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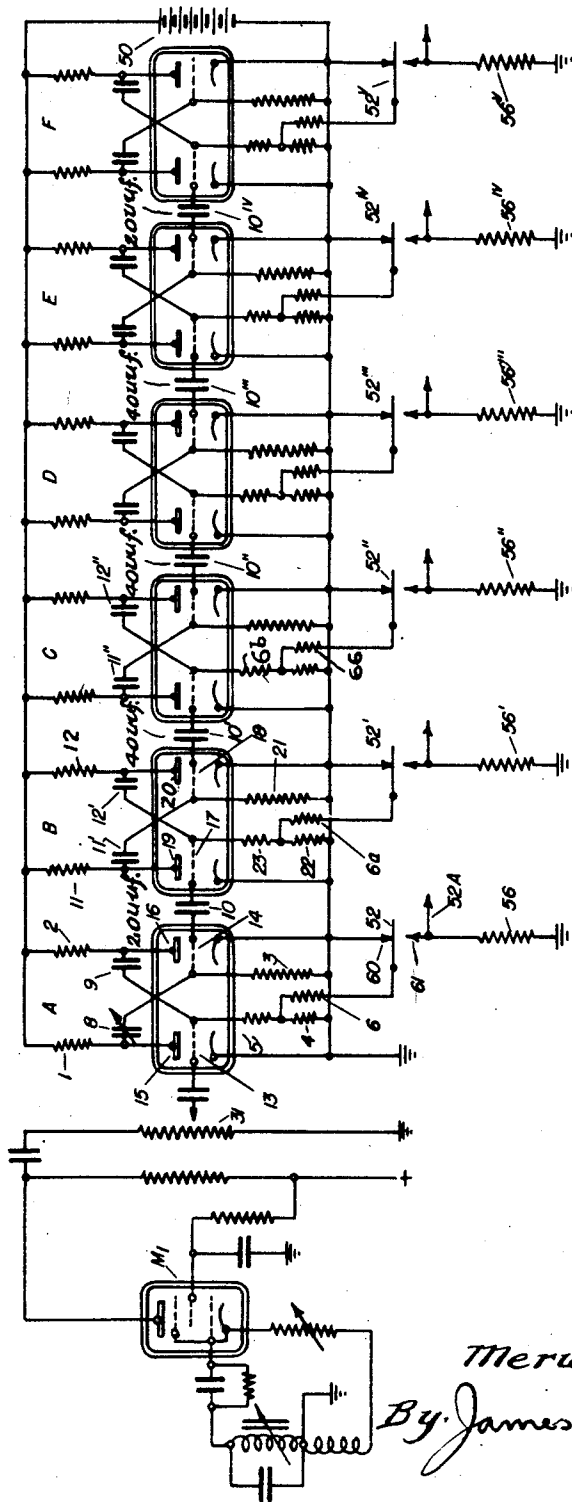
2,470,705

VIBRATO ORGANIZATION

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3 Sheets-Sheet 1

Fig. 1.



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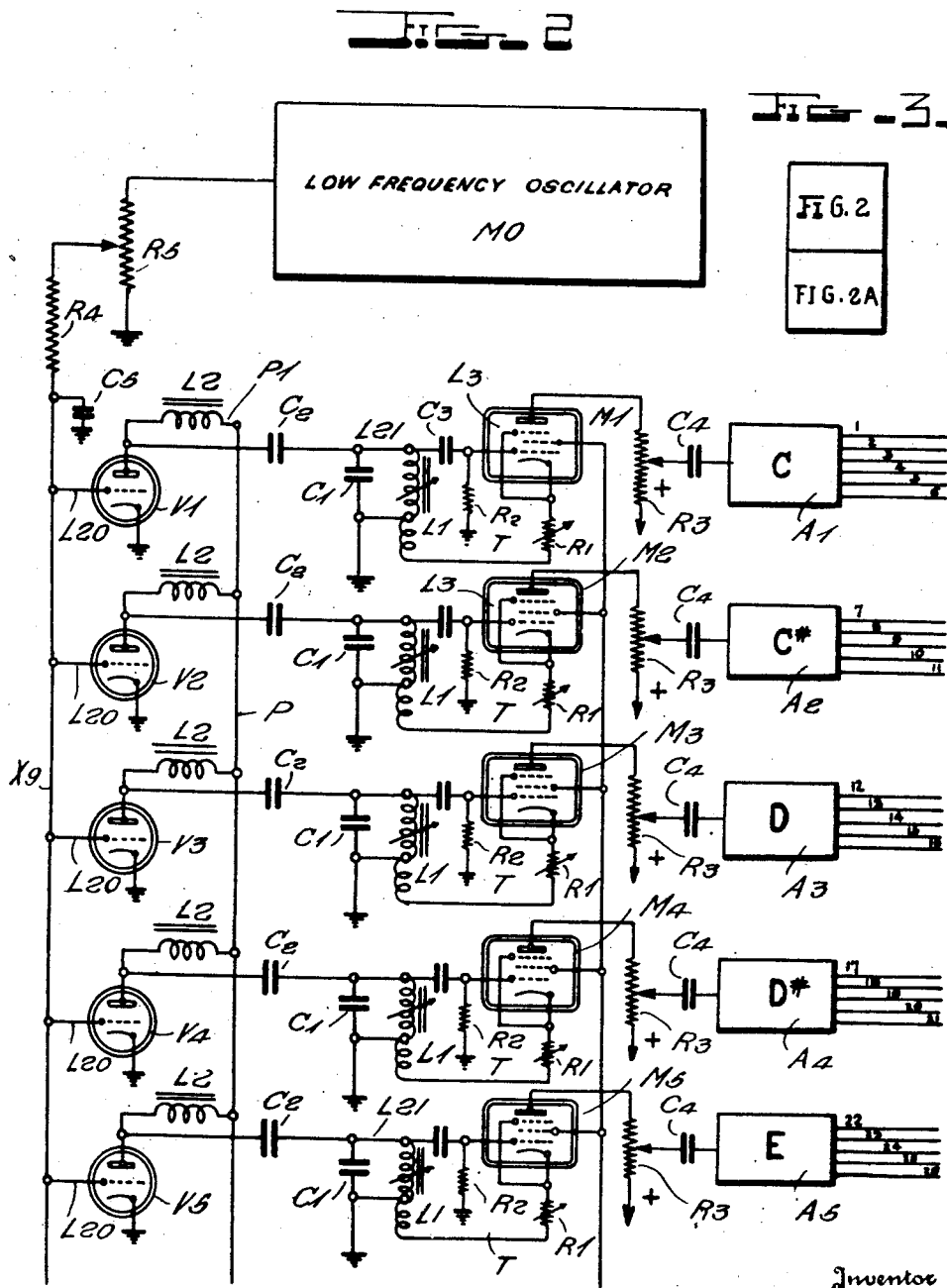
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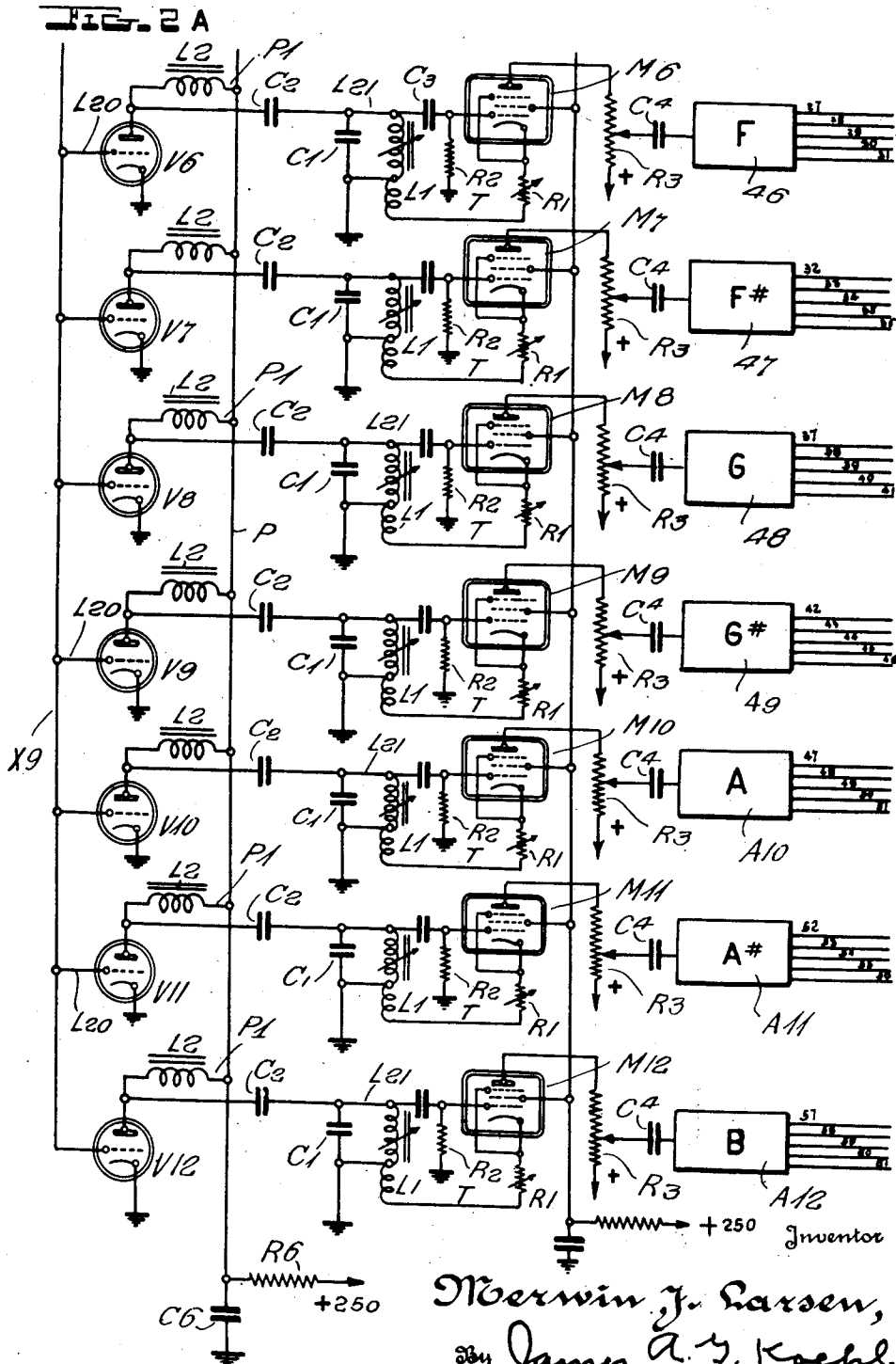
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VIBRATO ORGANIZATION

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Original application September 19, 1944, Serial
No. 554,837. Divided and this application June
27, 1946, Serial No. 679,618

3 Claims. (Cl. 250-36)

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This invention relates to devices for producing vibrato effects in the rendition of electrically produced music and is a divisional application of my application for Electric organ, Ser. No. 554,837, filed September 19, 1944, allowed May 9, 1946, now Patent No. 2,403,090, dated July 2, 1946.

An object of the invention is the production of vibrato effects in musical sounds resulting from activation of a loud speaker in response to transmission thereto of amplified tone signals of musical frequency.

A still further object is the provision of means for producing vibrato effects electronically and for controlling the frequency thereof as desired.

Another object is the provision of means for producing vibrato effects in a system employing master oscillators for controlling operation of generator of audio frequency tone signals.

Another object is the provision of means for producing vibrato effects in a tone generating system employing stabilized oscillators operating at predetermined tone frequencies corresponding to the pitch relation of notes of the chromatic scale, the arrangement of said means and connection thereof in said system being such as to insure against any change in pitch whether the vibrato is "on" or "off."

Other objects will appear from the following description and claims taken in connection with the accompanying drawings, in which:

Figure 1 is a diagram of the multivibrator stages connected in cascade;

Figure 2 and 2A are respective sections of a diagram of the vibrato connected in a system of frequency generators embodying a plurality of similar cascades of multivibrator stages; and

Figure 3 is a diagram showing the manner the intended order of arrangement of Figures 2 and 2A to furnish a complete electrical network embodying my improved vibrato.

My improved vibrato is primarily adapted for use in connection with frequency halving or dividing circuits employing space discharge devices such as oscillators or their equivalent, the same connected in cascade and controlled by a master oscillator or the equivalent thereof. Multivibrator stages as disclosed in the copending application of myself, James A. Oswald and Carl S. Schjonberg, filed September 17, 1943, Ser. No. 602,762, now Patent No. 2,410,882, dated November 12, 1946, have given excellent results. As my invention is designed primarily for use with electrical musical instruments employing keying circuits connected with sources supplying audio

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signals at the tone frequencies of notes of the even tempered musical scale, twelve cascades of multivibrator stages will be employed, such that stages comprising one cascade will supply electrical impulses at the tone frequencies of all C notes at octave separation. Another set of stages will supply electrical impulses at the tone frequencies of all C# notes at octave separation, and so on, to and inclusive of a set of stages supplying electrical impulses at tone frequencies of all B notes at octave separation.

At Figure 1 of the accompanying drawings a C note cascade of multivibrator stages and a master oscillator are illustrated, the same comprising stages A, B, C, D, E and F connected in cascade by electrical components so that stage B oscillates at a frequency which is the octave of stage A, stage C operating at a frequency which is the octave of stage B and so on to and inclusive of stage F which operates at a frequency which is the octave of stage E, the master control oscillator MI being connected to the grid circuit of the first stage A.

Each of the multivibrator stages includes a twin triode, including two sets of electrodes consisting of a cathode, control grid, and plate. The multivibrator A, for example, includes two sets of associated electrodes including grid 13 and plate 15, and grid 14 and plate 16. The input circuit of the twin triodes are completed through high resistance paths of different effective resistances, constituted in the case of control grid 13 and its associated cathode by the resistances 4 and 5, and in the case of the control grid 14 and its associated cathode, by resistance 3. The output circuit of the twin triode includes resistances 1 and 2 leading from plates 15 and 16, respectively, with variable condenser 8 connected between control grid 14 and a point intermediate resistances 1 and plate electrode 15, and fixed condenser 9, connected between control grid 13 and a point intermediate plate 16 and resistance 2. The dropping resistance 6 is connected to a point intermediate resistances 4 and 5 and leads to the playing key 52, movable between contacts 60 and 61. Contact 60 returns to the common input circuit bus of the several multivibrators, while contact 61 leads through grid biasing resistance 56 to ground, thus returning to the common cathode bus.

The resistive multivibrator circuit constituting stage A is coupled to the succeeding stage B through the coupling capacitance 10 having the value in the circuit illustrated of 20 mmf. to the control grid 17 of one set of the electrodes

of the twin triode in multivibrator stage B. The twin triode in multivibrator stage B includes two sets of electrodes constituted by control grid 17 and plate 19 with an associated cathode, and a control grid 18 and plate 20, with an associated cathode. The control grid 17, which connects to the coupled capacitance 10 also completes an input circuit through resistors 23 and 22, returning to the associated cathode. The input circuit for the opposite sets of electrodes is completed from control grid 18 through the resistance 21, returning to the associated cathode. The resistive paths are of different values as will be hereinafter explained. Dropping resistance 6^a connects to a point intermediate resistances 23 and 22 and leads to the playing key 52' with which is associated the resistance 56'.

The output circuit of the sets of electrodes constituting the twin triode of stage B includes resistances 11 and 12, connected in each of the plate supply leads and extends to the common plate supply bus. Fixed condenser 11' is connected to a point intermediate resistance 11 and plate 19 to control grid 18, while fixed condenser 12' is connected to a point intermediate resistance 12 and plate 20, and to the control grid 17. The control grid 18 is connected through coupling capacitance 10' which is of 40 mmf. to the control grid of the first set of electrodes of the twin triode constituting multivibrator stage C.

The circuits for the multivibrator stage C are similar to those described with respect to stages A and B except that the capacity values of condenser 11'' and 12'' are of greater value than the corresponding condensers in the preceding stages, as will be hereinafter explained in detail. The biasing circuit is represented as including playing-key 52'' connected to resistance 6^b with an intermediate point in the low resistance grid circuit. The contact system for the playing key is arranged in a manner similar to that hereinbefore described, where one of the contacts leads to bias resistor 56'', returning through ground to the common cathode bus.

Multivibrator stages D, E, and F are coupled through condensers 10'', 10''' and 10^{iv} of 40 mmf., 40 mmf., and 20 mmf., respectively. The biasing potential on the grid circuits of each of the multivibrator stages D, E, and F is similarly controlled through playing keys 52''', 52^{iv} and 52^v, respectively.

Referring to Figures 2 and 2A use is made of master oscillators M1, M2-M12 which are conventional electron-coupled oscillators with the exception that provision is made to vary the frequency thereof. Vacuum tubes made by Radio Corporation of America and identified as type 7A7 have proved satisfactory. There is one of said master oscillators for each individual cascade of multivibrators, the output wave from which is impressed on the control grid of the first stage of said cascade.

In Figures 2 and 2A a common lead P is adapted to be connected by a resistance R6 to a plate supply source, (not shown), said lead having a large capacitance C6 connected in shunt therewith. Small chokes L2 in the branch circuits P1 of common lead P are connected in the plate circuits of respective control tubes V1, V2-V12. At X9 is a common lead, the branch circuits L20 of which connect in the grid circuits of said respective control tubes.

At MO is a low frequency oscillator, the output of which has a potentiometer R5 in series with a dropping resistance R4 at the input termi-

nal of said common lead X9, a capacitance C5 being connected in shunt with said lead, as shown. A low frequency oscillator answering my requirements is found at page 181 of the publication entitled "UHF Techniques," by Brainerd.

The master oscillator tubes M1, M2, etc., for the first stages of the respective cascades, A1, A2, etc., of the multivibrator waveform generators are each thereof connected in a "tank" circuit T which is individual thereto and includes: a lead L21 connecting the plate of a respective control tube to the control grid of an associated master oscillator. In series with said lead are capacitances C2 and C3. A capacitance C1 is connected in shunt with said tank circuit and has a terminal point of connection between capacitances C2 and C3, the opposite terminal of said capacitance connecting with a variable inductance L1 between the field coils thereof. A terminal of one coil of said inductance connects with said lead L21 between capacitances C2 and C3, and, as illustrated, a terminal of the other coil of said inductance is connected in the cathode circuit of a respective master oscillator by an adjustable feedback resistance R1 and with the suppression grid of said master oscillator by a lead L3.

The low frequency oscillator MO may be any of several types such as one of the simpler R.-C. types, provided the output waveform is substantially sinusoidal. The rate is adjusted to approximately 6 cycles per second although manual control of the vibrato rate may in some instances be controlled as desired. The extent of the frequency sweep is under control by adjustment of the aforementioned potentiometer R5 in the output of said low frequency oscillator.

Resistance R4 is of the order of magnitude of 200,000 ohms and prevents the grids of the control tubes from swinging appreciably above their respective cathodes and at the same time, avoids possible overloading of the low frequency oscillator during its positive swing. Capacitance C5 which is connected in shunt with lead X9 is of the order of magnitude of 0.1 microfarad and functions as a filter to reduce the higher harmonics which tend to be produced during the positive portion of the cycle when the grids of said control tubes rise slightly above their respective cathodes, at which time, the plate resistance of said tubes are at their lowest value as is true also of the frequencies of the master oscillators. Both cathode and grid bias are eliminated by passing the plate supply to the control tubes through resistance R5 in the main plate supply lead P which is shunted by a large capacitance C6, say 40 microfarads. No change in pitch is in evidence whether the vibrato is "on" or "off." The vibrato is turned off by grounding the output of the low-frequency oscillator, preferably at the oscillator side of the dropping resistance R4 either by means of a switch or by adjusting potentiometer R5.

The small chokes L2 insure a much greater range in dynamic plate resistance than is possible with the use of resistances. This is due to the fact that a much higher plate voltage is retained, which, in turn, permits a lower plate resistance during the positive swing of the grid voltage cycle.

The design of the master oscillator with its frequency control circuit depends upon the maximum extent desired for the frequency swing. In a frequency vibrato to be used for musical purposes the extent of the frequency sweep, likely,

would rarely exceed 5 per cent which is a little less than a semi-tone. This would correspond to a change of approximately 10 per cent in either the inductance or the capacitance ($L1$ or $C1$) of the tank circuit as the frequency is inversely proportional to the square root of the product of the inductance and the capacitance. It has been found that if $C2$ is on the order of 0.1 of $C1$, an adequate maximum swing can be obtained, somewhat less than 5 per cent, provided a tube is selected and operated so that its dynamic plate resistance can become as low in magnitude as that of the reactance of $C2$ at the frequency of the master oscillator concerned.

In selecting the proper values, the choke $L2$ should have a reactance several times that of $C2$ at the oscillator frequency. For a given tube, $V1$, the optimum value of $C2$ is such that its reactance equals the lowest attainable value of the plate resistance of the tube. (Optimum is used in the sense that the greatest frequency change is possible with this value.) Should this optimum value of $C2$ be too high a percentage of $C1$ the tube selected will more than handle the maximum desired frequency swing and consequently $C2$ can be reduced. If, on the other hand, the optimum value of $C2$ is too small a percentage of $C1$, either the oscillator must be redesigned using a smaller $C1$ and a larger inductance, or a tube having a lower plate resistance must be used.

Assume as a design example that a 6SC7 or (7F7) triode section is to be considered as the control tube along with a master oscillator operating at a frequency of 3000 cycles per second. Without drawing appreciable grid current, at zero bias, the lowest attainable plate resistance is about 40,000 ohms with a plate voltage of 150 volts. In order, then, for the reactance of $C2$ to equal 40,000 ohms $C2$ would be about 0.0013 microfarad. This means that $C1$ should be about ten times as much or about 0.013 microfarad. The oscillator inductance $L1$ can be designed now to provide the proper frequency. In the plate lead of the control tube for choke $L2$ a "midget" 10-henry choke would be adequate as it would have a reactance of nearly 200,000 ohms at the oscillator frequency. The input on the grid of $V1$ should be great enough to swing the grid from zero bias to or near to the cut-off bias, for maximum vibrato, and less swing as desired.

The values given in the example above are intended to point out the approximate design only. In construction it is not necessary to design closely. To come "somewhere near" the design value usually is quite satisfactory.

For locking the multivibrators it has been found that there is an optimum potential which will provide best locking. The optimum potential is obtained readily by adjustment of the potentiometers $R3$ to which the multivibrators are connected through capacitances $C4$.

From the foregoing description, it follows that in combination with electron discharge devices producing audio signals at the tone frequencies of notes of the even tempered musical scale and comprising twelve cascades of said devices, the devices comprising each separate cascade will each thereof operate at an invariable frequency, each individual device of any cascade operating at a frequency one-half that of the preceding device of the same cascade. By reason of the embodiment herein of a low frequency oscillator having an output common to all tubes $V1$, $V2$ - $V12$, the output frequencies of which are controlled

as set forth and impressed on the master oscillators $M1$, $M2$ - $M12$ in response to periodic actuation of the tank circuits in which said master oscillators are connected, the rate of the vibrato can be changed as desired and will be the same any place in the gamut of the instrument.

What I claim as my invention is:

1. In a vibrato organization for electrical musical instruments, the combination comprising twelve frequency dividing circuits, said dividing circuits each embodying a plurality of space discharge devices adapted to produce frequencies at octave separation corresponding to the vibration frequencies of notes of the same letter in the even tempered musical scale; each of said space discharge devices having an output path provided with a selectively actuatable electric switch adapted to be controlled from the playing-key of a keyboard; a master oscillator for and individual to each separate dividing circuit for transmitting a controlling frequency to the highest frequency stage thereof; and means for producing a vibrato effect in the output waves of all of said dividing circuits, said means embodying a low frequency oscillator and a set of high vacuum control tubes connected in circuit with said low frequency oscillator and concurrently activated thereby, and means including tuned resonant tank circuits connected with said master oscillators of the respective dividing circuits and with said control tubes and capacitive circuits for periodically shunting said tank circuits during alternate changes in the effective resistance of said control tubes and changes of voltage on the grids thereof.

2. A vibrato comprising a master oscillator embodying a high vacuum tube having at least a plate, a control grid, and a cathode; a high vacuum control tube having a plate and a control grid; a tank circuit in which said master oscillator is connected, said tank circuit including a path connecting the plate of the control tube with the control grid of said master oscillator, said control tube having an impedance adapted to connect the plate of said tube with a plate supply source; the aforementioned path having condensers in series therein, a variable inductance in said tank circuit and including field coils and a capacitance in shunt therewith at a point between said series condensers and having a terminal connected to a terminal of one of the field coils, the other field coil of said variable inductance connected to the cathode of said master oscillator by a feed-back resistance, and an output circuit for said master oscillator, the same provided with an adjustable impedance.

3. A vibrato comprising a master oscillator embodying a high vacuum tube having at least a plate, a control grid, and a cathode; a high vacuum control tube having a plate and a control grid; a tank circuit in which said master oscillator is connected, said tank circuit including a path connecting the plate of the control tube with the control grid of said master oscillator, said control tube having an impedance adapted to connect the plate of said tube with a plate supply source; the aforementioned path having condensers in series therein, a variable inductance in said tank circuit and including field coils and a capacitance in shunt therewith at a point between said series condensers and having a terminal connected to a terminal of one of the field coils, the other field coil of said variable inductance connected to the cathode of said

master oscillator by a feed-back resistance, and
an output circuit for said master oscillator.

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