April 14, 1942. E. SEVERIN ET AL 2,279,500

CIRCUIT ORGANIZATION FOR PIEZOELECTRIC PICKUPS

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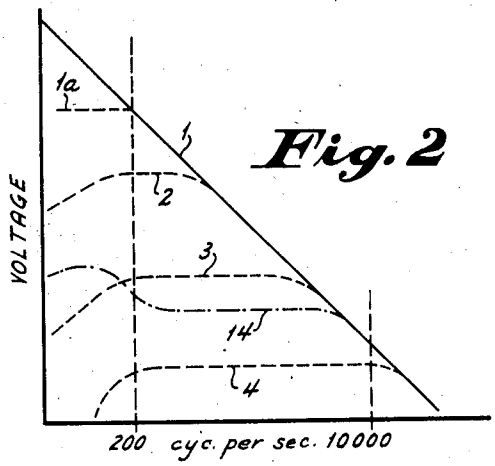

Fig. 2

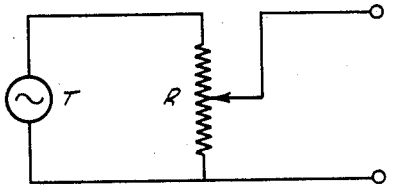

Fig. 1

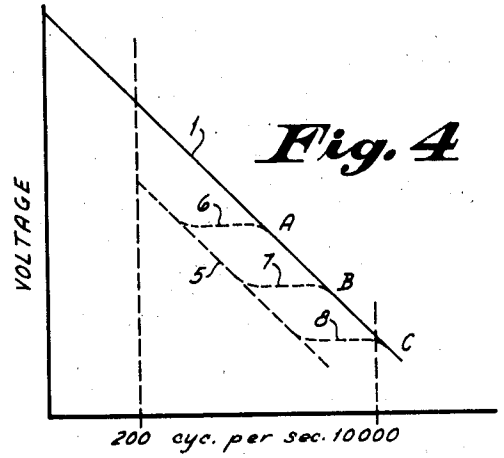

Fig. 4

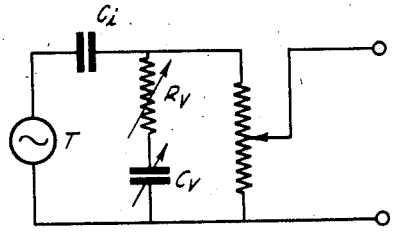

Fig. 3

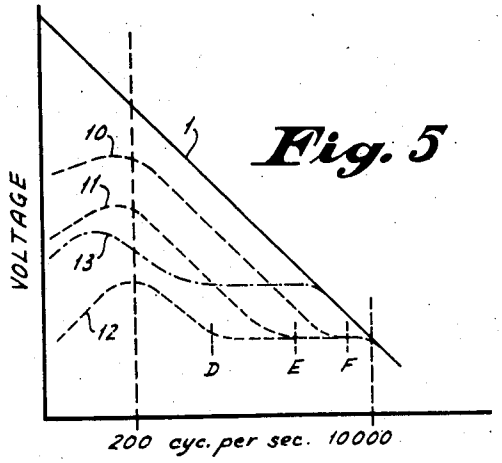

Fig. 5

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CIRCUIT ORGANIZATION FOR PIEZO-ELECTRIC PICKUPS

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2 Claims. (Cl. 179—100.4)

This invention relates to a novel circuit organization for piezo-electric pickups, as used in phonographs.

Piezo-electric pickups produce potentials proportional to the pressure. Since in the conventional kind of phonograph record, recording of the sound tracks is with constant "frequency amplitude" (referred to constant amplifier drive range) it follows that the recorded amplitude diminishes or droops with the frequency. The consequence is that when such phonograph records are played with piezo-electric pickups, the frequency curve arises roughly at an angle of 45 degrees in the direction of the low frequencies.

This shape of the characteristic is altered by the usual terminating resistance which at the same time serves for volume control. (Fig. 1.) The sound pickup is indicated at T, and the resistance at R. According to the size of this resistance, there result different frequency characteristics when reproducing sound from such record disks as shown in Fig. 2, where the frequency in terms of cycles per second is indicated along the abscissa axis plotted against the potential impressed across the resistance R along the ordinate axis. The straight-line graph 1 is the noload characteristic of a piezo-electric sound pickup which presents an angle of inclination or slope of around 45 degrees. This curve applies in the presupposition that the recording, down to the lowest frequencies, was with a constant frequency amplitude. However, this assumption is no longer true for the conventional phonograph disks for frequencies below 200-cycles per second. In fact, below this range, the cut is with constant amplitude so that the frequency curve has there a shape as shown by the dotted lines 1*a*.

The representation Fig. 2 clearly shows that a frequency characteristic having a form as indicated by graph 1*a* is unserviceable, but this curve can be changed by shunting a resistance to the transmission channel. According to the size of the resistance there result characteristics 2, 3 and 4. The lower the resistance (curve 4 applies to low R), the straighter the frequency band becomes. To be sure, the potential output diminishes considerably since the capacitive internal resistance of the generator is short-circuited by the resistance R. What is desired is a curve having roughly a shape as shown by graph 14. At a relatively high level a comparatively high potential is produced at the low frequencies, and this is of importance in view of the droop above referred to. The high frequencies are rendered the way they have been cut in the disk.

Such a shape is obtainable by the use of simple circuit elements with an organization as shown in Fig. 3. The sound pickup is designated again by T. The self-capacitance of this pickup is denoted by C_i, while the seriation comprising an ohmic resistance and a capacity shunted to the pickup is designated by R_v and C_v. These are shown to be variable. The influence of such variation of the said quantities is shown more clearly by reference to Figs. 4 and 5.

In most cases, it will suffice in practice first to determine the values of R_v and C_v required for a given sound pickup, and then to provide a fixed resistance and a fixed condenser, in case no variation of correction or compensation is desired. Fig. 4 illustrates the influence of a variation of the series resistance R_v in the assumption that a fixed condenser C_v is also connected. The straight line 1 again shows the no-load characteristic of the pickup. If only the condenser C_v is provided, it is shifted parallel to itself owing to the capacitive voltage division as far as the straight line 5 indicated by the dash-lines. According to the size of the resistance R_v there are obtained different transitions of the straight line 5 to straight line 1 as illustrated by the curves 6, 7 and 8. Curve 6 applies to a high value of R_v, curve 7 to medium and curve 8 to a low value of R_v. The transitions marked A, B, C, of curves 6, 7 and 8 to the straight line 1 occur in the presence of the limiting frequency ωgr. This limiting frequency, according to the desired quality or fidelity of reproduction of the pickup lies between 3000 and 8000 cycles per second. If C_i the self-capacitance of the pickup, then, according to the sense of this invention, there should be:

$$R_v \sim 1 \text{ to } 2 \times \frac{1}{\omega grr.C_i}$$

Fig. 5 shows the shape of the frequency characteristic when a relatively small, but constant R_v is cut in the circuit, and when C_v is raised. Straight line 1 shows again the no-load characteristic. Curves 10, 11 and 12 apply to an increasing C_v, curve 12 referring to maximum C_v.

According to the size of this series capacity, the straight line at a slope of 45 degrees changes into a parallel line to the abscissa axis at more or less high frequencies. The frequencies where this change occurs and which are designated by D, E and F, will in the following equation be designated by ωa and the latter will lie between 300 and 3000 cycles per second. According to the

invention, there results the following value for C_v:

$$C_v \sim 1 \text{ to } 2 \times \frac{1}{\omega a . R_v}$$

If the resistance R_v and the condenser C_v have been suitably chosen, then a curve shaped as shown at 13 is obtainable which roughly corresponds to the curve shape 14, Fig. 2, assumed to be desirable.

Where the piezo-electric pickup has a self-capacitance C_i of around 1000 centimeters, and this is a typical pickup often found in practice, then the series capacities C_v may range between 2,000 and 7,000 centimeters, while values ranging between 20,000 and 100,000 ohm have found to be preferable for the series resistances. The particular size to be chosen for these elements is a function of the particular frequency response characteristic that is desired, and the voltage drop that is deemed acceptable.

It is noteworthy that the circuit organization here shown is usable also for other capacitive generators such as piezo-electric microphones, and the like.

It can be seen from the above considerations that with comparatively simple means it is possible to obtain a frequency curve, by adopting the basic idea of the invention which will measure up to all demands.

What is claimed is:

1. A piezoelectric pickup device circuit arrangement including a variable resistance and a variable condenser connected in series with each other and in parallel with said pickup device, a pair of output terminals, a second resistance in parallel with said variable condenser and said first mentioned resistance, a variable connection from said second resistance to one of said output terminals, and a fixed connection from one end of said second resistance to the other output terminal.

2. A piezoelectric pickup device circuit arrangement including a resistance and a condenser connected in series with each other and in parallel with said pickup device, said resistance having a value which obeys the formula

$$R_v \sim 1 \text{ to } 2 \times \frac{1}{\omega r . C_i}$$

where ωr lies between 3,000 and 8,000 cycles per second and C_i the self-capacitance of the sound pickup, and that the series capacity is

$$C_v \sim 1 \text{ to } 2 \times \frac{1}{\omega a . R_v}$$

where ωa lies between 300 and 3,000 cycles per second, a pair of output terminals, a second resistance in parallel with said condenser and said first mentioned resistance, a variable connection from said second resistance to one of said output terminals, and a fixed connection from one end of said second resistance to the other output terminal.

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