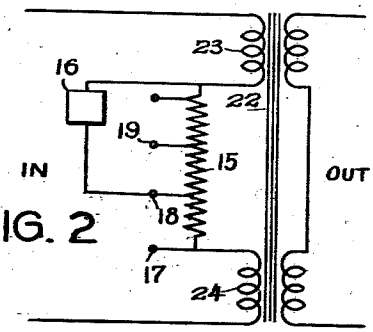


FIG. 2

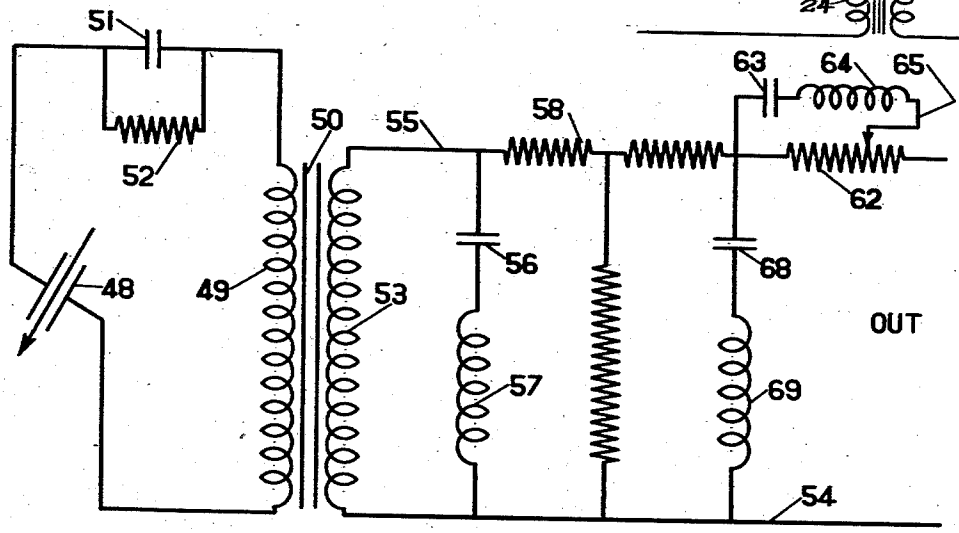


FIG. 3

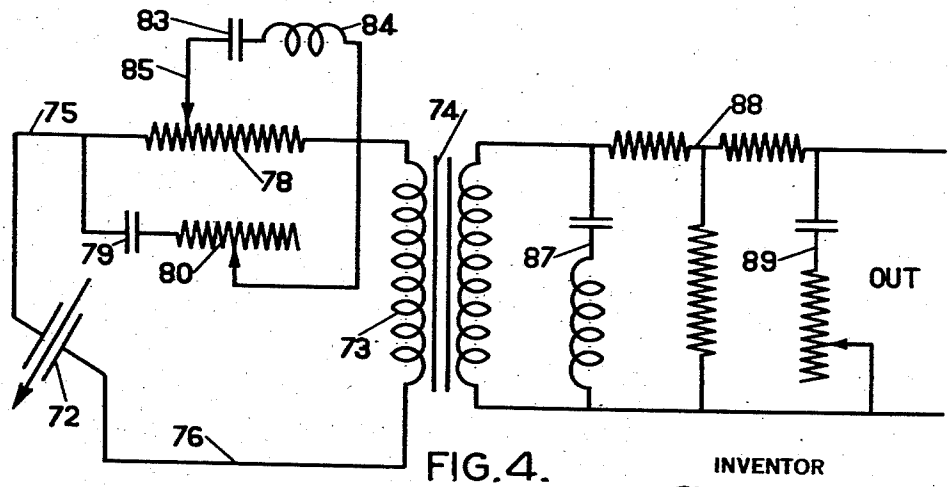


FIG. 4.

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EQUALIZER

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4 Claims. (Cl. 179—1)

The invention relates to an adjustable equalizer or tone control having various applications such as in radio broadcasts, talking picture dialogues, making records for electrical transcriptions and the like, broadcasting from such records, etc. The equalizer maintains the volume constant over the central part of the frequency range while adjusting the transmission over certain bands of high or low or both high and low frequencies in order to increase or decrease the response in these bands.

An object of the invention is to design an equalizer which can be adjusted to vary the transmission in a circuit at the low, high, or both low and high frequencies while in operation without affecting the volume of the output or the transmission over at least some portion of the middle part of the frequency range being transmitted through the circuit.

Another object of the invention is to construct an equalizer which fixes the minimum transmission through a circuit and provides for adjustment of the amount of maximum transmission in a particular frequency band. Adjustment may also be made for the position of the region of maximum transmission with respect to frequency.

Another object is to devise an equalizer circuit or network which will have a proportional effect upon the transmission of the circuit to be modified and by which the extent of proportional effect may be varied. In addition, an equalizer may be included therewith which controls the decrease in attenuation in a band of low frequencies below the range where the proportional effect in transmission exists.

Figure 1 is a view of a constant volume adjustable equalizer which utilizes a single resistance to provide attenuation in the circuit and to modify the effect of the reactive means in the circuit.

Figure 2 is a view of a constant volume adjustable equalizer connected between the split winding of a line transformer in order to form a balanced circuit.

Figure 3 is a diagrammatic view of a circuit including a piezo electric pick-up in which the equalizer of the invention has been connected.

Figure 4 is a diagrammatic view of a circuit including a piezo electric pick-up in which circuit an equalizer has been connected which controls the transmission through the circuit so that it is proportional with respect to frequency over some portion of the frequency range and, in addition, the decrease in attenuation may be varied as desired to increase or decrease the range of proportionality. The circuit also shows a bass booster by which the decrease in attenuation in a desired lower band of frequencies may be varied as desired.

In the process of recording, transmitting, and reproducing sound electrically, the ideal of course is a transmission, the efficiency of which is independent of frequency. However, it frequently occurs that one of the component links of the chain of circuits and devices is imperfect and transmits some frequencies better than others. It then becomes necessary to correct for this discrimination by the use of an equalizer or tone control which affects or modifies the circuit so that an inverse discrimination of approximate like amount occurs. Such an equalizer or tone control may also be used to compensate for the characteristics of the ear. For example, music picked up from a full orchestra at high volume and reproduced in the home at low volume must have the bass boosted in order to allow for the apparent loss thereof. Talking picture dialogue is recorded at the natural volume of speech and reproduced in a theatre at a much higher level which has an effect upon the ear which appears to unduly amplify the lower bass and the upper treble. Therefore, the lower bass and upper treble are usually attenuated somewhat in recording in order that the dialogue when reproduced in a theatre will not be over-emphasized in the lower and upper frequency bands.

The equalizer may take several forms and that illustrated in Figure 1 includes a resistance 15 connected in series in the circuit and the value of which is determined from the following series formula:

$$R=(Z_1+Z_2)\left[\left(\log_{10}^{-1}\frac{L_t}{20}\right)-1\right]$$

In this formula Z_1 is the impedance of the input generator, Z_2 is the impedance of the output generator, which impedances are in ohms, and L_t is the maximum boost or increase in gain in transmission of the circuit, in terms of decibels, to be produced by the equalizer.

A reactive means 16, such as a condenser, is connected with respect to the resistance 15 so that the reactive means modifies the effect of the resistance upon the circuit. The reactive means shunts the resistance and has a value so that at certain bands of frequencies the impedance thereof will be so high that the resistance 15 will produce its full attenuation. At another band of selected frequencies the resistance 15

will be partially or completely short circuited by the reactive means and hence reduces the attenuation which the resistance produces in the circuit in this selected frequency band.

That part of the resistance 15 which is connected in series with the reactive means 16 has an effect upon the circuit as a whole so as to modify the circuit either to increase or decrease the attenuation in the band of frequencies in which the reactive means operates and thereby control the transmission in the circuit of this band of frequencies.

In the equalizer above described, it will be noted that the resistance 15 at no time is varied and consequently an insertion loss has been added to the circuit which is constant or fixed at all times. This means that the maximum attenuation of the circuit is determined once and for all so that the volume or output through the circuit over the middle portion of the frequency range is unchanged. By adjusting the position of the connection with the resistance 15, thereby varying the amount of resistance in series with the reactive means 16, the transmission through the reactive means may be increased or decreased. The attenuation caused by the resistance 15 is modified or decreased in the desired band of frequencies controlled by the reactive means.

In the construction shown in Figure 1, the resistance 15 serves also as the variable resistance in series with the reactive means 16. This may be accomplished, for example, by providing a series of taps 17, 18 and 19 at predetermined spaced intervals along the resistance 15 and a movable contact which may be connected with any one of the taps. A connection with the tap 17, of course, provides no resistance in series with the reactive means, the tap 18 provides a small resistance from a portion of the resistance 15 in series with the reactive means, and the tap 19 provides a larger portion of the resistance 15 in series with the reactive means. Any other method of varying the amount of resistance in series with the reactive means 16, utilizing the resistance 15, is contemplated. By varying the amount of resistance in series with the reactive means, the attenuation caused by the resistance 15 may be decreased a desired amount within the range of variation provided by the resistance in series with the reactive means 16 and in a certain band or bands of frequencies controlled by the reactive means as discussed above.

Where a circuit is to be balanced to ground, identical compensating units, such as in Figure 1, may be put in either side of the circuit with the controls interlocked so that balance is maintained at all times. However, the preferred construction is illustrated in Figure 2 wherein a transformer 22 is provided which is a standard split winding line to line transformer having a ratio of one-to-one in both input and output circuits for the same impedance. With this type of construction, the compensating circuit is provided between the split windings 23 and 24. The equalizer illustrated in Figure 2 is the same as that shown in Figure 1, although any equivalent equalizer may also be used if desired. With this construction, duplicate equalizers need not be provided in each line with interlocked controls and the single equalizer balances both lines with a single unit.

In Figure 3 the equalizer is illustrated in a commercial form of circuit in which a piezo electric pick-up 48 is shown connected in circuit with the primary winding 49 of a transformer 50. A condenser 51 is connected in series in the circuit and a resistance 52 shunts the condenser. The secondary winding 53 of the transformer 50 is connected to the output through wires 54 and 55.

A resistance 62 is connected in series in the circuit and has a fixed value which is determined in accordance with the formula hereinbefore given so that it will provide a fixed insertion loss providing the maximum attenuation desired in the circuit. A series resonant circuit is connected in parallel with the resistance and comprises the condenser 63 and an inductance 64 in series therewith for decreasing the attenuation caused by the resistance 62 in a desired band of frequencies. A variable resistance is also provided in series with the condenser 63 and inductance 64 which, in the illustrated embodiment, is part of the resistance 62.

The resistance 62 may be a standard commercial potentiometer by means of which the variable connection 65 may increase or decrease the amount of resistance in series with the condenser and inductance. This resistance limits the decrease in attenuation caused by the parallel resonant circuit and when varied controls the amount of or decrease in the attenuation caused by the fixed resistance 62 in the desired band of frequencies. Although a potentiometer may be used in the construction illustrated, as described, this potentiometer is not so connected in the circuit that the amount of resistance 62 in series in the circuit is varied, but only the amount of resistance in series with the circuit 63, 64 and 65 is varied.

The usual scratch eliminator or filter may be connected across the wires 54 and 55 which comprises a condenser 56 in series with an inductance 57. A T pad 58 is connected in the usual fashion in order to prevent interfering cooperation between the scratch filter 56, 57 and the equalizer 62, 63, 64 and 65. A shunt resonant circuit may also be connected between the wires 54 and 55 which includes a condenser 68 in series with an inductance 69 which serves as a resonance peak remover.

In Figure 4 there is illustrated a portion of another circuit used in conjunction with a crystal pick-up or generator. The crystal pick-up 72 is connected with the primary widing 73 of a transformer 74 through the wires 75 and 76. The secondary winding of the transformer is connected to a generator. not shown but indicated by the word "out." The term generator is used in a broad sense and may be a tube, the mixing box of a broadcasting station, etc.

A resistance 78 of a fixed value is connected in series with the crystal pick-up and the primary winding 73 of the transformer. The value of the resistance is determined by the formula given hereinbefore and provides a fixed insertion loss in the circuit. Shunting the resistance 78 is a condenser 79, the value of which is determined, as described in my earlier copending application, so that the transmission through the circuit is either directly or inversely proportional to frequency over some portion of the frequency range, or corrects for a transmission which is directly or inversely proportional to frequency over some portion of the frequency range. A variable resistance 80 is connected in series with the condenser 79 to limit the decrease in attenuation caused by the condenser and hence modifies the effect of the condenser upon the circuit whereby an increase or decrease in the extent of the transmission which is proportional with respect to

frequency over some portion of the frequency range may be increased or decreased as desired. Although the specific embodiment illustrated in the drawings in Figure 4 shows the equalizer connected in series in the circuit, the equalizer may be connected in shunt between two generators depending upon the result to be achieved.

A bass boosting equalizer may also be provided with the above circuit in the condenser 83 connected in series with an inductance 84, the values of which are chosen in order to boost the bass in the lower frequency range in which the transmission of the circuit is not proportional to frequency. An adjustable connection 85 is provided for the connection of the bass boosting circuit 83, 84 with the resistance 78 whereby the decrease in attenuation caused by the bass boosting circuit may be varied in the band of frequencies controlled thereby.

It will be observed that in the above circuit the value of the resistance 78 is changed at no time. Its value is determined once and for all to provide the maximum attenuation in decibels desired in the circuit. Thereafter if a variation in the amount of attenuation is desired in the higher frequencies, this may be accomplished by varying the amount of resistance 80 in circuit with the condenser 79. The greater amount of resistance 80 utilized results in an increased attenuation in the circuit, and by progressively cutting out some of the resistance 80, the attenuation is decreased until all of the resistance 80 is cut out in which case maximum decrease in attenuation is obtained in the band of frequencies controlled by the condenser. Similarly, by adjusting the position of the adjustable connection 85, the decrease in attenuation in the lower band of frequencies may be controlled as desired. Maximum decrease in attenuation is obtained by having no portion of the resistance 78 connected in series with the bass boosting circuit 83, 84. It will be observed, therefore, that in this construction the resistance 78 serves a double function, namely, in providing a fixed insertion loss in the circuit which is at no time varied, and also in providing the variable resistance which is utilized to adjust the extent of decrease in attenuation in the bass frequencies.

A circuit 87 may also be provided, if desired, to remove the effect of mechanical resonance of the crystal generator. A T pad 88 and a scratch filter 89 also may be provided.

The circuit shown in Figure 4 may be reversed, if desired, and used to drive a crystal cutter which is a crystal generator of mechanical vibrations. The values of reactance, inductance, and resistance, however, would be altered by the formula given because of the different characteristics of the crystal cutter as compared to the crystal pick-up.

Various modifications will occur to those skilled in the art in the configuration, composition and disposition of the component elements going to make up the invention as a whole, as well as in the selective combination or application of the respective elements, and no limitation is intended by the phraseology of the foregoing description or illustrations in the accompanying drawing.

What is claimed is:

1. An electrical circuit comprising an input and an output generator, an equalizer connected in series therebetween including a resistance of a fixed value in series between the generators, reactive means connected in parallel therewith to reduce the attenuation caused by the resistance, and an adjustable connection between said reactive means and at least one intermediate point of the resistance to connect part of the resistance in series with the reactive means to vary the transmission therethrough in a desired band of frequencies.

2. An electrical circuit comprising an input and and output generator, an equalizer connected in series therebetween including a resistance of a fixed value in series between the generators, reactive means connected in parallel therewith to reduce the attennuation caused by the resistance in a selected band of frequencies, an adjustable connection between said reactive means and at least one intermediate point of the resistance to connect part of the resistance in series with the reactive means to vary the transmission therethrough in a desired band of frequencies, and a second reactive means connected in parallel with the resistance and selected to decrease the attenuation caused by the resistance in another band of frequencies.

3. An electric equalizer and transformer adapted to be connected in a circuit the transmission characteristics of which are to be modified comprising a transformer having a split winding, resistive means connected in series between the split winding, including a first portion having a predetermined fixed value to produce the maximum attenuation desired at any time in the circuit and a second portion, reactive means having a connection with the first portion of the resistive means and a value to control the attenuation of the fixed value portion of the resistive means in a desired band of frequencies, the second portion of the resistive means being connected with respect to the reactive means to control the effect thereof, and an adjustable connection for the second portion of the resistive means to increase or decrease its effective value to vary the decrease in attenuation caused by the reactive means.

4. An electrical circuit comprising an input and an output generator, an equalizer connected in series therebetween including a resistance of predetermined fixed value to produce the maximum attenuation desired and connected in the circuit, resonant reactive means connected in parallel therewith to reduce the attenuation caused by the resistance, and an adjustable connection between said reactive means and at least one intermediate point of the resistance to connect the part in series with the reactive means to vary the transmission therethrough in a desired band of frequencies.

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