Jan. 2, 1940. J. P. SMITH 2,185,870

VOLUME CONTROL DEVICE

Filed June 30, 1937 2 Sheets-Sheet 1

FIG. 2.

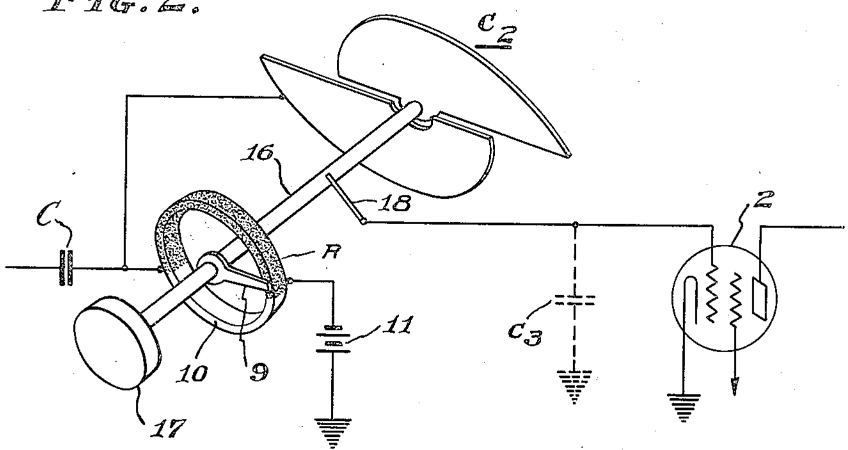
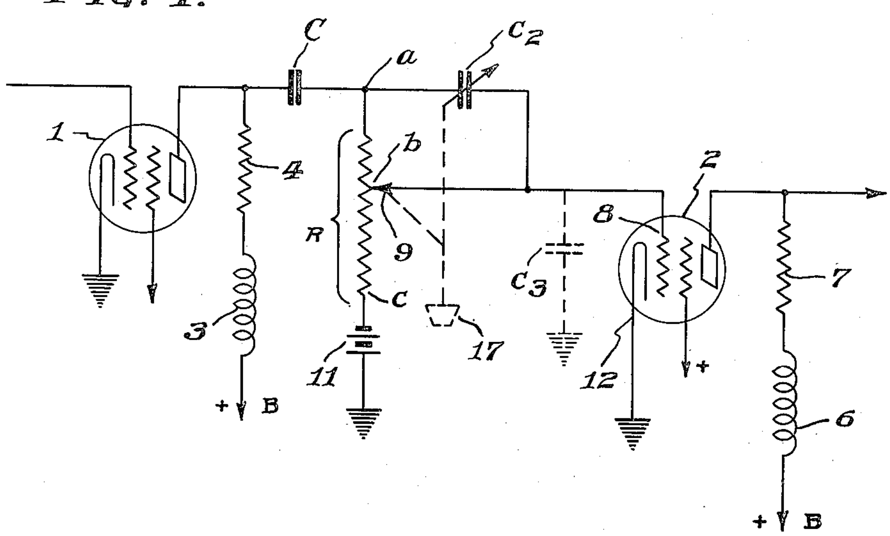


FIG. 1.



Inventor
John P. Smith

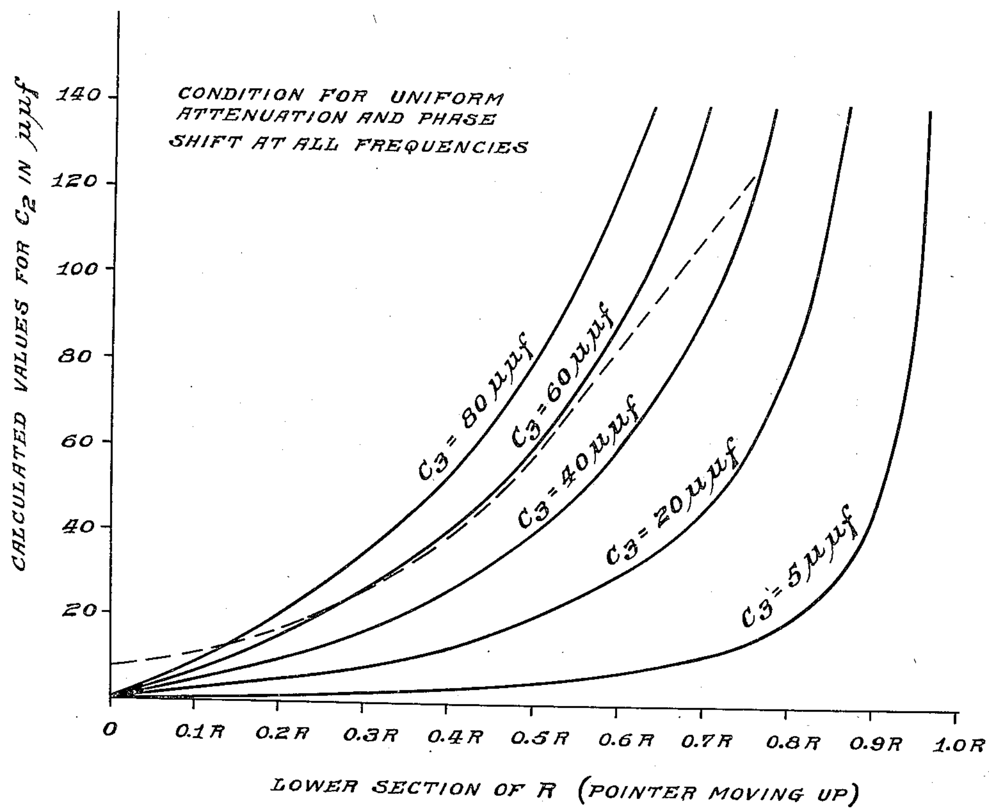
By [signature]

Attorney

VOLUME CONTROL DEVICE

Filed June 30, 1937 2 Sheets-Sheet 2

FIG. 3.



Inventor
John P. Smith

By [signature]

Attorney

Patented Jan. 2, 1940 2,185,870

UNITED STATES PATENT OFFICE

2,185,870

VOLUME CONTROL DEVICE

John P. Smith, Erlton, N. J., assignor to Radio Corporation of America, a corporation of Delaware

Application June 30, 1937, Serial No. 151,115

3 Claims. (Cl. 179—171)

My invention relates to volume control devices and particularly to volume control potentiometers for use in television amplifiers or other apparatus designed to pass signals covering a wide frequency band.

In television transmitters and receivers the video amplifiers must be designed to amplify signals having frequency components ranging from approximately 20 cycles to 50,000 cycles and higher. Such amplifiers are commonly of the resistance coupled type. In order to prevent attenuation and phase shift at the lower picture or video frequencies, the grid resistor and the coupling capacitor are made with as much resistance and capacity, respectively, as possible, the grid resistor value being limited by grid current and the capacitor value being limited by physical size.

When the grid resistor is given a reasonably high value, 0.5 megohm, for example, and is used as a volume control potentiometer, the ratio of high frequency voltage to low frequency voltage is different for different settings of the potentiometer because of the input capacity of the amplifier tube receiving signals from the potentiometer.

The reason the tube input capacity has this effect is that it is a fixed capacity shunted across one portion of the grid resistor while the remaining portion of the grid resistor has a negligible or comparatively small amount of capacity across it. As a result, when the movable contact point is at the center of the grid resistor, the high frequency components are attenuated much more than the low frequency components. When the contact point is moved in either direction from the center, this difference in the attenuation of the high and low frequency components is decreased. It will be apparent that when the volume is changed, the frequency characteristic of the amplifier is changed.

It is, accordingly, an object of my invention to provide an improved volume control device for amplifiers or other apparatus passing signals having a wide frequency band. It is a further object of my invention to provide an improved volume control potentiometer.

It is a still further object of my invention to provide an improved volume control potentiometer which has substantially the same frequency response characteristic over the entire volume range.

In the preferred embodiment of my invention I connect a variable capacitor across that portion of the potentiometer resistor which is not shunted by the tube input capacity. The variable capacitor is ganged with the potentiometer slider whereby its capacity is changed as the slider is moved, the capacity increasing as the slider is moved in a direction to increase the volume. In this way the volume control device is made to function as a capacity potentiometer at the high frequencies.

The invention will be better understood from the following description taken in connection with the accompanying drawings in which—

Figure 1 is a circuit diagram of one embodiment of my invention,

Figure 2 is a schematic diagram showing one possible mechanical arrangement of the potentiometer shown in Fig. 1, and

Figure 3 is a group of curves which are referred to in explaining my invention.

Referring to Fig. 1, my invention is shown applied to a picture signal amplifier such as the video amplifier of a television receiver. Two amplifier tubes 1 and 2 of the screen grid type are shown. The plate of the tube 1 may be supplied with a suitable operating voltage through a "peaking" coil 3 and a plate resistor 4, the peaking coil being employed to extend the high frequency response of the amplifier in a well known manner. The plate of the tube 2 may also be supplied with voltage through a peaking coil 6 and a plate resistor 7.

The plate circuit of tube 1 is coupled to the grid circuit of tube 2 through a coupling condenser C, this condenser being connected to the high voltage end of a grid resistor R which also functions as a potentiometer resistor for manual volume control.

The grid 8 of tube 2 is connected to a point on the resistor R through a variable contact point 9. A biasing battery 11 or other suitable biasing source is connected between the resistor R and the grounded cathode 12 of tube 2 for applying a suitable negative bias to the grid 8.

It will be seen that up to this point an ordinary resistance coupled amplifier has been described, the grid resistor being utilized for volume control purposes. It has previously been explained that such a circuit is unsatisfactory for signals having a wide frequency range because of the tube input capacity indicated at C_3. It will be noted that the capacity C_3 is always connected between the points *b* and *c* on resistor R, the point *b* being where the slider 9 makes contact.

In accordance with my invention I connect a variable capacitor C_2 across the upper portion of resistor R, that is between the points *a* and *b*. The capacitor C_2 and the contact point 9 are mechanically connected or ganged whereby the capacity of C_2 is changed when the contact point 9 is moved. A fairly satisfactory arrangement, for example, is to employ a straight line frequency condenser as capacitor C_2 and so gang it with resistor R that when contact point 9 is in the middle of R the capacity of C_2 equals the capacity of C_3, the capacity of C_2 increasing as pointer 9 is moved towards *a*. The potentiometer R in this case should be substantially linear.

The potentiometer R and the capacitor C_2 may be ganged as shown in Fig. 2, the pointer 9 and the rotor plate of condenser C_2 being attached to a shaft 16 which may be rotated by a volume control knob 17. In Figs. 1 and 2 like parts are indicated by the same reference numerals. If the shaft 16 is a metal shaft it functions as a connection between the pointer 9 and the rotor plate of capacitor C_2. The connection of the pointer 9 to the grid of the tube 2 may be made through a brush 18 which rides on the shaft 16. Since the resistor R should be substantially non-inductive, it preferably is of the carbon type. For example, it may consist of a ring 10 of insulating material such as a phenol condensation product which is impregnated throughout 180 degrees of its circumference with a resistance material as indicated by the stippled portion of the ring.

A volume control potentiometer constructed as described in the preceding paragraphs using a linear resistance potentiometer R and a Hammarlund straight line frequency capacitor C_2 (designed for 180 degree rotation) was found to be satisfactory although the plates of this capacitor were not exactly the correct shape as will be pointed out hereinafter.

In order to obtain uniform attenuation and phase shift at all frequencies for different potentiometer settings, there should be the following relation between the resistance and capacitive elements:

$$\frac{X_{ab}}{X_{bc}}=\frac{R_{ab}}{R_{bc}}$$

where

X_{ab}=reactance between points *a* and *b*
X_{bc}=reactance between points *b* and *c*
R_{ab}=resistance of R between points *a* and *b*
R_{bc}=resistance of R between points *b* and *c*

The reactances X_{ab} and X_{bc} are the reactances of capacitor C_2 and of capacity C_3 if distributed capacity across R is neglected. Preferably the potentiometer R is designed to have minimum distributed capacity. For this reason it may be desirable to have the resistance material for R on a linear support instead of on a circular one whereby the pointer 9 must be moved in a straight line instead of in a circular path. If the usual rotatable capacitor is employed for C_2 this will necessitate the use of a suitable mechanism for translating linear motion into circular motion.

In Fig. 3 the solid line curves show the way in which the capacity of C_2 should vary as the contact point 9 is moved along resistor R. Curves are shown assuming different values of tube capacity C_3, the solid line curves being calculated from the above equation. The dotted line curve shows how the capacity of the Hammarlund condenser in the previously described embodiment of the invention varied with different potentiometer settings. It will be seen that this condenser followed the theoretical curve closely when pointer 9 was in the middle region of R where the difference in the attenuation of high and low frequencies is the greatest providing a correcting capacitor C_2 is not used.

It will be understood that the capacity C_3 may include some capacity that has been added to the circuit so that changing tubes will have less effect upon the potentiometer adjustment. For example, the input capacity of a certain type of tube may be anywhere from 8 to 10 micro-microfarads. By connecting a 20 micro-microfarad condenser across the input electrodes of the tube 2, the percentage change in C_3 caused by a change in tubes is decreased.

Also it will be understood that the plates of capacitor C_2 may be shaped to compensate for distributed capacity across the resistor R.

While I have described the potentiometer R as being linear, it is apparent that it need not be linear so long as the capacitor C_2 is properly designed with respect to the potentiometer characteristic.

I claim as my invention:

1. A volume control device for supplying an electric discharge tube having input electrodes and a certain input capacity, said device comprising a resistor across which a signal is impressed, an adjustable contact point on said resistor, means for connecting across said input electrodes the portion of said resistor between said contact point and one end of said resistor, and a variable capacitor connected across the remaining portion of said resistor, said variable capacitor and said adjustable contact point being so mechanically connected that the capacity of said variable capacitor is increased in response to an increase in the resistance in the first-mentioned portion of said resistor, the ratio of said first-mentioned portion to said remaining portion being substantially equal to the ratio of the reactance of said input capacity to the reactance of said variable capacitor.

2. A volume control potentiometer comprising a resistor having a movable contact point thereon, a variable capacitor electrically connected between said contact point and one end of said resistor, and means for so mechanically connecting said capacitor and said contact point that the capacity of said capacitor is increased in response to said contact point being moved towards said end, said resistor and said movable contact point forming a substantially linear potentiometer and said capacitor having substantially a straight line frequency characteristic.

3. In an amplifier for amplifying signals covering a wide frequency band, an electric discharge tube having an output circuit, an electric discharge tube having input electrodes and a certain input capacity, a potentiometer resistor coupled across said output circuit, means for coupling said input electrodes across a portion of said resistor, a variable capacitor connected across the remaining portion of said resistor, means for varying the ratio of said first portion to said remaining portion, and means for increasing the capacity of said variable capacitor in response to an increase in said ratio, said last means so changing the capacity of said variable capacitor that the ratio of the resistance of said first portion to the resistance of said remaining portion is substantially equal to the ratio of the reactance of said input capacity to the reactance of said variable capacitor.

JOHN P. SMITH.