June 10, 1941. M. Z. MROZ 2,245,354

ELECTRICAL MUSICAL INSTRUMENT

Filed Dec. 8, 1938 2 Sheets-Sheet 1

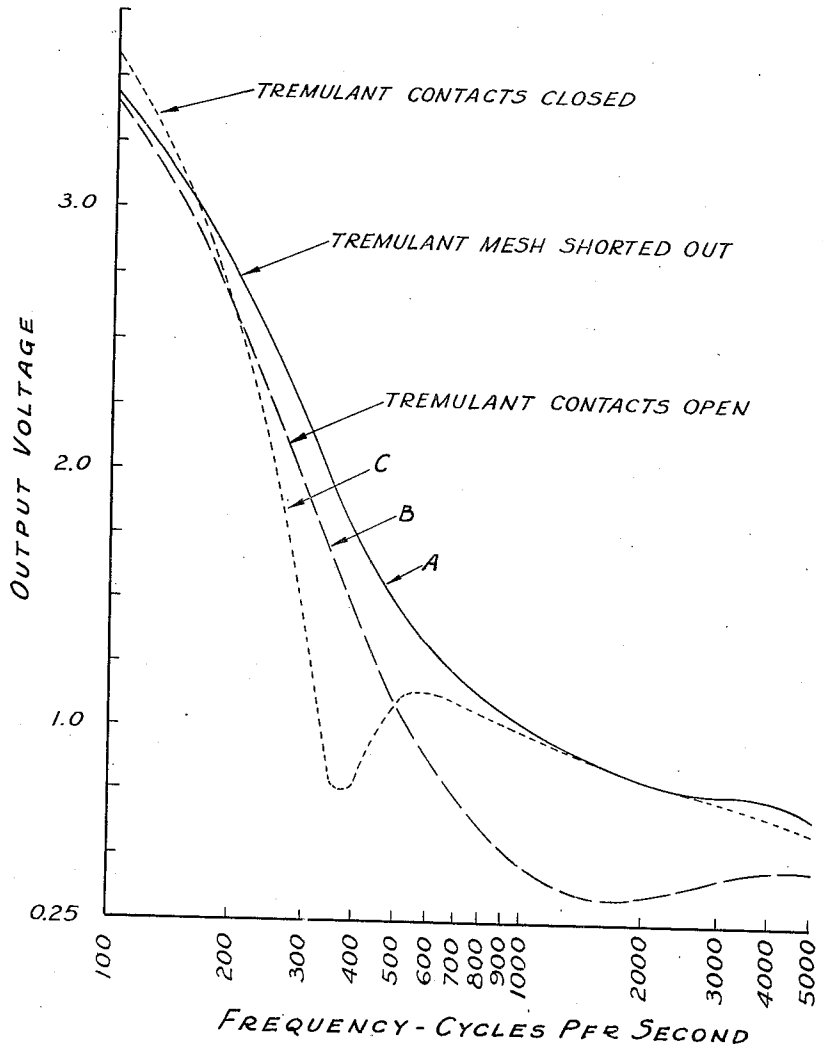


Fig. 1

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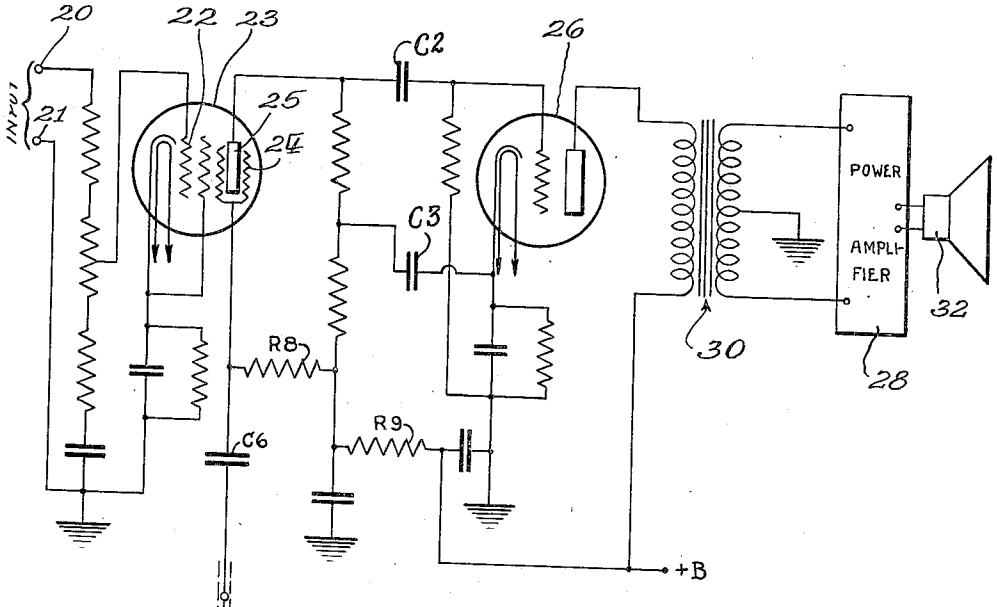
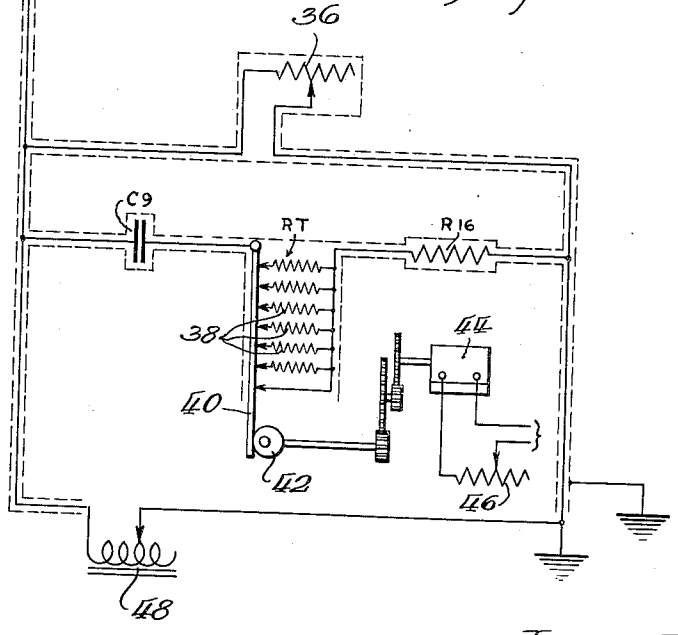


Fig 2



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UNITED STATES PATENT OFFICE

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ELECTRICAL MUSICAL INSTRUMENT

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6 Claims. (Cl. 84—1.25)

My invention relates generally to electrical musical instruments, and more particularly to improved apparatus for producing tremulant effects for such instruments.

Various types of apparatus have been utilized to produce a tremulant effect in the output of electrical musical instruments. Generally, such devices have comprised means for varying the impedance of the signal carrying circuit and thus were effective to cause amplitude modulation of the signal as a whole. In the amplitude modulation of a signal composed of a plurality of different frequencies, the modulation was substantially equally pronounced with respect to each of the frequencies. Such modulation of the signal produced an effect which was not entirely satisfactory when the instrument was played in an enclosure having adverse acoustical conditions.

In accordance with the principles of my invention, the tremulant effect is obtained in a novel manner whereby the amplitude modulation of the signal is not uniform throughout the frequency range of the instrument, but instead, takes place in such manner that the amplitude of one frequency may be increasing, while that of another frequency is decreasing. Stated in another way, the amplitude modulations of different frequencies are out of phase. This type of tremulant causes a continuous variation in the relative amplitudes of the component frequencies so that the musical effect approaches that of a vibrato, i. e., a periodic change in pitch, more closely than that of a customary tremulant.

It is thus an object of my invention to provide an improved tremulant circuit and apparatus for electrical musical instruments, in which the amplitude modulations of the different component frequencies of a signal are appreciably out of phase.

A further object is to provide a tremulant apparatus for electrical musical instruments capable of producing a signal containing a plurality of frequencies, which is periodically effective to cause some of the frequencies to increase in amplitude while causing other frequencies to decrease in amplitude.

A further object is to provide a tremulant apparatus for electrical musical instruments in which the effectiveness of the amplitude modulation is non-uniform throughout the frequency range of the instrument.

A further object is to provide an improved method of producing a tremulant effect in the output of electrical musical instruments.

Other objects will appear from the following description, reference being had to the accompanying drawings in which:

Figure 1 shows several instantaneous frequency response curves of the apparatus at different points in the tremulant cycle; and,

Figure 2 is a wiring diagram showing an exemplary form of apparatus or circuit which may be used to perform the method and accomplish the objects of the invention.

In electrical musical instruments such as the electric organ shown in the patent to Laurens Hammond, No. 1,956,350, granted April 24, 1934, the output circuit is designed to attenuate the high frequencies to a greater extent than the lower frequencies, for reasons fully described in said patent. The nature of the frequency responsive curve of the output circuit of such an organ is represented by the full line curve A of Figure 1. An ordinary tremulant apparatus or circuit in which the impedance of the output circuit is periodically varied, as by a cyclically variable resistance or potentiometer, does not cause any appreciable change in the general shape of this curve A, but merely causes it to be translated vertically, i. e., all of the different frequencies are similarly affected and all are increasing in amplitude during approximately one-half of the cycle, and decreasing in amplitude during the remaining portion of the tremulant cycle.

In accordance with the principles of my invention, the general shape of the response curve is being continuously changed by the tremulant apparatus so that the effect of the tremulant differs with the frequency of the signal. The variation is of such character that of two different frequencies included in the signal, the tremulant apparatus may cause amplitude modulation of one frequency in an increasing direction, while at the same time, another frequency is decreasing in amplitude, and vice versa. This effect is illustrated in Figure 1, wherein the dash-line curve B represents the response of the apparatus at one instant during the tremulant cycle, while the dotted line curve C represents the response of the output circuit at another instant of the tremulant cycle. The response curves of the output circuit at instants intermediate those represented by the curves B and C may lie intermediate the curves B and C, or may be of such shape as to cross the curves B or C, or both, at one or more points.

An examination of Figure 1 discloses that between the interval represented by the curves B and C, frequencies below 200 cycles are, on the average, progressively increasing in amplitude;

frequencies from about 200 to approximately 500 cycles are, in general, decreasing in amplitude; and frequencies above 500 cycles are generally increasing in amplitude.

The curves B and C are merely illustrative of the response curves which may be obtained by any suitable mesh placed in the output circuit of the instrument in which one or more of the impedances are periodically varied at a tremulant rate. In fact, the curves B and C are representative of the response which may be obtained by a relatively simple network including the variable impedance. If a more complicated network were employed, the response curves would be more irregular than those which are represented by the curves B and C, that is, they would have a greater number of peaks and valleys, and it will ordinarily be desirable to provide a network which will result in response curves which in this respect are more irregular than the curves B and C.

The musical result obtained by thus varying the response curve of the output circuit periodically at a tremulant periodicity is sensed rather as an indefinable richness in the tone than as an ordinary tremulant, which latter is usually perceived as a periodic change in amplitude. This is due to the fact that the effect more closely approaches that of a vibrato than that of a tremulant.

As the impedance of one of the elements of the complicated network in the output circuit is changed, the peaks of maximum response shift from frequency to frequency, and thus, if there is a wide range of frequencies present in the output signal, the effect upon the ear will be that of a frequency shift rather than a change in amplitude. Of course the changes take place at the periodicity of the usual tremulant in the order of 7 C. P. S. As a result, there are so many changes in amplitude, some frequencies increasing and others decreasing, that the ear is unable to follow the individual changes, but instead, hears the composite effect and perceives it more as a qualitative change in the tone than as a change in amplitude.

The changes in the frequency response of the output circuit may be accomplished in a great many different ways by any one of a nearly infinite variety of networks connected in various ways in the output circuit of the instrument. The principles underlying the design of such networks are well understood, and since reference may be had to various texts on the subject, it is unnecessary herein to set forth these principles or to elaborate upon the various circuits in which the structural features of the invention may be embodied or by which the method of the invention may be performed.

As a specific example of one form in which the invention may be embodied, reference may be had to the diagram of Figure 2.

In Figure 2, the signal, usually composed of a plurality of different frequencies, upon which the tremulant is to be impressed, is supplied to input terminals **20**, **21**. While the tremulant apparatus may be used for various types of electrical musical instruments, it is particularly designed for use in connection with electric organs, such as the type disclosed in the aforesaid Patent No. 1,956,350.

The relatively low voltage signal supplied by such instrument to the input terminals **20**, **21** of a preamplifier may be impressed upon the input circuit including the grid **22** of a pentode **23** forming the first stage of the preamplifier. The screen **24** of the tube **23** is connected to a source of plate potential indicated as +B through a voltage dropping resistor R8 and resistor R9. The plate **25** of the tube **23** has its output circuit resistance-coupled to the input circuit of tube **26**, suitable blocking condensers C2 and C3 being provided in the input circuit thereof. The tube **26** forms the second sage of the preamplifier, while the output of the tube **26** is coupled with a power amplifier **28** by a transformer **30**. The power amplifier **28** supplies one or more loud speakers **32**.

Assuming a sustained signal of constant amplitude supplied to the input terminals **20**, **21**, the tone produced by the loud speaker **32** would be of constant quality and intensity. In accordance with the present invention, however, an additional circuit affecting the potential of the screen grid **24** of the tube **23** is provided. This circuit, when rendered effective, periodically changes the impedance of a circuit connecting the screen grid to ground, at a tremulant rate, in the order of 6 or 7 C. P. S.

The tremulant apparatus is connected to the screen **24** through a blocking condenser C6 which may have a value of .1 microfarads, throuh a conductor **34**. The conductor **34** is connected to ground through three parallel circuits, the first of which comprises a variable resistance **36** by means of which the degree of effectiveness of the tremulant is controlled. This resistance may be in the order of 0—100,000 ohms, and will, of course, effestively ground the conductor **34** when it is adjusted to its minimum resistance.

The second of the parallel circuits connecting conductor **34** to ground includes a condenser C9 which may have a value in the order of .0045 microfarads, and which is in series with a variable resistance RT and a fixed resistance R16, which latter may have a value of approximately 1200 ohms. The variable resistance RT is changed from zero to maximum value periodically at a tremulant rate in the order of 6 or 7 C. P. S., and is diagrammatically illustrated as comprising a plurality of resistors **38** which are adapted to be progressively connected in the circuit, and disconnected therefrom, by a bus bar **40** which is oscillated by a continuously rotating eccentric **42**. The eccentric **42** is driven through a suitable speed reducing gearing from a motor **44**, the speed of which may be controlled by a variable resistance **46** in its power supply circuit.

The third of the parallel circuits connecting the conductor **34** to ground includes an inductance **48** which may have a value in the order of 250 henries. This inductance may, if desired, be adjustable, although in most instances it will be preferable to have it of fixed value.

Assuming that a signal containing a large number of frequencies is impressed upon the input terminals **20**, **21** of the preamplifier, and that the variable resistance **36** is adjusted to an intermediate value, the tremulant resistance RT, as it is varied between its maximum and minimum values, will vary the effective impedance of the circuit by which the screen **24** of the tube **23** is connected to ground. The inductance **48** is of such value that it will offer very little impedance to the lowermost frequencies, and as a result, the gain of the tube **23** will be at its maximum with respect to the lower bass notes which will not be very greatly affected by the tremulant apparatus. The choke **48**, does, however, offer appreciable impedance to the higher frequencies so that the

latter are modulated by the varying tremulant resistance RT, and a pronounced tremulant is therefore impressed upon frequencies in the treble register. The modulation is of course effected by the variation in gain of the amplifier tube 23, since, when the impedance of the circuit connecting the screen and ground is low, the gain of the tube will be high, whereas, when the impedance of this circuit is high, the gain of the tube will be low. It will be readily apparent that by choosing an inductance 48 and a condenser C9 of proper values, the frequency response of the network, and hence of the amplifier as a whole, may be made to follow substantially any desired pattern. By utilizing a more complicated network, the frequency response of the apparatus may be made more irregular. The circuit may thus be made to produce results which appear to be most desirable from the point of view of the musician.

While I have shown the condenser C9 connected in parallel with the inductance 48, it will be readily apparent to those skilled in the art that the condenser C9 may be placed in series with the inductance 48 instead of in series with the tremulant resistor RT and resistance R16.

Using the circuit and apparatus shown in Figure 2, the frequency response of the output circuit has been determined and found to follow the curves shown in Figure 1, the curve B representing the response when the tremulant contacts RT are open, while the curve C represents the response when the tremulant contacts are closed. It will thus be seen that the relatively simple network of Figure 2 produces comparatively regular response curves. Since to a certain extent it is desirable to have a frequency response represented by curves with a larger number of peaks and valleys than are found in the curves B and C, it will be apparent that in most instances it will be desirable to provide a more complicated network than that shown in Figure 2. Furthermore, the network may be associated with the output circuit in other ways than in the screen circuit, and it will be apparent to those skilled in the art that the tremulant network may, in the form in which it is shown, or in other forms, be associated with other elements of the output circuit such as the suppressor grid of one of the amplifying tubes, the control grid through a degenerative feedback circuit, or in connection with other elements of the output circuit. The method of my invention may therefore be performed by using any one of a large variety of different circuits and apparatus.

While I have shown a particular embodiment of my invention, it will be apparent to those skilled in the art that numerous modifications and variations may be made without departing from the underlying principles of my invention. I therefore desire by the following claims to include within the scope of my invention, all such equivalent methods, apparatus, and circuits, whereby substantially the results of my invention may be obtained in substantially the same way or by substantially the same means.

I claim:

1. In an electrical musical instrument in which the electrical signals are amplified by a multielectrode electron discharge device having a screen grid and translated into sound, means for producing a tremulant effect comprising a network connecting said screen to a point of fixed potential, said network including inductive and capacitative reactances, and a variable resistance, and means for varying said resistance at a tremulant periodicity.

2. The combination set forth in claim 1 in which said screen is connected to said point of fixed potential by an additional manually adjustable variable resistance.

3. The combination set forth in claim 1 in which said network includes two parallel circuits connecting said screen and said point of fixed potential, one of said parallel circuits including a condenser and a periodically varying resistance, and the other of said parallel circuits including an inductance.

4. The combination set forth in claim 1 in which said network includes three parallel circuits connecting said screen grid to said point of fixed potential, and in which the first of said parallel circuits includes a manually adjustable resistance, the second of said circuits includes a condenser and periodically varying resistance in series, and the third of said circuits includes an inductance.

5. The combination set forth in claim 1 in which said network comprises a periodically varying impedance of average value which is relatively high for signals of high musical frequency, and a circuit shunting said impedance and including an inductance offering no appreciable impedance to signals of low musical frequency.

6. In an electrical musical instrument in which the electrical signals are amplified by a multielectrode electron discharge device having an electrode the potential of which determines the degree of amplification of the device, and in which the amplified signal is translated into sound, means for producing a tremulant effect comprising, a network connecting said electrode to a point of fixed potential, said network including inductive and capacitive reactances and a variable resistance, and means for varying said resistance at a tremulant periodicity.

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