April 28, 1942. L. HAMMOND 2,281,495

FREQUENCY GENERATOR

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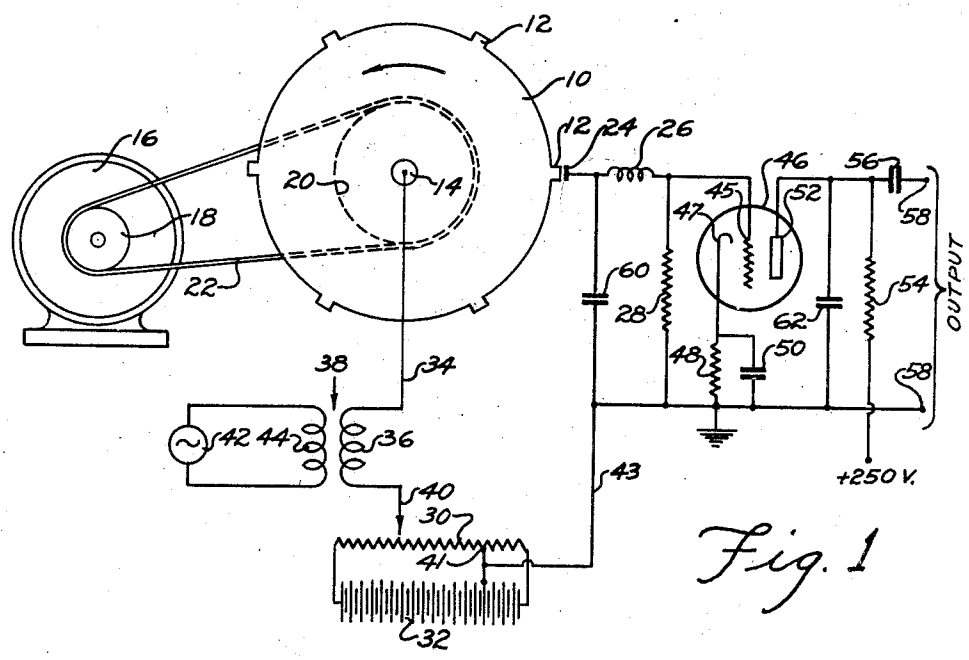

Fig. 1

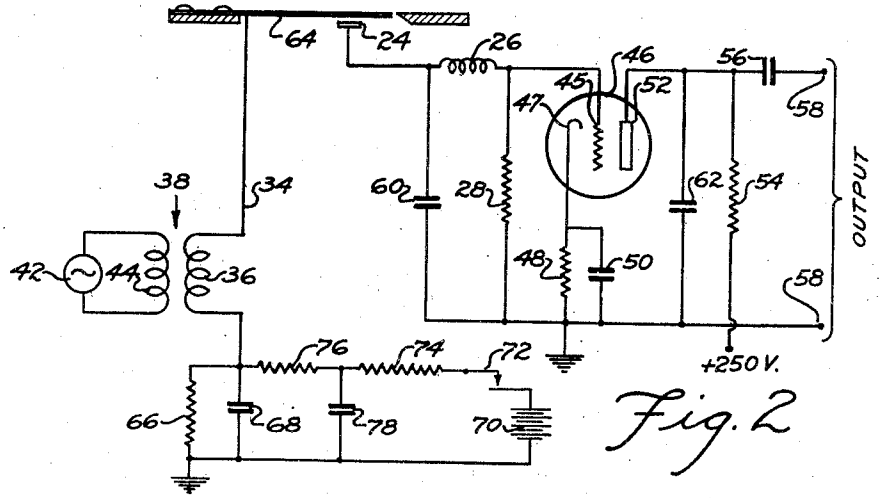

Fig. 2

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FREQUENCY GENERATOR

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7 Claims. (Cl. 175—363)

My invention relates generally to electrical frequency generating means, and more particularly to electrostatic or varying capacity oscillation generators.

In endeavoring to generate electrical oscillations by means of a continuously varying capacitor which is polarized by applying a direct current potential thereto, it has been found that upon removal of the polarizing potential, the generator continues to supply an unwanted signal at a relatively low level. If the generator is to be used for any purpose which has as a requisite condition that the signal cease upon removal of the polarizing potential, as is the case when the generator is to be used as a signal source for an electrical musical instrument, such continued generation of the signal makes the use of the generator undesirable.

Apparently the continued sounding of the signal after the removal of the polarizing potential is due to a residual potential or polarization present in the generating system. However, this residual potential is not a constant potential for which compensation can be made by polarizing the generator in the opposite direction. In fact, not only is there a variation in the polarizing potential which is found necessary to compensate for or cancel the residual polarization, but sometimes it is necessary to apply to the generator a positive potential while at other times a negative potential must be applied to accomplish such cancellation. The action of the generator is, in this respect, so erratic in its operation from day to day, due possibly to changes in atmospheric conditions, that it has been found to be impractical to endeavor to provide means for cancelling the residual polarization of the generator in this manner.

It has been suggested that this residual polarization of the generator is due to the contact potentials at the points of connection between different metals used in the generator circuit. However, such theory does not appear fully to explain the presence of the residual potential since, if it were due to this contact potential effect, it would be expected that the direction of polarization would be the same at all times.

It is therefore my theory, although I know of no means for making quantitative determinations to prove its correctness, that the residual potential is due to the presence of a dielectric, other than fluid air, between the metallic parts which move relative to one another to form the varying capacitor or electrostatic generator. This dielectric may possibly be in the form of an extremely thin and irregular film of oil which cannot be removed from the metallic parts by washing in the usual solvents, or may be a film of gas adhering to the metallic surfaces. Another possibility is that the dielectric is formed by an extremely thin layer of a metallic oxide, or by particles of dust or other dielectric material adhering to the metallic surfaces.

I have discovered that this disadvantageous effect due to residual polarization of the generator may be substantially completely removed by applying locally to the electrodes of the varying capacitor or electrostatic generator, a high frequency potential such as that supplied by a radio frequency oscillator.

It is therefore a primary object of my invention to provide an improved varying capacitor or electrostatic frequency generator which will cease supplying a signal upon removal of the polarizing potential applied thereto.

A further object is to provide an improved frequency generating means in which the amplitude of the output may readily and consistently be varied from its maximum value to zero by controlling the value of the direct current polarizing potential applied thereto.

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

Figure 1 is a diagrammatic view of a rotary type electrostatic generator or variable capacitance and associated circuits; and,

Figure 2 is a diagrammatic view of an electrostatic frequency generator of the vibrating reed type with associated circuits.

Referring to Figure 1, the generator comprises a disc or wheel 10 of metal having a plurality of salient projections or teeth 12. The wheel 10 is secured to a shaft 14 which is driven from a suitable source of power 16 by driving means such as pulleys 18 and 20 and belt 22.

An electrode 24 of metal is located closely adjacent the path of movement of the ends of the teeth 12, the wheel 10 of the electrode 24 forming the plates of a condenser, the capacity of which is varied through a considerable range as the wheel 10 is rotated due to the change in distance between the electrode 24 and the peripheral edge of the wheel 10. The electrode 24 is effectively maintained at ground potential through a circuit consisting of a radio frequency choke coil 26, and a grid resistor 28. The potential of the wheel, which is electrically connected to the shaft 14, may be made positive or negative with respect to ground, by connection to a potentiom-

eter resistance 30 connected across a direct current potential source 32. The connection is made through a conductor 34, the secondary winding 36 of a transformer 38, and a contactor 40 which may be brought into contact with the potentiometer resistance 30 at any point along the length thereof. An intermediate point 41 on the resistance 30 is grounded through a conductor 43.

A source 42 of high frequency oscillations, which may be in the form of a radio frequency vacuum tube oscillator, has its output connected to the primary 44 of the transformer 38, and thus, when in operation, may superimpose high frequency oscillations upon the polarizing potential applied between the wheel 10 and electrode 24. The varying capacity between the wheel 10 and electrode 24 causes a voltage change which is impressed upon the grid 45 of an amplifying electron discharge device 46, the cathode 47 of which is connected to ground through a self-biasing resistor 48 by-passed by a condenser 50. The plate 52 is connected to a suitable source of plate current indicated as a terminal +250 V. through a load resistor 54. A blocking condenser 56 is connected between the plate 52 and one of two output terminals 58, the other terminal 58 being connected to ground.

A small radio frequency by-pass condenser 60 is connected between the electrode 24 and ground, this condenser together with the R. F. choke 26 forming a filter to prevent radio frequency from being impressed upon the grid 45. A further small by-pass condenser 62 is connected between the plate 52 and ground to remove the radio frequency from the output of the tube 46. It will be understood that the frequency of the generator 42, if not at a radio frequency, is preferably of sufficiently higher frequency than that generated by the wheel 10, that it may be substantially completely filtered from the output of the generator by the choke 26, condenser 60 and condenser 62.

In Figure 2, the invention is illustrated diagrammatically as applied to a vibrating reed type generator comprising a suitably supported metallic reed 64 which vibrates in close proximity to an electrode 24. The reed may be of the free-free type and energized by air under pressure on one side thereof, or in any other suitable manner. It will be understood that the reed 64 of Fig. 2 corresponds to the wheel 10 and its projections 12 of Fig. 1. Such of the ele ents of the circuit of Fig. 2 which are counterparts of elements of Fig. 1, have reference characters applied thereto corresponding to those applied to the similar elements of the previously described circuit of Fig. 1.

The circuits of Fig. 2 are similar to those shown in Fig. 1 except for the circuit for controlling the application of the direct current polarizing potential to the varying capacitor consisting of the reed 64 and its pickup electrode 24. This circuit includes a high resistance 66 connecting the reed 64 to ground through the secondary 36, the value of the resistance being such as to permit discharge of a condenser 68, which is in parallel therewith, at a predetermined slow rate.

The condenser 68 is charged from a source 70 of direct current potential upon closure of a key operated switch 72, the rate of charging being controlled by series resistors 74 and 76 and a condenser 78 which connects the junction of resistors 74 and 76 to ground. When the switch 72 is closed, the polarizing potential on the reed 64 builds up gradually, as condensers 78 and 68 are charged through the resistor 74, and resistors 74 and 76 respectively. The signal at the output terminal will thus have a gradual attack.

Upon opening the switch 72, the polarizing potential will drop gradually at a rate determined by the discharge of condensers 78 and 68 through the resistor 66. The resistors 74 and 76 are preferably of considerably lower value than the resistor 66. Thus, the resistor 76 will not have an appreciable effect upon the rate at which these condensers discharge. As a result of the gradual discharge of the condensers, the signal at the output terminals 58 will decay gradually. It will be apparent that the attack and decay rates may be predetermined by proper selection of the values for the resistors, 66, 74 and 76 and of the capacities of condensers 68, 78.

A circuit arrangement of the type shown in Fig. 2 is particularly useful when the frequency generator is used as a source of tone frequency in an electrical musical instrument.

Assume that the wheel 10 is being rotated (or the reed 64 continuously vibrated), and the slider 40 is brought into contact with the resistor 30 at a point having a considerable potential difference with respect to ground (or the switch 72 closed). This polarizing potential thus impressed between the wheel 10 (or reed 64) and electrode 24 will be modulated due to the changes in the capacity between these elements caused by rotation of the salient projections 12 past the electrode 24 (or vibration of reed 64 toward and away from electrode 24). The resultant voltage change on the electrode 24 will be of a relatively small value, and will be amplified by the electron discharge device 46 so as to appear across the output terminals 58 at a useful amplitude.

Assuming for a moment that the high frequency generator 42 is not in operation, upon connecting the contactor 40 to a point 41 on the resistance 30 which is at ground potential, it might be taken for granted that the signal generated by the apparatus would cease, since theoretically the wheel 10 and electrode 24 would be at the same potential. It is found, however, that this is not the case, but that under these circumstances the signal will continue at a relatively low amplitude, but at sufficient amplitude to make the generator undesirable for purposes which require that the signal be completely cut off upon removal of the polarizing potential. This continued generation of the signal is due to the presence of what I, for convenience, refer to as a "residual potential" or "residual polarization" between the wheel 10 and electrode 24. Furthermore, it will be found that this residual potential can, in each instance, be removed by adjusting the sliding contactor 40 to some position on the resistance 30 other than a point at ground potential. However, there is no definite potential which will always be effective to neutralize or compensate for this residual potential. Sometimes a neutralizing or compensating potential which is positive with respect to ground, and at other times a neutralizing potential which is negative with respect to ground, may be required to cause the generator output to drop to zero value.

When, however, the generator 42 is rendered operative to superimpose a high frequency voltage upon the direct current polarizing potential, it is found that the residual potential effect disappears as soon as the sliding contactor 40 is connected to a point of ground potential. Thus, by virtue of the superposition of the radio frequency upon the polarizing potential, the gener-

ator may be easily and reliably controlled to cause it to discontinue generating the signal whenever desired.

As above intimated, I have been unable to determine, with any degree of certainty, the exact cause of the residual polarization of the generator. It may be caused by a minute film of oil, metallic oxide, or adsorbed gas on the wheel 10, or on its electrode 24, or on both. Or particles of dust or other foreign matter may adhere to the wheel or electrode. The effect appears to be less pronounced as the atmospheric humidity increases. If, as I believe, the effect is due to the presence of a dielectric film or dielectric particles on the wheel or electrode, it would be expected that increased humidity would render the dielectric less effective to retain a residual polarizing potential.

It is within the realm of possibility that the residual polarization is due to the contact potential between the different metals, included in the polarizing circuit, but this explanation of the phenomenon appears to be less likely to be correct than that set forth in the preceding paragraph.

The amplitude of the high frequency voltage supplied by the oscillatory generator 42 need not be very great, but only sufficient to exceed by a reasonable margin the residual potential under the most adverse conditions of operation. In practice, however, the alternating voltage supplied by the generator 42 may be relatively high, since its effect is confined to the generator circuit because the high frequency is filtered from the output circuit.

In so far as indicated by my experiments with this type of apparatus, the high frequency voltage supplied by the generator 42 may be impressed across the capacitor either in the circuit between the wheel (reed) and ground, or in the circuit between the electrode and ground, or may be impressed directly upon the capacitor by induction. The essence of the method of eliminating the undesired residual polarizing potential is that a high frequency alternating voltage be present between the two capacitor parts at the time the polarizing potential is removed.

The generator may be used as a frequency source for electrical musical instruments or any other purpose for which a signal of determinable frequency and readily controllable amplitude may be found to be desirable.

While I have shown and described a particular embodiment of my invention, it will be apparent to those skilled in the art that numerous modifications and variations may be made in the form and construction thereof, without departing from the more fundamental principles of invention. I therefore desire, by the following claims, to include within the scope of my invention all such similar and modified forms of the apparatus disclosed, by which substantially the results of the invention may be obtained by substantially the same or equivalent means.

I claim:

1. In an electrical signal generator, the combination of a varying capacitor, means to derive a signal from said capacitor, a source of direct current, means to connect said source across said capacitor to polarize the latter, a high frequency generator, and a circuit for superimposing high frequency voltage from said generator upon the polarizing potential impressed upon said capacitor.

2. In an electrical signal generator, the combination of a varying capacitor having a moving part and a fixed part, means for applying a polarizing potential across said capacitor parts, means for deriving a signal from said capacitor due to changes in capacitance caused by the movement of one of said parts relative to the other, a generator of high frequency oscillations, and a circuit for impressing oscillations from said generator across said parts, thereby to eliminate residual polarizing potential across said parts upon removal of the polarizing potential thereon.

3. A device for originating an electrical wave, comprising a variable condenser, means to operate said condenser to cause periodic variations in its capacity, means operable at will to impress a direct current polarizing potential on said condenser, and means to eliminate any residual polarizing potential which may remain on said condenser after the direct current polarizing potential is removed, comprising a source of high frequency electrical oscillations, and a circuit for impressing oscillations from said source upon said condenser.

4. In an electrical signal generator, the combination of a varying capacitor having relatively moving parts separated by a dielectric, means for applying a polarizing direct current potential across said capacitor parts, means for deriving a signal from said capacitor due to changes in capacitance caused by the relative movement of said parts, a source of high frequency oscillations, and a circuit for impressing oscillations from said source across said parts, thereby to eliminate residual polarizing potentials across said parts upon disconnection of the polarizing potential therefrom.

5. In an electrical signal generator, the combination of a varying capacity generator, a signal output circuit therefor, a source of direct current, means to connect said source across said generator to energize the latter, a high frequency voltage source, and a circuit for continuously impressing a high frequency voltage from said latter source across said generator.

6. The method of removing the residual potential from an electrostatic generator which is polarized by the application of a direct current potential thereto, which comprises applying a high frequency alternating voltage to the generator, and filtering the high frequency voltage from the output of the generator.

7. The method of removing the residual polarization from a varying capacity type generator which is polarized at intervals by the application of a direct current potential thereto, which comprises continuously applying a high frequency alternating voltage to the generator.

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