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ELECTRONIC CHIME SYSTEM

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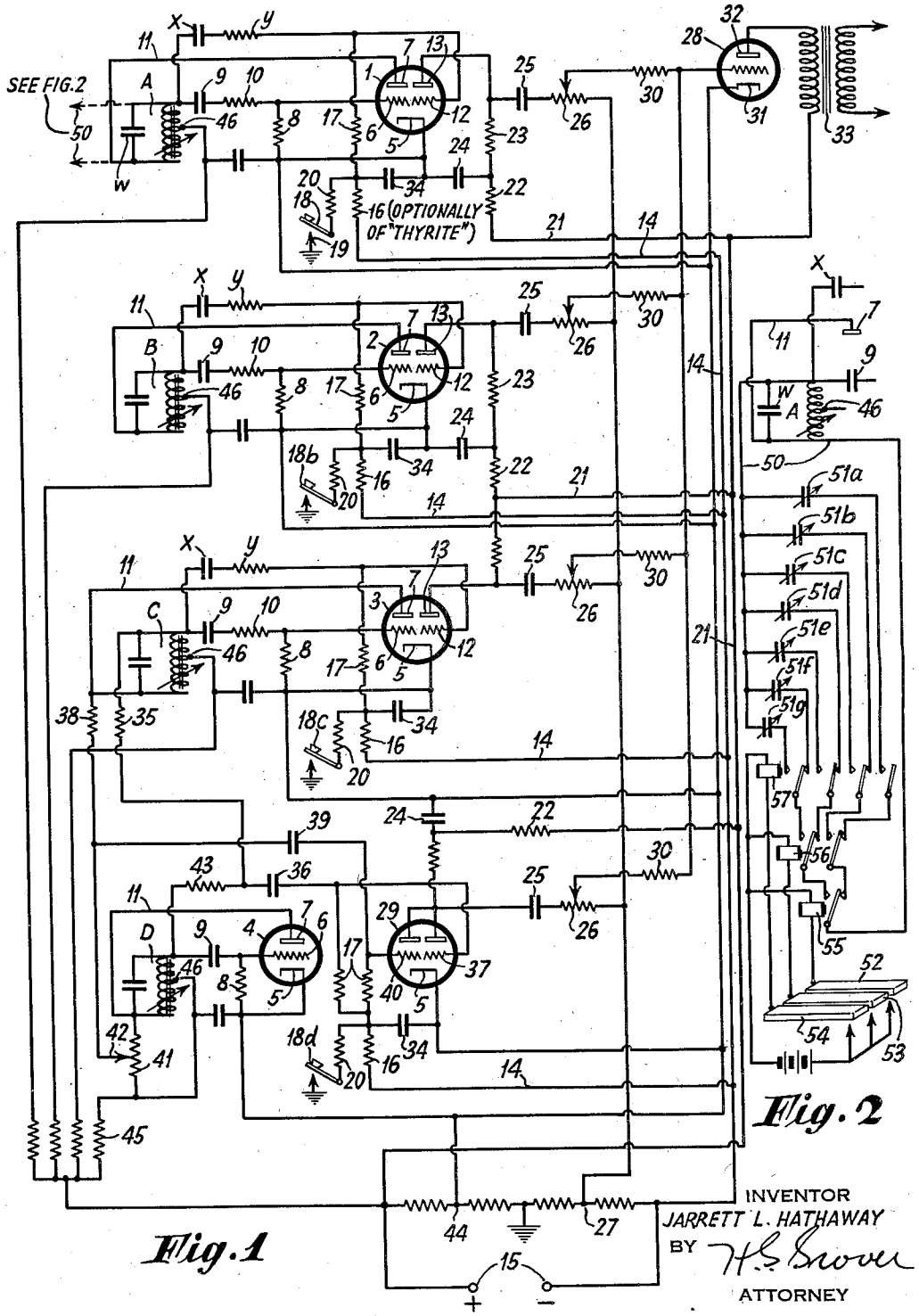


Fig. 1

Fig. 2

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ELECTRONIC CHIME SYSTEM

Jarrett L. Hathaway, Manhasset, N. Y., assignor to Radio Corporation of America, a corporation of Delaware

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11 Claims. (Cl. 84—1.26)

This invention relates to an electronic chime system and more particularly to improvements in apparatus and methods for producing the simulation of chime tones electronically.

It is an object of my invention to provide an electronic chime system wherein several discharge tube oscillators are electrically tuned and are available for producing certain fundamental tone frequencies to be utilized either separately or in mixtures for the simulation of chime tones.

It is another object of my invention to provide an electronic chime system, the electronic oscillators in which possess exceptionally good frequency stability.

It is another object of my invention to devise an electronic chime system in which several fundamental frequency oscillators are available for producing output energy which is rich in harmonics, this energy being preferably combined to produce composite tones for the simulation of chimes or large bells.

Other objects of my invention will be made manifest in the detailed description to follow.

In carrying out my invention I have found it desirable to provide a plurality of tuned circuit oscillators each in combination with an amplifier. The amplifier is normally held at a cut-off bias until the note of the associated oscillator is to be sounded. At this time the bias is suddenly dropped by means of a contact to a voltage where amplification occurs. After breaking said contact the bias is caused to slowly increase until cut-off is again reached. During this slow change in the bias the effect upon the output of the amplifier is one of gradual decay which very nicely simulates the diminuendo effect of a chime tone after the chime has been struck.

As will be observed in the more detailed description to follow, it is possible in carrying out my invention to combine the outputs of two or more oscillators for producing composite tones which may or may not be harmonically related to one another. When the frequency relation between the oscillators departs slightly from an integral ratio, beat-notes occur which are commonly noticed in the striking of large chimes and bells.

The details of my invention will be best understood upon reference to the accompanying drawing, in which

Figure 1 shows in combination a plurality of oscillator circuits and associated amplifier circuits together with means for sounding the chime tones at will in any desired order, and in further combination with time constant devices, whereby the chime tones may be sustained for a desirable period, and

Fig. 2 shows a fragmentary portion of the complete circuit as modified.

Included in the circuit arrangements also are devices for controlling the "attack" or build-up period to full volume of each tone as struck.

Referring to the drawing, I show therein four tuned circuits A, B, C and D. Each of these tuned circuits consists preferably of a capacitor and a variable iron core inductance. Variability of the tuning I have found to be conveniently accomplished by means of an iron screw threaded into a non-magnetic supporting member so as to be adjustably brought into the magnetic field of the inductance. By this arrangement it is possible to obtain very accurate tuning to a desired audible frequency, since it is only necessary to adjust the air gap between the inner end of the screw and the inductance.

The tuned circuits A, B, C and D are respectively associated with oscillator electrodes in each of four electron discharge tubes 1, 2, 3 and 4, respectively. The tubes 1, 2 and 3 are shown as twin triodes, whereas tube 4 is shown as a single triode. The oscillator electrodes of the tubes 1, 2, 3 and 4 include a cathode 5, a control grid 6 and an anode 7. The grid 6 is self-biased with respect to the cathode by means of a grid bias resistor 8. Each tuned circuit A, B and C is coupled across a capacitor 9 and resistor 10 to its associated oscillator tube input circuit. A feed-back connection 11 is shown interconnecting the anode 7 with one end of the tuned circuit. The complete oscillator circuit as shown is one which produces a sine wave. Output energy from the oscillator is available across the coupling condenser x and resistor y for controlling the grid 12 in the amplifier section of each of the twin triode tubes 1, 2 and 3. This amplifier section includes also an anode 13. The amplifier section is biased to cut-off by virtue of a negative potential applied through the conductor 14 from a direct current potential source 15. Two resistors 16 and 17 of relatively high value are interposed between the negative terminal of the direct current source 15 and the grid 12.

The cathodes of all of the discharge tubes shown in the circuit arrangement are carried at a common potential which is derived from a tap 44 slightly above ground potential on the potentiometer shown directly above the source 15. Anode potential is supplied from the source 15 through several resistors 45 to respectively different taps 46 on the inductance windings of the tuned circuits A, B, C and D.

Means are provided for suddenly reducing the bias on the grid 12. Such means are illustrated herein as a key 18 having a grounded contact 19 for feeding ground potential through a resistor 20 and thence to the junction point between the resistors 16 and 17.

My system includes means for controlling the

decay period after the initial build-up or "attack" has reached maximum amplitude. The decay period is mainly controlled by the time required for the bias voltage on the grid 12 to build up to the cut-off value as determined by the time constant of condenser 34 and resistor 16. However, a change of shape of the decay curve can be brought about by the use of condenser 24 and resistor 22 in the output circuit. It will be observed that the amplifier output circuit is fed with positive potential from the source 15 through conductor 21, resistors 22 and 23 to the anode 13. Resistor 22 has a value of about 1 megohm, whereas resistor 23 is of the order of 50,000 ohms. The junction point between the two resistors 22 and 23 is coupled across a capacitor 24 to the cathode. The capacitor 24 is preferably of the order of 1 mfd. This condenser is normally charged to full anode voltage while the tube is at cut-off. When the bias is suddenly dropped by closing the key 18 this condenser 24 is discharged because of the anode current flow. Thus a high peak output occurs after the initial closing of the key, but the level drops rapidly due to the loss of charge on the capacitor 24 while the grid bias increases. The output may be taken off by the coupling condenser 25 leading to a potentiometer 26 and thence to a point of suitable negative bias potential 27 on a potentiometer, the several sections of which are shown immediately over the terminals of the source 15. The voltage of the potentiometer tap 27 is chosen as one suitable for biasing the amplifier tube 28 which receives control energy from the amplifier section of each of the tubes 1, 2, 3 and 29. The function of the tube 29 will be explained hereinafter. Each of the potentiometers 26 is provided with an adjustable tap feeding across an impedance 30 to the control grid of tube 28. The output circuit of the tube 28 is shown including a cathode 31, an anode 32 and the primary winding of the transformer 33, this primary being fed with positive potential from the source 15.

The two notes which may be selectively struck at will by closing either of the keys 18 and 18_b result from the operation of the duplicate circuit arrangements shown in connection with tuned circuits A and B. These circuit arrangements are identical except for the values of certain components by which the tone frequency of the oscillator is determined. This time constant of the "attack" depends upon the use of a capacitor 34 of preferably 4 mfd., and a resistor 20 of about 1500 ohms.

The circuit arrangement for striking the third chime tone is similar in most respects to those for the first two chime tones. The third circuit associated with the tuned circuit C is, however, arranged not only to supply its fundamental tone across the amplifier section of the tube 3 in response to the closure of the key 18_c, but the oscillator portion of this circuit arrangement is also available for supplying its tonal frequency to the fourth section of my electronic chime system. Connections are made, therefore, through the upper end of the tuned circuit C, through a resistor 35 to a coupling condenser 36 and thence to a control grid 37 in the twin triode tube 29. The lower end of the tuned circuit C is connected across a resistor 38 and a capacitor 39 to the control grid 40 in the twin triode tube 29.

Both sides of the twin triode tube 29 serve as amplifiers for a composite chime tone as developed in the oscillators with which the tuned circuits C and D are associated. The oscillator tube 4 in combination with the tuned circuit D develops an audio frequency output which is fed across the potentiometer 41. This potentiometer has an adjustable tap 42 leading to the coupling condenser 39 so that the grid 40 in the tube 29 may be jointly controlled by the respective outputs from the oscillator portion of the tube 3 and the oscillator tube 4. The resistor 43 in circuit between the tuned circuit D and the coupling condenser 36 is effectively in a branch circuit with the aforementioned resistor 35.

In the operation of each of the four sections of my improved electronic chime system the keys 18, 18_b, 18_c and 18_d are respectively momentarily closed in any desired sequence. With each key closure the bias on the amplifier section of the associated tube is reduced to a value where the tube draws current and amplification occurs. The time delay in building up the amplitude of the output oscillations is determined by the respective values of the condensers 34, etc., in combination with their associated resistors. The restoration of the negative bias on the amplifier tubes by gradual build-up of a charge on the capacitors 24 through resistors 16 is one which determines the decay period of the output from each amplifier tube and thus the duration of the chime tone is determined. Each of the chime tones as delivered to the input circuit for the tube 28 is amplified and transmitted across the transformer 33 to any suitable utilization device (not shown).

The curve of the decay characteristic can be modified by the use of a so-called "Thyrite" resistor in place of the resistor 16. The material of which such a resistor is composed, as is well known, is such that it possesses a non-linear voltage-resistance characteristic. After opening the key 18 the output from the amplifier tube 1 would then drop more abruptly in amplitude than in the case where the resistor 16 is linear in its characteristic, assuming a fixed total decay time.

In cases where the sound of bells is to be simulated the important fundamental tones which are to be combined are derivable from two or more oscillators, as shown, for example, in the third and fourth sections of the system above described. In certain cases, however, it may be desirable to employ a plurality of amplifier tubes in order to obtain a proper mixing of the tone frequencies without cross-modulation effects, such as might result from feeding several tones to a single mixer tube.

The circuit constants of the fourth section of my chime system, including the tubes 4 and 29, are preferably such as to develop composite tones simulating the hour striking chime in a tower clock.

In the production of bell-like tones it is found desirable to amplify second harmonics of at least two fundamental tones and combine them so that miscellaneous other harmonic and combination tones serve to create a striking impact relatively high in pitch, which decays relatively fast. A low frequency tone then persists, sounding similar to the hum frequency of a bell. This second harmonic accentuation and fundamental cancellation is adjusted for the lower frequency tone from oscilaltor 4 by means of potentiometer 42, as shown.

Referring to Fig. 2, I show therein a control system which may readily be added to any of the tuned circuits A, B, C and D. Illustrative connections to the tuned circuit A are indicated in

Fig. 1 by the dotted lines 50. In Fig. 2, however, the tuned circuit A is shown having a choice of parallel condensers 51_a, 51_b, etc., which are selectively connectable to the tank circuit A for purposes of changing the oscillator frequency. Any number of these condensers $51_a \ldots 51_g$ may be provided but, by way of example, I have shown seven of them which would be sufficient for pre-adjusting the oscillator frequency to any one of the eight notes in a musical scale. Each of the condensers $51_a \ldots 51_g$ is adjustable to provide an additional capacitance which, in parallel with the condenser *w* of the tank circuit A, would tune the oscillator to one of the notes of a musical scale.

In order to select different ones of the condensers $51_a \ldots 51_g$ to be connected in parallel with the condenser *w*, it is preferable to provide a set of keys 52, 53 and 54, each individually connected to one of the relays 55, 56 and 54 respectively. The closure of the keys 52, 53 and 54 either singly or in different combinations enables an operator to make any desired selection of a single one of the condensers $51_a \ldots 51_g$ for this purpose. Thus, for example, if key 52 alone is depressed, then relay 55 is operated and this connects condenser 51_d in parallel with condenser *w*. If keys 52 and 53 are both depressed, then condenser 51_f will be connected. If all three of the keys 52, 53 and 54 are simultaneously depressed, then condenser 51_g will be connected. The highest note will be obtained when none of the keys 52, 53 and 54 are closed, since in this case there would be no addition to the capacitance of the condenser *w*. Other relay arrangements, may, of course, be provided in place of the one shown in Fig. 2. The basic idea, however, is to provide in this alternative embodiment of my invention means for facilitating quick adjustments of the tuning of the oscillators A, B, C, etc., prior to the closure of the chime sounding keys 18, 18_b, etc. In certain instances the use of selective tuning for one or more of the tank circuits A, B, etc. may result in a possible reduction in the required number of such tank circuits and associated tubes.

By way of illustration of a specific embodiment of the invention which has been found satisfactory in operation, I give below the chosen values of various resistors and capacitors as used for fixing the time constant of the "attack" period on the bias reducing means and also of the decay period following the opening of the key circuits:

	Tone frequency			
	256	427	341	Bell
Control of attack:				
Resistor #17 ..... meg..	.5	.5	.5	2.2 2.2
Resistor #20 ..... ohms..	1,500	1,500	1,500	1,500
Condenser #34 ..... mfd..	4	3	2	3
Control of decay:				
Resistor #16 ..... meg..	3	3	3	3
Resistor #22 ..... meg..	1.5	1.5	.....	0.2
Condenser #24 ..... mfd..	1	1	.....	1
Condenser #34 ..... mfd..	4	3	2	3

Various modifications of the invention as herein disclosed are, of course, to be contemplated and can be readily carried into effect by those skilled in the art. The invention itself is, therefore, limited only in accordance with the claims.

I claim:

1. In combination, a plurality of electronic sound frequency generators, an amplifier stage coupled to each generator, means for normally biasing each amplifier stage to cut-off, keying means momentarily closable for removing the cut-off bias from each stage selectively, and means including a time-constant circuit having resistance and capacitance connected to each said biasing means and to each said keying means for producing in any selected output circuit of said amplifier stages a gradual decay period of output energy, which period is of relatively long duration compared with the circuit closure period of said keying means.

2. The combination as defined by claim 1 and including auxiliary coupling means connected between one generator and the appropriate amplifier stage of another generator, whereby said stage is caused to amplify composite tone frequencies.

3. In an electric sound producing system, an oscillation generating electron discharge tube having a cathode, an anode and a control electrode, an input circuit for said tube having resonance at an audio frequency, a feed-back connection from said anode to a suitable point on said resonant circuit, an amplifier stage having an input circuit coupled to the source of oscillations in said tube, means for normally biasing said amplifier stage to cut-off, a time-constant circuit operative to control both input and output sides of said amplifier stage, and keying means whereby a relatively brief interruption of the cut-off bias on said amplifier stage initiates a prolonged activation thereof subject to a gradual decay characteristic which is determined by said time-constant circuit.

4. A system in accordance with claim 3 in which a non-linear resistor is provided in said time-constant circuit for accentuating the initial portion of said decay characteristic.

5. A chime tone frequency generator and amplifier comprising a multi-function discharge tube having an oscillator portion and an amplifier portion, a tank circuit having a capacitor and an adjustable inductance for tuning the input side of said oscillator portion, means for normally maintaining a cut-off bias control of said amplifier portion, keying means for rendering said amplifier portion conductive, means including a time-constant device having resistive and capacitive elements under the influence of anode potentials in said amplifier portion for prolonging the conductive state thereof during an appreciably long period following the opening of said keying means.

6. A device according to claim 5 and having a plurality of normally open-circuited capacitors, and selective means for placing any of said capacitors in shunt with the capacitor of said tank circuit, thereby to alter the frequency of said oscillator portion.

7. A system for producing chime tones comprising a plurality of electronic oscillators each having a tuned output circuit and an input circuit coupled to said output circuit, an electronic amplifier fed with energy simultaneously from a selected plurality of said oscillators, an input circuit having means connected thereto for normally maintaining a cut-off bias on said amplifier, means including a key for momentarily removing said cut-off bias, thereby to cause said amplifier to deliver an output current of superposed frequencies corresponding to those fed thereto by said selected oscillators, and means including a time constant device having re-

sistive and capacitive elements under the influence of output potentials from said amplifier for prolonging the conductive state thereof during an appreciably long period after the key has restored said cut-off bias.

8. A system according to claim 7 and having a non-linear resistor included as one of said resistive elements.

9. A chime system comprising a plurality of electronic low frequency generators, each generator having a resonant input circuit and an output circuit, electronic means for amplifying the energy derived from said output circuit, means including a biasing source for normally blocking said amplifying means, keying means momentarily operable to unblock said amplifying means by removing the blocking bias therefrom, and a time constant circuit connected to said amplifying means and constituted as a device for producing a prolonged decay period of output energy from said amplifying means beyond the unblocking period of said keying means.

10. A chime system according to claim 9, wherein certain of said generators are tuned to frequencies having a dissonant relation one to another, whereby beat-notes are developed in the output energies therefrom.

11. A system for the electronic generation of electric energy which, when translated into sound waves, simulates the tones of a cathedral bell, said system comprising a plurality of discharge tube oscillators tuned to frequencies having a dissonant relation to one another and being rich in the output of harmonic frequencies, means for combining the output energies from different ones of said oscillators, means for applying gradual attenuation to said output energies during an appreciable period which corresponds with the resonance period of said cathedral bell after the latter has been struck by its tongue, and means for differentially adjusting the decay periods of said attenuating means with respect to different fundamental and harmonic frequency components of said output energies.

JARRETT L. HATHAWAY.