Aug. 13, 1940. T. J. GEORGE 2,211,540

ELECTRICAL MUSICAL INSTRUMENT

Filed April 6, 1937 4 Sheets-Sheet 1

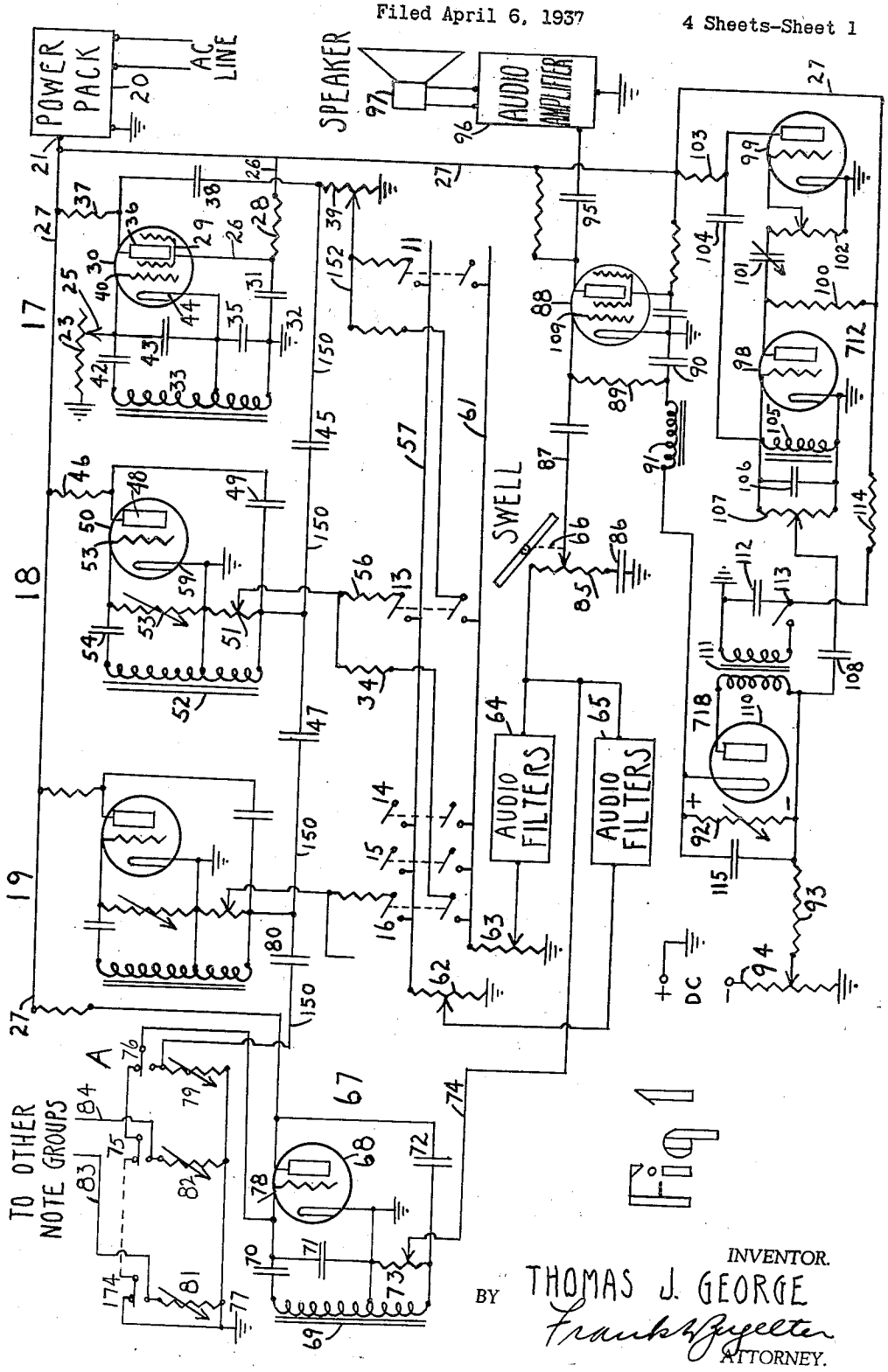


Fig 1

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ELECTRICAL MUSICAL INSTRUMENT

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Fig 2

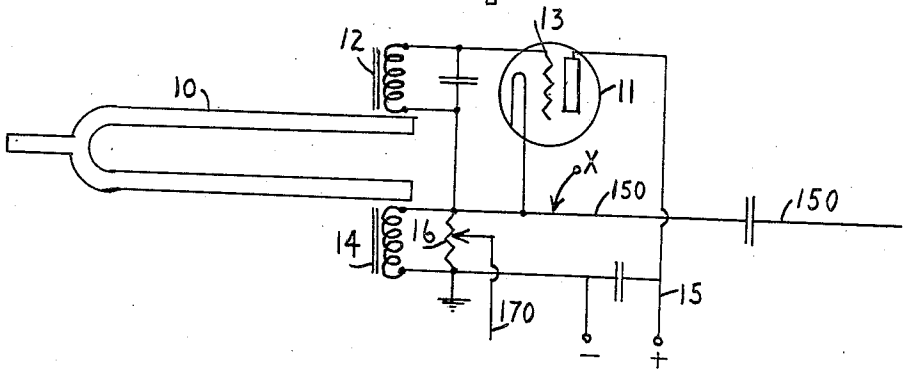


Fig 3

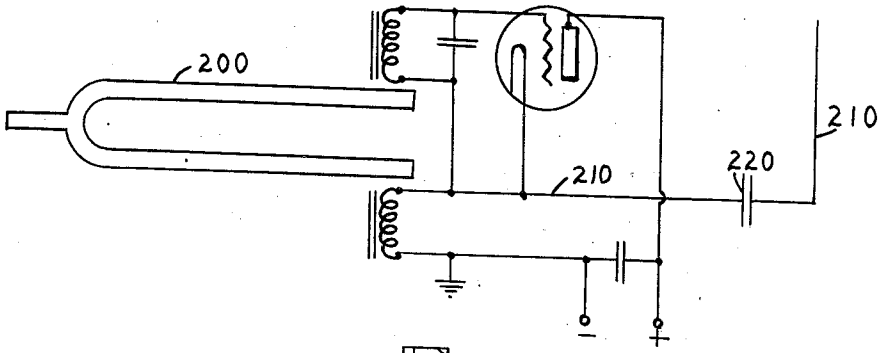
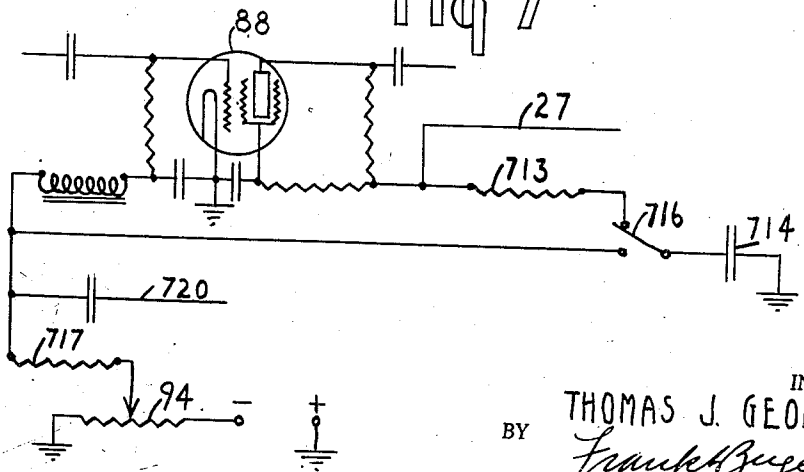


Fig 7



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Aug. 13, 1940. T. J. GEORGE 2,211,540

ELECTRICAL MUSICAL INSTRUMENT

Filed April 6, 1937 4 Sheets-Sheet 3

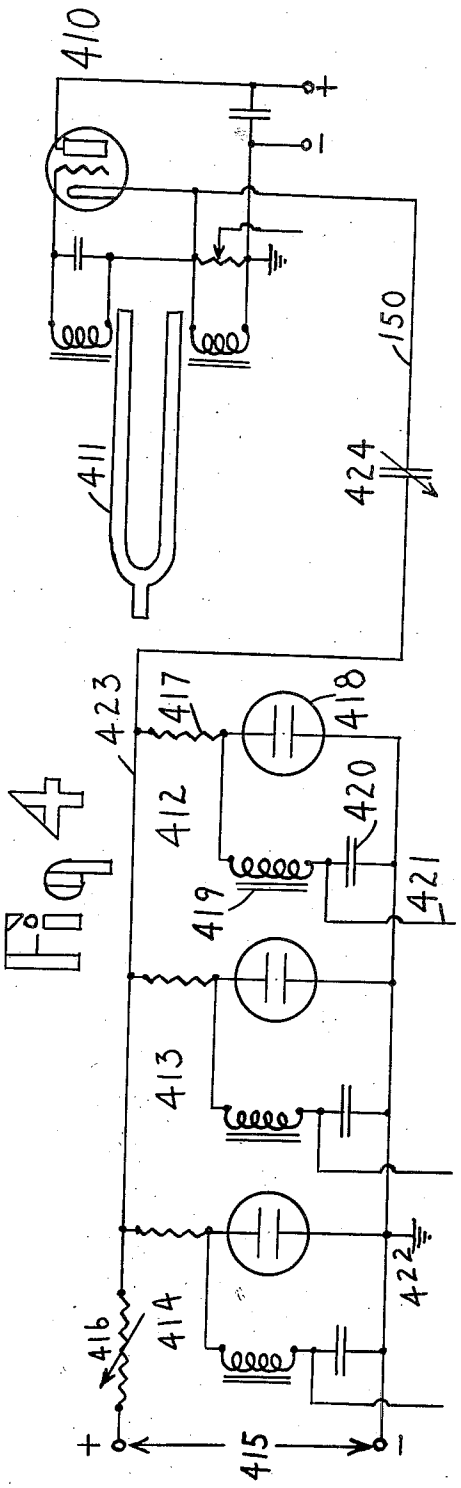


Fig 4

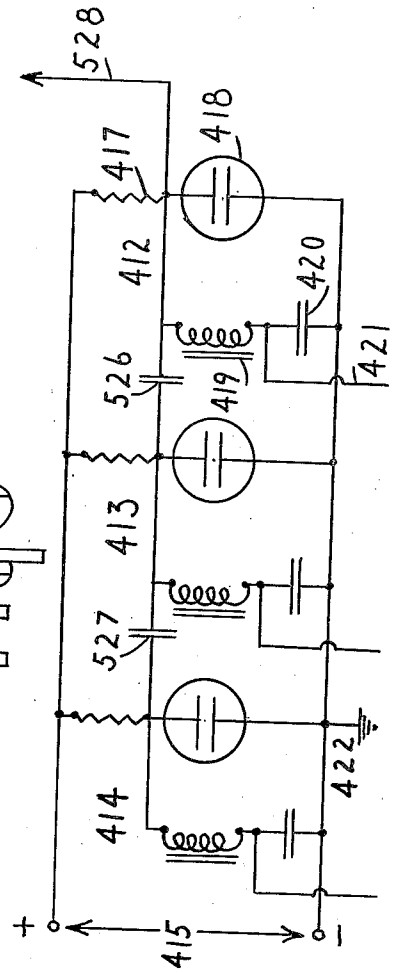


Fig 5

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Aug. 13, 1940. T. J. GEORGE 2,211,540

ELECTRICAL MUSICAL INSTRUMENT

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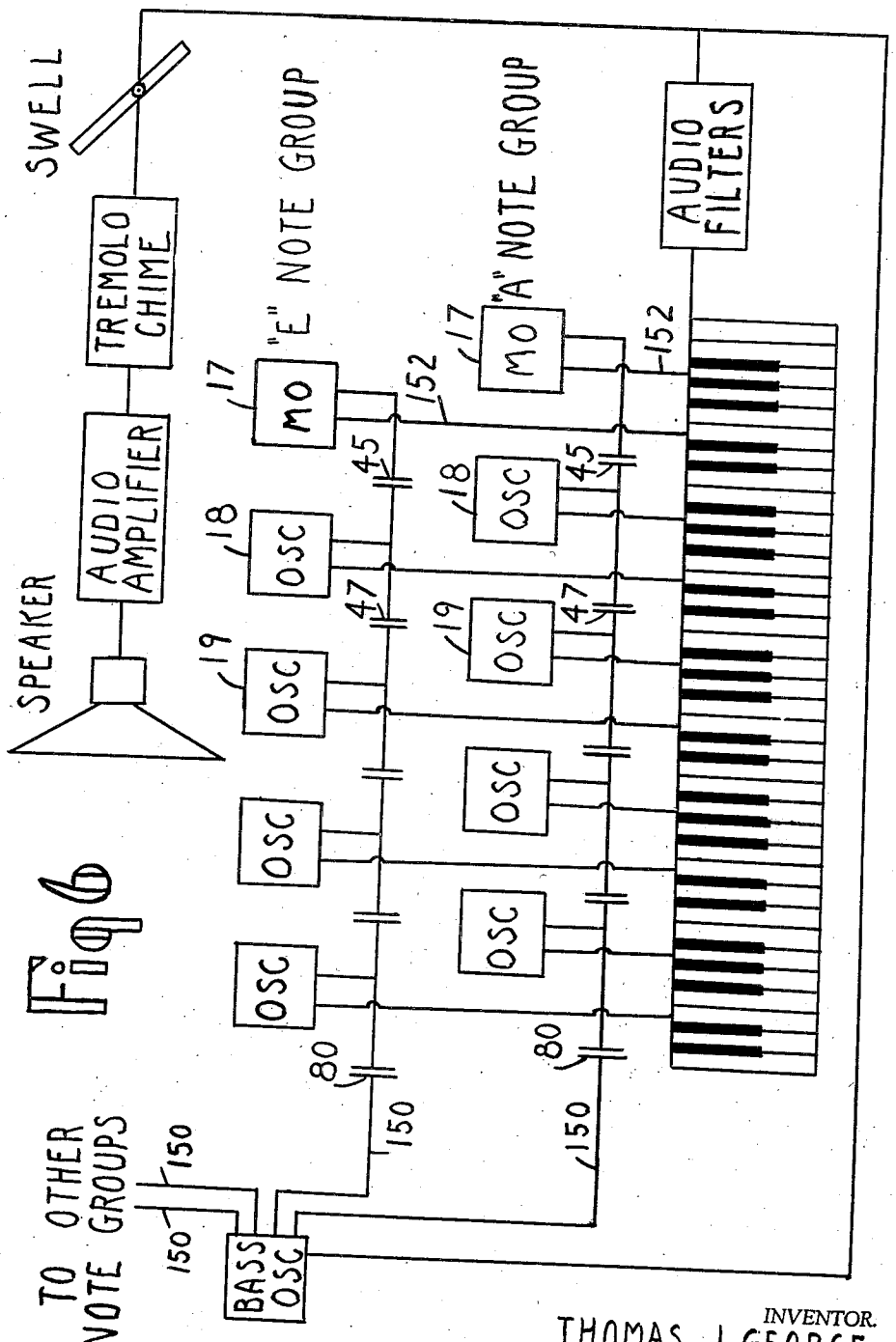


Fig 6

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Patented Aug. 13, 1940 2,211,540

UNITED STATES PATENT OFFICE

2,211,540

ELECTRICAL MUSICAL INSTRUMENT

Thomas J. George, Cincinnati, Ohio, assignor to Hammond Instrument Company, Chicago, Ill., a corporation of Delaware

Application April 6, 1937, Serial No. 135,285

3 Claims. (Cl. 84—1.21)

This instrument relates to electrical musical instruments of the type using various vacuum tubes and the like for attaining various sounds, tones and control thereof. The invention is concerned with improvements over the disclosures in similar devices, disclosed in such patents as Youngblut 2,045,172, Kock 2,046,463, Coupleux 1,980,911, Bethenod 1,789,032, Young 1,823,716, Hitchcock 1,877,316 and the like.

An object of the invention is to provide an improved arrangement of parts, whereby so called glow discharge tubes may be used to advantage.

Another object is to provide tuning means that may be readily coordinated to standard tuning forks or the like and permit said tuning forks to control the pitch or frequency of vacuum tube oscillators and glow discharge oscillators, thus making the oscillators as constant in frequency as the forks controlling them.

Another object is to provide certain simplifications and elimination of parts, and circuit arrangements as contrasted with prior art structures.

Another object is to keep all oscillators of different octaves, but of the same note, in perfect tune with each other at all times, and to provide means whereby they may be tuned simultaneously with a single tuning control.

These and other objectives are attained by the means described herein and disclosed in the accompanying drawings, in which:

Fig. 1 is a diagrammatic representation of the electrical relationship of various parts comprehending one form of the invention.

Fig. 2 is a diagrammatic detailed drawing of a regenerative tuning fork oscillator, forming a detail of the invention.

Fig. 3 is a variation of the device shown in Fig. 2.

Fig. 4 is a diagrammatic detailed drawing of glow discharge tube oscillators as used in a modified form of the invention.

Fig. 5 is a variation of the arrangement in Fig. 4.

Fig. 6 is a diagrammatic sketch showing generally the relationship of various parts of an instrument embodying the invention.

Fig. 7 is a diagrammatic drawing showing an arrangement of parts for producing a chime effect.

In Fig. 1, the parts represented are related in the following ways.

Visualizing the keyboard of an ordinary organ, piano, or similar keyboard instrument, the individual keys are recognized as the means that a player contacts for initiating the creation of sound. In conjunction with Fig. 1, it is to be understood that as a player depresses a given key, he closes an electrical switch. Such switches are indicated at 11, 13, 14, 15 and 16. It is to be understood that similar switches are provided, one for each key of the instrument. For the purpose of simplifying explanation of the invention, only a few of the various identical circuits are shown. Each key actuated switch controls a circuit through its own or associated oscillator, to the sound producing device such as an audio amplifier and loud speaker.

In Fig. 1, the oscillators, of which one is provided for each note to be produced by the instrument, incident to operation of the individual keys of the keyboard, may be considered in groups, each group comprising all of the same notes of the instrument, but each of the notes being in but one of the succeeding octaves. Three of the oscillators, of a group that may be designated the A, or A note group, are shown in Fig. 1. Each such note group comprises a master oscillator 17 and one associated or additional secondary or supplemental oscillator for each octave of the instrument. Accordingly, there are provided in the instrument, twelve note groups as C, C♯, D, D♯, E, F, F♯, G, G♯, A, A♯, and B, each comprising a master oscillator and associated supplemental or secondary oscillators. Fig. 1 shows only a master oscillator 17 and two secondary oscillators, 18 and 19. The master oscillator includes in its tuned frequency, the tuned frequencies of all of the secondary oscillators, in even divisible factors. For example, in Fig. 1, the master oscillator, is, we will say, tuned to oscillate at 1760 c. p. s. (cycles per second) and will be considered as note A of the highest octave of the instrument. The first supplemental oscillator 18 is tuned to oscillate at 880 c. p. s. and thereby gives note A of the second highest octave of the instrument. Each next lower octave note A has an oscillation frequency of one-half that of the next higher octave note A. Thus oscillator 19 has a frequency of 440 c. p. s. and so on, determined by the number of octaves to be included in the complete instrument. Each master oscillator controls all of its associated secondary or supplemental oscillators in this manner. The oscillator of the higher frequency controls the oscillator of the next lower frequency. Thus, master oscillator 17 controls oscillator 18. Oscillator 18 controls oscillator 19, etc.

The electrical energy used to actuate the oscillators is obtained from a common power source for all the parts of the instrument, and is indi-

cated at 20 as a power pack. The power pack is of any suitable construction, and may be any of the standard equipment of power packs available on the market, for rectifying and converting the available commercial alternating current obtained from power supply lines, to the desired direct electrical current to be used in the operation of the electrical musical instrument.

As shown herein, the positive tap 21 of the power pack 20 is electrically connected with each of the master oscillators in the manner in which master oscillator 17 is connected in Fig. 1, over common supply lead 27.

Each master oscillator includes a master tuning control means 23 which is a high resistance rheostat acting as a variable grid leak for effecting tuning. The lead 26, tapped on the group supply line 27, has connection, through resistance 28 with the screen 29 of tetrode 30. Although in this case a tetrode is used, any multi-electrode tube could be used, such as triode, pentode, etc. Screen 29 is by-passed to ground through condenser 31 at 32 and also is connected with the grounded end of inductance 33 and with the grounded side of stabilizing condenser 35.

The anode or plate 36 of tetrode 30 is connected to supply line 27 through coupling resistance 37 and to one side of output condenser 38 and which condenser has its other side connected to control lead 150 and output potentiometer 39.

The grid 40 of tetrode 30 is connected to the adjustable tuning means 25 of the master tuning control means 23, to one side of grid condenser 42, which condenser has its other side connected to one end of inductance 33, and also to one side of stabilizing condenser 43. The opposite side of condenser 43 is connected to one side of condenser 35, to tap on inductance 33, and to the cathode 44 of tetrode 30.

At 45 is a coupling device which in this case is a condenser, but which may be a resistance, an inductance, a transformer, or any means for impressing some of the output voltage from oscillator 17 upon oscillator 18 for the purpose of controlling the frequency of the secondary oscillator 18. The secondary oscillator also has connection with group supply line 27 through resistance 46. Each succeeding secondary oscillator, such as 19 and such additional oscillators of a given note group, have similar connections with the group supply line 27 and a capacity such as 45 interposed between such succeeding oscillators in the same way as the capacity 47 is interposed between oscillators 18 and 19. Each of the secondary oscillators and the connections thereof are alike except for being tuned to different frequencies as previously explained. Therefore an explanation of secondary oscillator 18 only will be given.

The anode 48 of triode 50 is connected to resistance 46 and to one side of plate condenser 49. The other side of condenser 49 is connected to one end of output potentiometer 51, to one end of inductance 52 and to capacities 45 and 47. Although a triode is used in this case, any multi-electrode tube could be used.

The grid 53 of triode 50 is connected to one side of grid condenser 54 and to one end of variable grid resistance 53. The lower end of resistance 53 is grounded. When switch 13 is closed manually by a specific key of the instrument, as previously explained, the output from oscillator 18 is fed from plate 48 of triode 50 through condenser 49, through potentiometer 51 to resistance 56 and from there through closed switch 13 to bus bar 57. It may also pass through resistance 34 to the lower contact of switch 16 for closure to bus bar 61 if switch 16 should be operated. The bus bar 57 is common to all upper switches of all finger operated keys, and bus bar 61 is common to all lower switches. It should be mentioned that the upper and lower switches associated with a given key, close to their respective bus bars 57 or 61 simultaneously, upon operation of the key. In this regard, it will be noted, that the master oscillator also may have connection to bus bar 57, by way of switch 11 and potentiometer 39; and to bus bar 61, through the lower contact of switch 13. This produces overtones, explained below.

Reverting now to triode 50, the cathode 59 thereof, is grounded and has connection with the tap on inductance 52. The inductance has connection at its one end with one side of grid condenser 54.

Attention is now called to the second bus bar 61. The bus bar 61 is used for completing circuits for effecting overtones or harmonics. In other words, when playing in a given octave, it is possible to also play, at the same time, the same notes in the next higher octave. The bus bar 57 consolidates all of the oscillations of the given octave, which may be termed the fundamental, and the bus bar 61 consolidates all of the oscillations of the overtones in the octave above. Suitable volume controls 62 and 63 are connected with the bus bars 57 and 61 and are connected through customary audio filters 64 and 65 and swell pedal control means 66. It will be seen that this arrangement provides a means of combining octaves, with results similar to the well known "coupling" arrangement of a pipe organ with this improvement, that by means of potentiometers 62 and 63 the volume of the fundamental and second harmonic may be individually adjusted. Suitable stops are provided on the instrument for bringing the overtone feature into and out of operation. The means therefor may conform with any of the arrangements employed in the art.

Each of the oscillators is individually tuned to its approximate desired frequency, which frequency is determined by the capacities of grid and plate condensers, by the size of the inductance used, and by the resistance of the variable grid resistance. The coupling of the oscillators as shown herein, causes each next higher oscillator of each note group to so control and dominate the next lower oscillator, that master tuning is effective from the so called master oscillator of each note group of oscillators. Thus, in Fig. 1, when oscillators 17, 18, and 19 have been tuned approximately to the frequencies noted, oscillator 17 will assume control and thereafter the final tuning of all oscillators in the "A" group may be effected simultaneously by variation of grid resistance 23. A twofold advantage thus results. All oscillators of the same note group are always perfectly in tune with one another. Also, slight retuning when necessary, may be effected quickly, by only one control, since all oscillators are tuned in one motion.

Fig. 2 shows an improved type of master oscillator. Here an ordinary tuning fork 10 is used to control the frequency of oscillatiion of vacuum tube 11. The grid of this tube is connected to coil 12 which is an iron core inductance so placed in close proximity to one of the vibrating tines of the fork that an alternating voltage is set up in the coil and impressed upon the grid 13. This

voltage is amplified in the plate circuit of the tube and the resulting plate current fluctuations in passing through another iron core inductance 14 which is placed in close proximity to the other tine of the fork, causes the fork to vibrate at its own natural period of vibration. Thus an alternating voltage having the same frequency as the fork is generated, which frequency does not depend upon the tube for its constancy, but upon the mechanical properties of the tuning fork. Thus a voltage of exceedingly constant frequency is available.

This oscillator can therefore be advantageously substituted for master oscillator 17 in Fig. 1. To do this, supply lead 15 in Fig. 2 is connected to lead 27 in Fig. 1. Potentiometer 16 in Fig. 2 assumes the purpose of potentiometer 39 in Fig. 1 and output lead 170 connects to lead 152 in Fig. 1. The control lead is 150 in both figures.

With this change made, and with all secondary oscillators brought into tune with the master oscillator, all oscillators in the entire note group will be permanently in tune, with one another.

Reverting again to Fig. 1, at 67 is shown another oscillator which may be used to generate the very low frequencies, corresponding to the bass pedal notes of an organ.

Since the pedal board is arranged to be played with the feet, and since it is seldom necessary to play more than one pedal note at one time, an economy may be realized by letting one oscillator generate all notes of the pedal bass.

Triode 68 is arranged in an oscillating circuit with inductance 69, grid condenser 70, tuning condenser 71 and plate condenser 72. Output of the oscillator is controlled by potentiometer 73 over lead 74 to the swell control 66.

Each bass foot pedal controls a switch 174, 75, and 76. These switches are so wired in series that when all pedals (and switches) are normal, ground 77 is applied to grid 78, and the tube does not oscillate. If any pedal, as for example the A pedal, is operated, switch 76 is operated. The ground is removed from the grid, and the variable grid resistance 79 is connected thereto, permitting the tube to oscillate, at a frequency determined by the constants 69, 70, 71, 72, the tube itself, and variable grid resistance 79. Control lead 150 from the lowest oscillator in the A note group is also connected to the grid of oscillator 67 through coupling condenser 80. If now resistance 79 is varied until the frequency of oscillation becomes approximately half the frequency of the lowest oscillator in note group A, the oscillator 67 will be drawn into exact tune with the note group, by virtue of the voltage impressed upon its grid through condenser 80 over control lead 150. In like manner, switches 174 and 75 when operated will permit oscillator 67 to be tuned by means of their associated resistances 81 and 82 and held in tune with the corresponding note groups over control leads 83 and 84.

Thus a single oscillator can be used to generate, for example, a full octave of bass notes, each note of which will always be in perfect tune with its associated note group.

Referring again to swell control 66, it will be seen that the lower end of the potentiometer 85 is connected to condenser 86, the other lead of which condenser is grounded. As the output lead 87 is moved from the high end of the resistance 85 toward the low end, the rate of attenuation of the high frequency voltages is virtually the same as for the low frequency voltages. If resistance 85 were grounded directly instead of connecting to condenser 86, the rate of attenuation for the low frequencies would be higher than that for the high frequencies. The practical result of this arrangement is that for all volume levels, the bass and treble notes have the same relative output.

Lead 87 connects to the grid of special audio amplifier tube 88. This tube is of the so called super control type, having a remote cut-off bias feature. Its plate and screen are fed through suitable resistances from the common supply lead 27. The cathode is grounded. Grid coupling resistance 89 connects at one end to lead 87, and at the other end to by-pass condenser 90, and also to iron core choke 91. The other side of choke 91 connects through resistance 92 and resistance 93 to direct current supply 94 which furnishes a negative potential for determining the normal operating grid bias for amplifier tube 88. The output voltage is fed through condenser 95 to audio amplifier 96 and to speaker 97 where the impulses are converted into sound.

At 98 and 99 are two vacuum tubes which together with their associated condensers, resistances and iron core inductance, are arranged to generate a sine wave oscillation of very low frequency, (a few cycles per second). Tube 98 receives its plate potential from the common supply line 27. Condenser 101 couples through grid resistance 102, the grid of tube 99 to the plate of tube 98. The plate of tube 99 receives its plate potential through resistance 103 from lead 27 and through condenser 104 is coupled to the grid of tube 98. Tube 98 drives tube 99 which in turn drives tube 98. Thus a continuous oscillation is maintained, and a sine wave voltage is built up across choke 105, condenser 106 and potentiometer 107. Through condenser 108 this slowly oscillating voltage is superimposed upon the grid voltage from source 94 applied to the grid 109 of amplifier tube 88. Thus the grid bias on this tube slowly fluctuates above and below the normal operating point. As a result the gain of the tube 88 increases and decreases at the same rate, as the oscillation of tubes 98 and 99, giving an apparent tremolo effect to the sound coming from the amplifier and speaker. By means of variations in the capacity of condenser 101, the speed of fluctuations or tremolo may be varied to suit the player. Potentiometer 107 permits adjustment of the degree of tremolo.

At 110 is a rectifier tube arranged with its associated equipment, to permit the simulation of a chime, bell, piano, or any similar musical percussion instrument. At 114 is a resistance connected to supply lead 27, through which condenser 112 is maintained in a charged condition. When switch 113 is closed, the charge on this condenser is applied to the primary winding of transformer 111. A pulse of induced voltage is built up in the secondary winding of transformer 111 which is rectified by tube 110 and applied across variable resistance 92 and condenser 115 with polarity as marked, positive at the cathode of tube 110 connected to the upper end of resistance 92 and negative at the lower end of this resistance. As mentioned above the grid of amplifier tube 88 normally has a negative potential upon it from source 94.

In operation of the chime circuit, a voltage is built up across resistance 92 and condenser 115 whose polarity is opposite to that of the voltage source 94. The condenser becomes charged and this charge at once begins to leak

selectively operable switches, the switches and oscillator being normally inoperative, a variable tuning means for each switch, said switches when operated singly, adapting the oscillator to oscillate at a frequency approximately determined by the variable tuning means associated with the selected switch, a master control means for each switch, said master control means generating frequencies harmonically related to but differing from the frequencies generated by said oscillator the frequency of the oscillator being exactly determined by the master control means connected to the selected switch whereby to permit the generation, one at a time, of a plurality of exactly predetermined frequencies by one oscillator, said oscillator generating a single frequency only at one time.

2. In an electrical musical instrument having a plurality of sources of signals of the different frequencies of the musical scale, having a plurality of key controlled switch means and having an output system including electro-acoustic translating means; the combination of an oscillator, means rendered operative by said switch means to tune said oscillator closely but not exactly to a frequency determined by the operated switch means, and means for simultaneously impressing upon said oscillator a signal from one of said sources having a frequency which is harmonically related to but differs from that of the note determined by the operated switch means.

3. In an electrical musical instrument of the type having a keyboard, a plurality of sources of electrical frequencies corresponding to some of the notes of the musical scale and having a means for translating into sound signals selected by the operation of said keys; the combination of a single oscillator for supplying signals of a plurality of different frequencies bearing harmonic relationship to some of the frequencies supplied by said sources, means under the control of said keys for tuning said oscillator to a frequency closely corresponding to the note represented by the operated key, and means controlled by said key for impressing upon said oscillator a signal from one of said sources having a frequency which is harmonically related to but differs from that represented by the operated key, said frequency from said selected source being impressed upon said oscillator to determine the exact frequency of oscillation thereof.

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Aug. 13, 1940. P. KOLLSMAN 2,211,543

REMOTE SPEED INDICATOR

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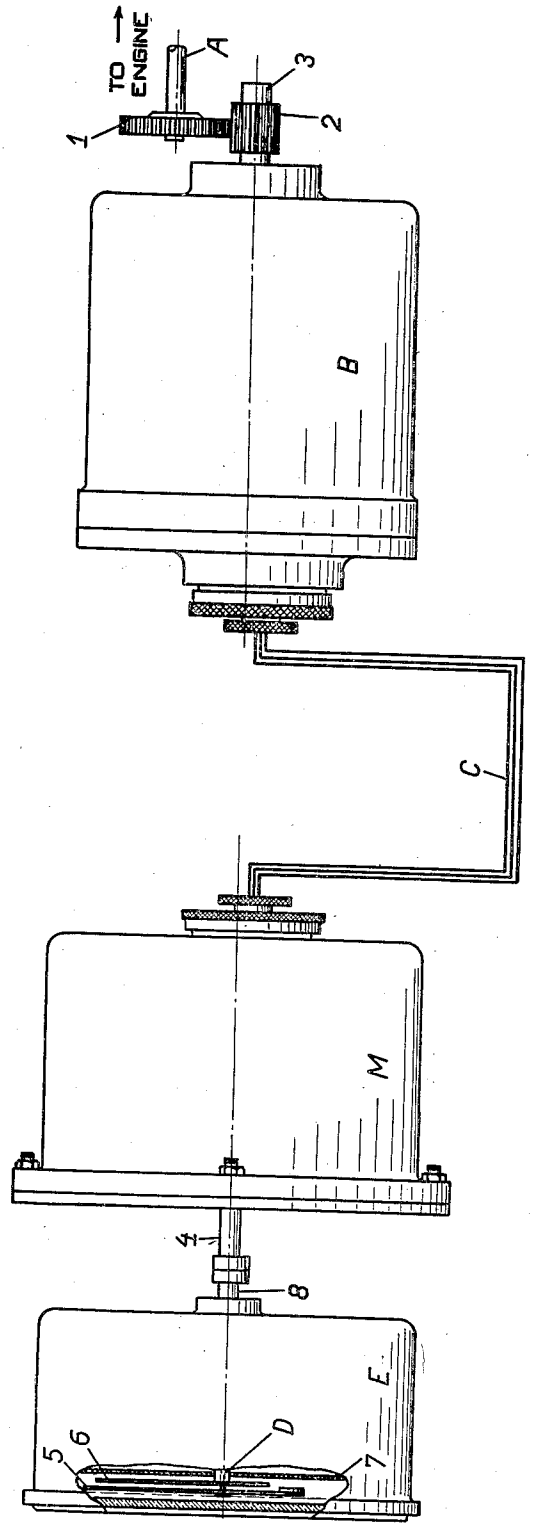


Fig. 1

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