March 21, 1950 L. HAMMOND ET AL 2,501,172

ELECTRICAL MUSICAL INSTRUMENT

Filed May 15, 1946 3 Sheets-Sheet 1

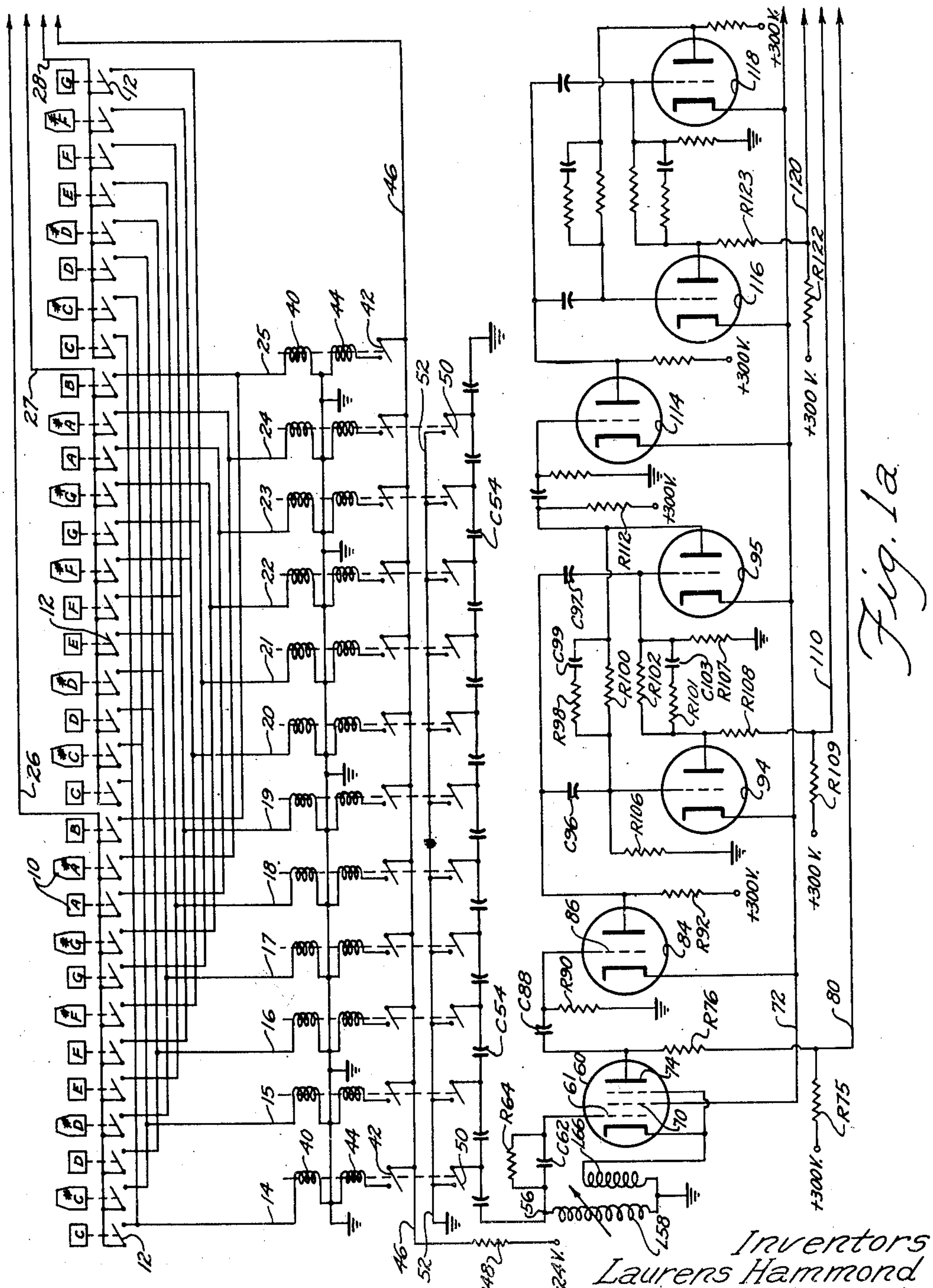


Fig. 1a

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ELECTRICAL MUSICAL INSTRUMENT

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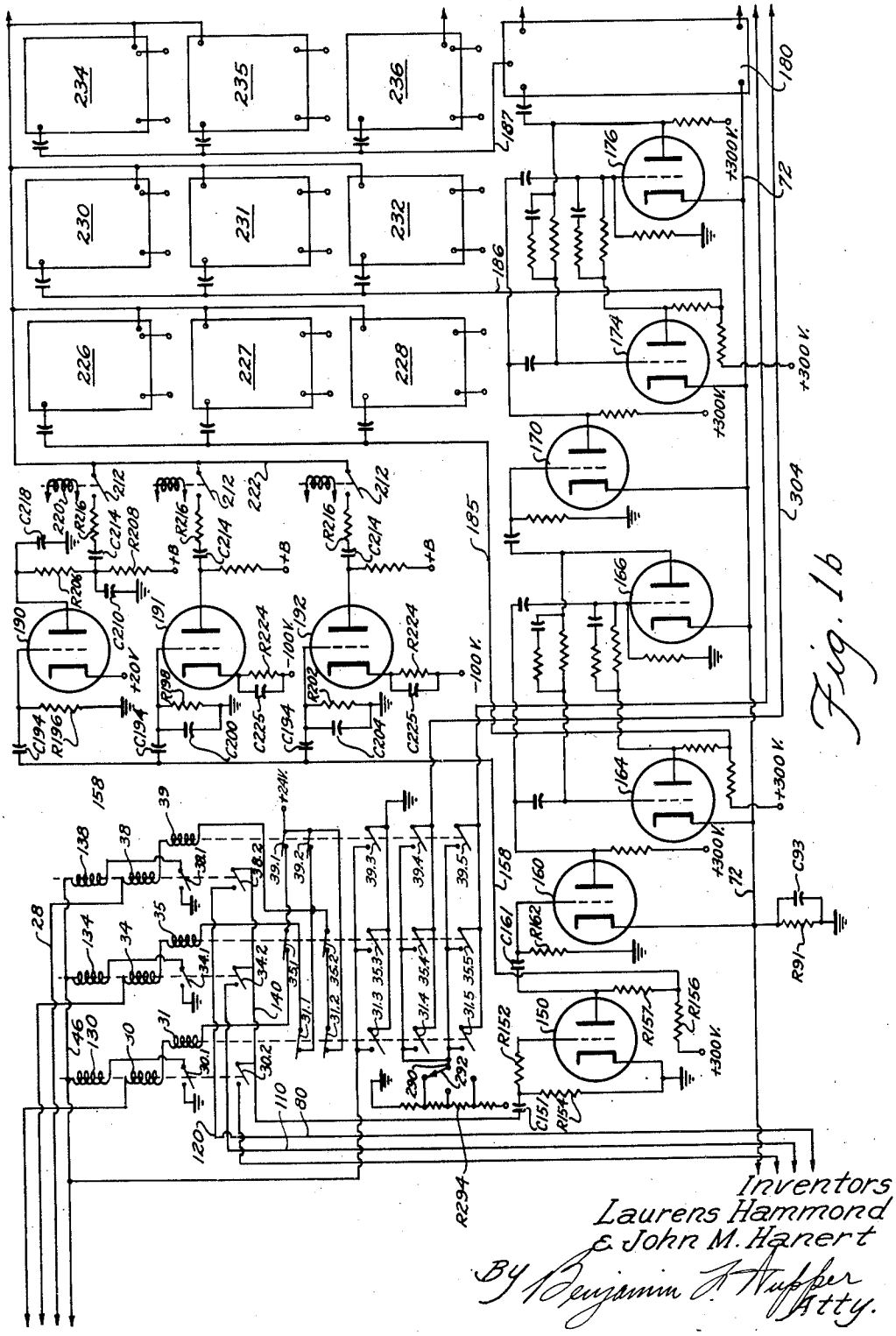


Fig. 1b

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ELECTRICAL MUSICAL INSTRUMENT

Filed May 15, 1946 3 Sheets-Sheet 3

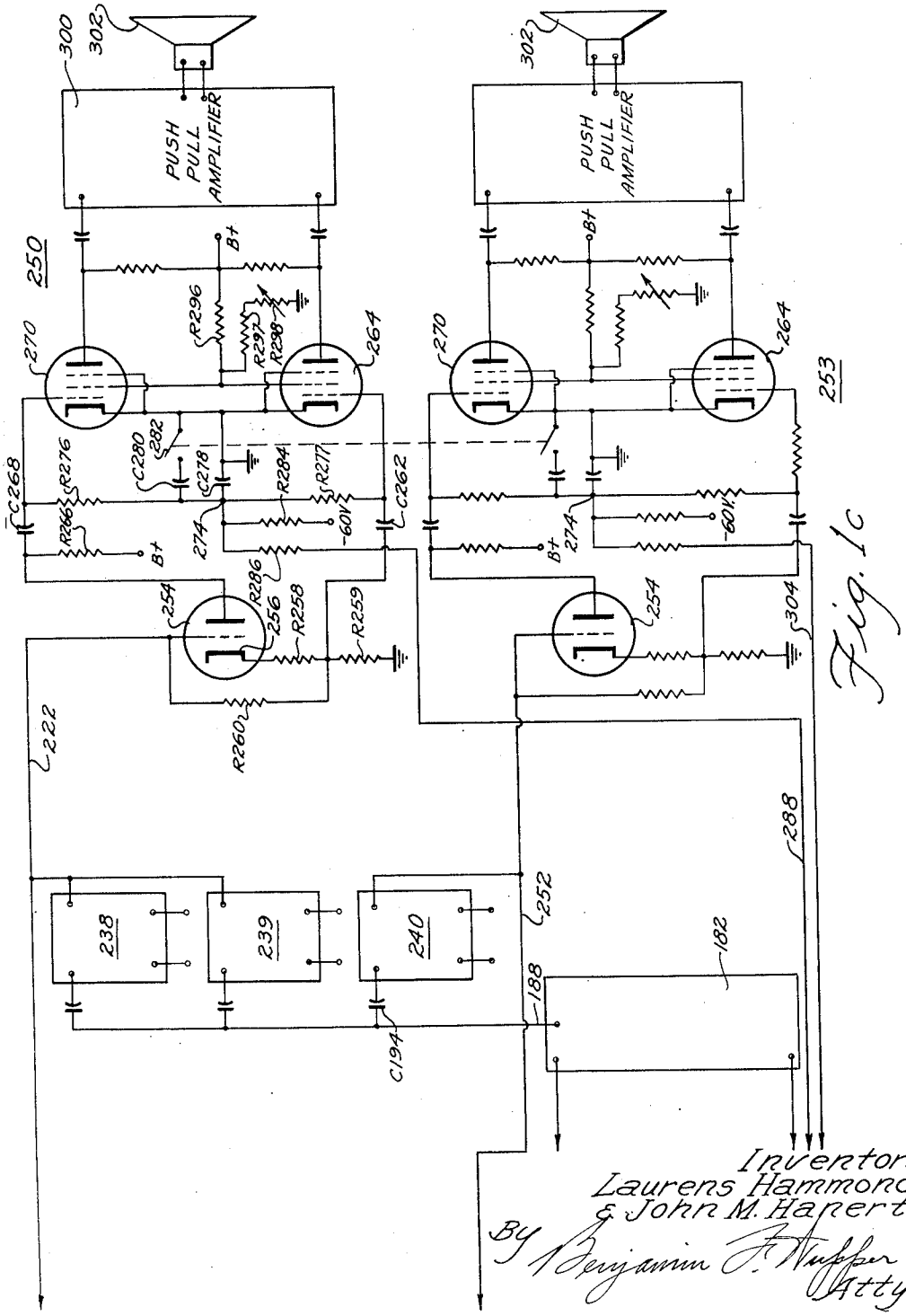


Fig. 1C

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Patented Mar. 21, 1950 2,501,172

UNITED STATES PATENT OFFICE

2,501,172

ELECTRICAL MUSICAL INSTRUMENT

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Application May 15, 1946, Serial No. 669,991

16 Claims. (Cl. 84—1.26)

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Our invention relates generally to electrical musical instruments and more particularly to improvements in means for producing and controlling organ bass tones.

In the conventional pipe organ the pipes for the production of bass tones are necessarily very large and thus expensive, and they require a greater amount of air supply than the smaller treble register pipes, thereby making necessary the use of relatively large power consuming blowers. Similarly in electric organs the production of the bass tones imposes somewhat greater loads upon the electronic components than is imposed by the generation and transmission of tones in the treble register and greater difficulty is experienced in producing bass tones of pleasing quality and of the desired intensity.

Furthermore the bass tones of an electric organ are usually controlled by the pedal clavier, and since one of the player's feet is usually required for the operation of the swell pedal, he is usually forced to depress the pedals in a detached or nonlegato manner. This results in the production of bass tones which are discontinuous. In the rendition of many musical selections this effect is not desirable. This undesirable effect may be partially remedied by the reverberative characteristics of the room in which the instrument is being played, or by the provision of means for introducing the reverberation effect artificially, as for example, by the mechanism disclosed in the prior patent of Laurens Hammond, No. 2,230,836. The addition of such reverberation mechanism adds to the cost of the instrument and does not completely satisfy the musical requirements, because when two pedals are depressed in rapid succession the reverberant decay portion of the tone controlled by the first depressed pedal is heard simultaneously with the initial or attack portion of the tone controlled by the second depressed pedal, so that unless the two tones are harmonically related, a certain amount of dissonance or "muddying" effect is obtained. This undesired simultaneous adding of the two bass tones limits the undistorted output of the amplifier, thus greatly increasing its cost for a given acoustic power output.

To overcome all of these difficulties and disadvantages and high cost encountered in the production of organ bass tones, we have provided an improved bass tone generating, controlling, and producing apparatus which may readily be incorporated in a conventional pipe organ so as to be controlled by the console keys, pedals and registration controls, and may with equal facility be

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incorporated in electric organs to produce the bass tones thereof in a more satisfactory and economical manner than was previously possible.

It is therefore a primary object of our invention to provide an improved organ bass tone generating, controlling, and producing apparatus which is of relatively simple construction, which is reliable in operation, and which is capable of producing musical effects not heretofore attainable by the largest pipe organ or by electric organs.

A further object is to provide an improved organ bass tone generating and controlliwng apparatus whereby the tones may be sounded with predetermined attack and decay characteristics.

A further object is to provide an improved bass tone generating and controlling apparatus wherein upon the release of a depressed pedal of the pedal clavier the tone will continue sounding at a predetermined decay rate until another pedal is depressed, whereupon the note corresponding to the second depressed pedal will commence sounding with a predetermined attack.

A further object is to provide an improved bass tone generating and controlling apparatus which may be connected for operation from the console of the customary pipe organ, in which the electronic portions of the instrument may be located in the pipe loft, or swell chamber, and in which a minimum number of wires is required to connect the bass tone generating apparatus with the organ console.

A further object is to provide an improved bass tone producing electrical musical instrument having an improved relay system for controlling the instrument.

A further object is to provide an electrical musical instrument particularly for the generation of bass tones in which there are three master sources generating frequencies at octave intervals, in which there are a series of cascaded frequency dividers, the output of which may be selectively utilized for the acoustic generation of the tones, and in which relay means are provided to select which of the three frequency generators is to control the frequencies generated by the cascaded series of frequency dividers.

A further object is to provide an attack and decay apparatus which is direct current operated and in which the high frequencies are caused to decay more rapidly than the low frequencies.

A further object is to provide a pedal clavier controlled multi-octave electronic tone generating system of the oscillator and cascaded frequency divider type, in which the tuning range of

the oscillator is small in comparison with the pitch range of the pedal clavier, in which the signal utilization circuits are permanently coupled to a single frequency divider generating system, and in which the several auxiliary frequency dividers associated with the oscillator provide input signals to the main frequency division generating system of sub-octave frequencies relative to the master oscillator frequencies. By this means the tones derived from the main frequency divider generating system are prefectly uniform over the entire range of the pedal clavier and simple single pole signal throw switches may be employed for the various "stops."

A further object is to provide an electric bass tone producing and controlling apparatus in which a plurality of tone qualities may be selectively utilized either one at a time or in any desired combination.

A further object is to provide an inexpensive electric bass tone generating unit which may be incorporated in a pipe organ in the place of the large bass pipes and which will produce tones equivalent to those obtainable by several ranks of pipes.

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

Figures 1*a*, 1*b* and 1*c* together constitute a schematic wiring diagram of the complete instrument.

Referring to Fig. 1*a*, the instrument is controlled by a pedal clavier comprising a plurality of pedals 10 illustrated as 32 in number to cover the frequency range C=32.703 to G2=196.00 C. P. S. when playing at 16' pitch. These pedals constitute the conventional pedals of a pipe organ which has been constructed and installed or may be the pedal clavier of a new pipe organ or electric organ. As in a conventional pipe organ, each of the pedals 10 operates a switch 12. The switches 12 for the first octave are adapted, upon depression of their associated pedals to connect a bus 26 respectively to conductors 14 to 25 respectively, while the pedals 10 of the middle octave of the clavier through their switches 12 connect a bus 27 respectively to the conductors 14 to 25, and the switches 12 for the pedals 10 representing the notes C to G of the highest octave connect a bus 28 respectively with conductors 14 to 21 respectively.

The bus conductor 26 is normally connected through relay windings 30 and 31 and switches 35.1 and 39.1 to a source of energizing current indicated as a +24 v. terminal. Similarly the bus conductor 27 is connected through relays 34 and 35 and switches 31.1 and 39.2 to the +24 v. terminal. The bus conductor 28 is likewise connected through a pair of relay windings 38 and 39 and switches 35.2 and 31.2 to the +24 v. terminal.

Each of the conductors 14 to 25 is connected to ground through relay winding 40. Thus when any of the pedals 10 is depressed to close its switch 12, a circuit will be completed through one of the relay windings 40 and through the relay windings 30—31, 34—35 or 38—39, depending upon the particular key depressed.

When any of the relay windings 40 is energized it closes its associated switch 42 thereby completing a circuit from ground through a holding winding 44, switch 42, a conductor 46, resistor R48 to a source of operating potential, indicated as a +24 v. terminal.

Energization of one of the relays 40 also effects closure of a tuning switch 50. One pole of each of the tuning switches 50 is connected to a grounded conductor 52 while their other poles are respectively connected to the junctions between a series of tuning capacitors C54. These capacitors C54 are connected in series between ground and a terminal 56 of a variable tuning inductance L58, the other terminal of which is connected to ground. Inductance L58 forms part of an oscillator comprising a pentode 60 having its control grid 61 connected to the terminal 56 through a capacitor C62 which is shunted by a grid leak resistor R64. The cathode of pentode 60 is connected to ground through an inductance L66 which is in mutually inductive relation with L58. The suppressor grid of pentode 60 is connected to the cathode thereof while the screen grid 70 is connected to a conductor 72. The plate 74 of pentode 60 is supplied with plate current from a suitable potential source indicated as a terminal +300 v. through load and voltage dividing resistors R75 and R76 connected in series, the junction of these resistors having a signal conductor 80 connected thereto.

A pulse sharpening and rectifying triode 84 has its grid 86 connected to the plate 74 through a blocking capacitor C88 and is connected to ground through a grid resistor R90. The cathode of triode 84 is connected to conductor 72 while the plate thereof is connected to the suitable source of plate potential indicated as +300 v. through a load R92. Cutoff bias is provided by a parallel resistor R91 and capacitor C93 connecting conductor 72 to ground. (Fig. 1*b*.)

The negative pulses appearing at the plate of triode 84 is impressed upon the control grids of alternate pulse responsive frequency dividing triodes 94 and 95 through capacitors C96 and C97. The grid of a triode 94 is connected to the plate of triode 95 through a mesh comprising series resistor R98 and capacitor C99 having a resistor R100 in parallel therewith. Similarly the grid of triode 95 is connected to the plate of triode 94 through a mesh comprising R101 and C103 in series and R102 in parallel therewith. The grids of triodes 94 and 95 are connected to ground respectively through R106 and R107. The plate of triode 94 is connected to a +300 v. source of plate potential through R108 and R109, the junction point of these resistors having a signal conductor 110 connected thereto. The plate of triode 95 is connected to a source of plate current shown as +300 v. through a load resistor R112.

A pulse sharpening and rectifying triode 114 is coupled to the output of triode 95 in the same manner as the triode 84 is coupled to the output of pentode 60, and the triode 114 supplies sharp unidirectional negative impulses for the operation of an alternating pulse responsive frequency dividing triodes 116 and 118, which have associated circuit elements similar to the triodes 94 and 95, and function in the same manner. The signal from the triode 116 is obtained through a conductor 120 connected to the junction of plate load resistors R122 and R123 of the triode 116.

When the relay 30 is energized by the depression of a pedal in the lowermost octave of the clavier it closes its switch 30.1 and thereby completes a circuit through a holding winding 130, this circuit being traced from the grounded pole of switch 30.1 through the winding 130, conductor 46, R48 to the +24 v. terminal. Similarly, energization of relay winding 34, upon depression of a pedal in the middle octave, by closure of its switch 34.1 energizes a holding winding 134, and

holding winding 138 is similarly energized through closure of switch 38.1 upon depression of a pedal in the incomplete highest octave. Energization of the relay 30 also results in closure of its switch 30.2 thereby connecting signal conductor 120 to conductor 140. Similarly, energization of relay 34 by closure of a switch 34.2 connects signal conductor 110 to the conductor 140 and energization of relay 38 by closure of switch 38.2 connects conductors 80 and 140.

Energization of the relay 31 also effects closure of switches 31.3, 31.4 and 31.5. Similarly energization of relay 35 causes closure of switches 35.3, 35.4 and 35.5, and energization of relay 39 causes closure of switches 39.3, 39.4 and 39.5. The function of this latter group of switches will be explained hereinafter, it being necessary merely to mention here that the relays 31, 35 and 39 are "fast operating," that is, they close rapidly and open rapidly relative to the speed of operation of the relays 40—44, 130—30, 134—34, and 138—38. The time differential in the operation of these relays is sufficient that when a pedal 10 is released to open its switch 12 the relay 31 (35 or 39) will be deenergized and the switch contacts 31 and 31.2 will close and its switch contacts 31.3, 31.4 and 31.5 will open, all before the associated relays 40—44 and 130—30 become deenergized to permit opening of the switches operated thereby. Thus, whichever of the switches 31.3, 35.3 and 39.3 was closed by the energization of its relay will, upon release of the depressed key, open, and thus disconnect the ground from conductor 46 so that potential will be available to retain the holding relay winding 44 of the last depressed pedal in energized condition and the switches 42 and 50 thereof will remain closed, and thus the oscillator 60 will remain tuned to the frequency represented by the last pedal which was depressed.

It will be noted that the relays 40, 44 for the two "B" pedals are not provided with a switch 50, so that upon initially supplying current to the instrument as a whole the oscillator 60 will be tuned to the frequency of the note B.

From the foregoing it will appear that when a pedal in the lowermost octave is depressed the signal from the lowest alternate pulse responsive divider stage comprising the triodes 116 and 118 will be impressed upon the conductor 140 by closure of switch 30.2, that when the pedal depressed is in the middle octave range, the signal from the intermediate frequency divider stage comprising triodes 94 and 95 will be impressed upon the conductor 140 by closure of switch 34.2, and that when a pedal in the highest octave range is depressed a signal from the oscillator 60 will be impressed upon the conductor 140 due to closure of switch 38.2.

Since each of the divider stages divides by the factor 2, the signals produced thereby will be in octave relationship. These signals when impressed upon conductor 140 are supplied as the input signal to a rectangular wave distorting triode 150 through a blocking capacitor C151 and series grid resistor R152. The grid of the triode 150 is connected to ground through the series resistor R152 and a resistor R154. The cathode of this triode is connected to ground, while the plate thereof is connected to a suitable source of plate potential, indicated as +300 v., through series voltage dividing load resistors R156 and R157, the junction of these resistors having a conductor 158 connected thereto.

The signal supplied by the triode 150 is impressed upon the grid of triode 160 through a blocking capacitor C161, and this grid is connected to ground through a grid resistor R162. The rectifying triode 160 functions in the same manner as the triodes 84 and 114 and is similarly connected to a pair of alternate pulse responsive triodes 164 and 166 constituting the first stage of an alternate pulse responsive frequency divider system. The second stage of this system comprises a pulse sharpening and rectifying triode 170 which supplies a signal pulse to the pair of triodes 174 and 176 which constitute the second stage of the frequency dividing system. The third stage is indicated by a block 180 while the fourth and last stage is indicated by a block 182.

The output signal from the first divider stage is impressed upon a conductor 185, that from the second dividing stage upon a conductor 186, that from the third and fourth stages upon conductors 187 and 188 respectively. The signal appearing on the conductor 188 will thus have a fundamental frequency corresponding to that of the note of the depressed pedal while the signal appearing upon the conductors 187, 186, 185 and 158 will have fundamental frequencies corresponding to the second, fourth, eighth and sixteenth harmonics respectively of the depressed pedal. The fundamental frequencies appearing upon the conductors 188, 187, 186, 185 and 158 will therefore be, in pipe organ terminology, of 32 foot, 16 foot, 8 foot, 4 foot, and 2 foot pitches.

The signal appearing on a conductor 158 is impressed upon the inputs of three triodes 190, 191 and 192 respectively through blocking capacitors C194. These triodes have associated with their input circuits different types of meshes, the mesh associated with the triode 190 being a simple grid resistor R196, that associated with triode 191 comprising a grid resistor R198 having a capacitor C200 in parallel therewith, while the mesh associated with input of pentode 192 constitutes a resistor R202 in parallel with a capacitor C204.

The plate of the triode 190 is connected to a suitable source of plate potential through voltage dividing load resistors R206 and R208, the junction of these resistors being connected to ground through a high frequency by-pass capacitor C210 and connected to a pole of a switch 212 through a blocking capacitor C214 in series with a resistor R216. A capacitor C218 also serves as a second stage of high frequency by-pass from the plate of triode 190 to ground. The switch 212 forms part of a relay 220 energized from the suitable stop tablet operated switch forming part of the organ console. In electrical musical instruments the switch 212 may be located at the console and manually operated.

The switch 212 for the output of triode 190, when closed, forms a path for the transmission of the signal to an output conductor 222. Thus upon closure of this switch 212, a very bright trombone-like tone having both odd and even harmonics will be impressed upon the conductor 222. It will be noted that the cathode of triode 190 is at a relatively high positive potential, being connected to a +20 v. terminal, thereby rectifying its current-limited symmetrical input wave (composed of odd harmonics only) to produce an assymmetrical output wave having both odd and even harmonics.

The triodes 191 and 192, similar to the triode 190, are adapted to have their plates connected to the signal conductor 222 upon closure of relay

switches 212, completing a circuit from the plates of these tubes through resistors R216 and blocking capacitors C214. The cathodes of triodes 191 and 192 are connected to a source of negative potential, indicated as a terminal —100 v., through self-bias resistors R224, having capacitors C225 in parallel therewith. The values of the circuit elements associated with the triodes 190, 191 and 192 are such that the signal output appearing on the conductor 222 from the triode 190 is a very bright trombone-like tone, that from the triode 191 is intermediately bright diapason-like while that from the triode 192 is a much less bright flute-like tone.

In a similar manner the symmetrical odd-harmonic signal supplied by conductor 185 may be modified through selective utilization of triodes and associated meshes similar to the triodes 190, 191 and 192 and their connected circuit elements, these tone modifying meshes being represented by blocks 226, 227, 228. Similar tone quality and modifying meshes 230, 231 and 232 are connected with the conductor 186. The signal supplied by the conductor 187 may be modified by selective utilization of meshes 234, 235 and 236, while the signal supplied to the conductor 188 may be selectively modified by utilization of meshes 238, 239 and 240.

The tone modifying meshes 226, 230, 234 and 238 are similar to those associated with the triode 190. The tone modifying meshes 227, 231, 235 and 239 are similar to those associated with the triode 191, and the meshes 228, 232, 236 and 240 are similar to those associated with triode 192.

The amplifying system 250 for the signals appearing upon the conductor 222 comprises a triode 254 operating as a phase splitter with its cathode 256 connected to ground through series voltage dividing resistors R258 and R259. The junction of these resistors is connected to the grid through grid resistor R260 and this junction is also connected through a blocking capacitor C262 with the input of a remote cut-off variable mu pentode 264. The plate of triode 254 is supplied with current through plate load resistor R266 and the signal is transmitted through a blocking capacitor C268 to the control grid of a second variable pentode 270. The pentodes 264 and 270 are thus supplied with the signal in push pull. The cathodes of these pentodes are connected to ground, as are their suppressor grids, while the grids thereof are connected to a terminal 274 through grid resistors R276 and R277. The terminal 274 is connected to ground through an attack and decay capacitor C278 which is adapted to have a capacitor C280 connected in parallel therewith upon closure of a switch 282 which may be relay operated. The terminal 274 is connected to a suitable cutoff biasing potential source, indicated as a terminal —60 v., through a resistor R284. The terminal 274 is also connected through an attack resistor R286 with a conductor 288 which, it will be noted, is connected to one pole of each of the switches 31.5, 35.5 and 39.5.

The other poles of these switches are connected to a conductor 290, the potential of which is determined by the position of a three-position switch 292 cooperating with taps on a voltage divider R294 for providing graded voltages such as 5, 10 and 20 volts. The screen grids of pentodes 264 and 270 are connected to a terminal +B through a voltage dropping resistor R296 and are connected to ground through series fixed resistor R297 and variable resistor R298, the adjustment of the latter determining the cut-off of the pentodes 264 and 270, so as to prevent the transmission of a signal when no pedal is depressed. The plates of these pentodes are supplied with operating potentials in the customary manner and the output signal thereof is impressed upon the input of a push-pull power amplifier 300 which supplies current to a speaker 302.

The amplifier 253 for the signals appearing on the conductor 252 from meshes 236 and 240 is similar to the amplifier 250 except that the values of the various components are different so as to permit more efficient transmission and amplification of the lower frequencies.

The amplification system 253 differs from the amplification system 250 in several important respects. As shown in the diagram the signals supplied to the amplifier 253 comprise the Bourden 16 foot tone as well as the sub-bass 32 foot tone. These extremely pure low frequency tones require a very great amount of acoustical energy to radiate the sound at an audible level. If an attempt were made to combine electrically tones such as the diapasons and trombones with these deep tones, cross modulation would occur unless an extremely linear and powerful amplifier, as well as a very extensive speaker system, were supplied. By means of the arrangement shown in Fig. 1c these low frequencies are produced through a separate amplifier and loudspeaker system. This amplifier and loudspeaker system produces a considerable of harmonic distortion (especially the loudspeaker system) which is of no importance musically as it merely introduces a small quality modifying effect.

Another important reason for providing two independent bass tone amplifying systems is to make it possible to have the two Bourden tones associated with amplifier 253 decay at a rate approximately one third that of the bright tones produced by the amplifying system 250. This is extremely important musically as otherwise the ear would interpret the tone quality as changing as it decayed away. In order to produce uniform quality of tone during the decay period it is important that the very low frequencies decay much more slowly than the high frequencies. Furthermore, it is desirable that the low frequencies in the bass tones decay slowly relative to their high frequencies so that the clarity of the music being played on the manuals of the organ shall not be blurred by the persistence of the high frequencies in the bass tones. On the other hand, it is highly desirable that the low frequencies of the bass tones persist for a relatively long period of time so as to facilitate legato pedal playing.

The sizes of the amplifiers 250 and 253 will vary, depending upon the size of the auditorium in which the bass tones are to be radiated. In general the amplifier 253 will be approximately four times as powerful as the amplifier 250. Similarly the speakers for the amplifier system 250 may be adapted for high frequency radiation and have relatively low power acoustic output as compared to the bass speakers for the amplifier system 253. The latter are preferably of heavier construction and may be operated with a considerable degree of non-linearity for the sake of increased efficiency.

In view of the similarities, the amplifier 253 will not be described in detail and similar reference characters have been applied to some of the corresponding parts. The potential on the terminal

274 of the amplifier 253 is determined by the potential on conductor 304, which is connected to one pole of each of the switches 31.4, 35.4 and 39.4 while the other terminals of these switches are connected to the conductor 290.

As previously stated, the apparatus of the invention is to be utilized in conjunction with the pipe organ or electric organ to provide means for producing and controlling the bass register tones thereof. Thus the instrument is played by the musician using the same technique as is employed in playing pipe organs and electric organs. Whenever a pedal is depressed, as for example pedal "A" in the lowermost octave, the closure of its switch 12 results in the energization of its associated relay windings 40, 44 thereby closing the associated switches 42 and 50. The closure of its switch 50 results in tuning the oscillator 60 to the required "A" frequency. As a result divider stages 94—95 and 116—118 successively divide the frequency of the oscillator 60 by 2, and these sub-multiple frequencies are impressed upon the conductors 80, 110 and 120 respectively.

Closure of the switch 12 also results in energization of the relay 30—130 and relay 31. The energization of relay 30 establishes a holding circuit through the winding 130 by closure of switch 30.1. Energization of relay 31 results in opening the circuits for relay windings 34, 35 and 38, 39 by opening switches 31.1 and 31.2. Therefore if any pedal in the middle or highest octave of the clavier is depressed the closure of its switch 12 will be incapable of completing circuits through the latter relay windings or through the relay windings 40, 44 associated with the tuning circuits.

The energization of relay 30, by its closure of switch 30.2, selects the output signal from the frequency divider 116, 118 by connecting conductor 120 to the input of the box wave pulse sharpening triode 150. Therefore the four stages of frequency dividers controlled by the triode 150 will operate at the frequency "A" of the four lower octave pitches corresponding to the 4, 8, 16 and 32 foot pitches. The signals supplied by these four frequency dividing stages together with the output of the 2 foot output of triode 150, are impressed upon their tone modifying meshes, and depending upon which of the stops on the organ console are operated to energize the circuits of the relays 220, the signals will be supplied to conductors 222 and 252 and impressed on the input circuits of amplifiers 250 and 253.

Energization of the relay 31 by closure of its switches 31.4 and 31.5 impresses a potential, predetermined by the adjustment of the volume control voltage divider R294, upon the control grids of the push pull amplifier pentodes 264 and 270 in the manner previously described. The potential on these control grids builds up gradually due to the attack resistors R286 and attack and decay capacitors C278 and optionally connected capacitor C280. The tone is thus produced by the speakers associated with the amplifiers 250 and 253 with a tonal intensity envelope having gradual attack and gradual decay characteristics.

The control of the overall intensity of the output of the instrument is effected by operation of the swell shutters of the pipe organ swell box in the customary manner, since the speakers 302 are located in the swell chamber of the pipe organ. When the instrument is used in conjunction with an electric organ the volume control may be effected in any suitable manner, as by varying the potentials applied across the volume control voltage divider R294.

If as above assumed, the "A" pedal of the lower octave is depressed, and if this pedal is held depressed and another lower pedal depressed, the only effect will be that the tuning of the oscillator 60 will be changed to accord with the pitch associated with the second depressed pedal. The tonal output of the instrument will thus be changed in pitch but unchanged in volume and the tone produced upon depression of the second depressed pedal will not have slow attack but will merely continue at the same steady intensity level. If a higher pedal in the same octave as a previously depressed pedal is operated, it will not have any effect.

While we have shown and described a particular embodiment of our 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 the invention. We therefore desire, by the following claims, to include within the scope of our 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.

We claim:

1. In an electrical musical instrument having a source capable of supplying signals of musical scale frequencies throughout a range of several octaves, and a tone signal generating system controlled by the source and including a plurality of cascaded frequency divider stages, each of the latter operating to halve its input frequency; the combination of a plurality of pedals constituting a pedal clavier of a range of several octaves, means operable upon the depression of one of the pedals to cause a signal of corresponding frequency from the source to be impressed upon the first stage of the tone signal generating system thereby to control the frequency at which the latter operates, an output system including electroacoustic translating means, and means for selectively coupling one or more stages of the tone signal generating system to the output system.

2. In an electrical musical instrument, an oscillator for supplying signals of musical scale frequency throughout the range of several octaves, a tone signal generating system including a plurality of cascaded frequency divider stages, each operating to halve its input frequency, several octaves of playing pedals, means operable upon the operation of any of the pedals to cause a signal of pitch corresponding to that of the operated pedal to be impressed upon the first stage of the tone signal generating system to control the pitches at which the latter operates, an output system including electroacoustic translating means, and means for selectively coupling the stages of the tone signal generating system to the output system.

3. In an electrical musical instrument having a plurality of groups of playing keys, a plurality of relatively slow-operating note relays of number corresponding to the number of keys in a group, a holding circuit for each of said relays, switches respectively operable by said keys, energizing circuits for each of the note relays completed respectively upon closure of the switches of the different groups of keys corresponding in position in their groups to the position of the relay in its group, a fast-operating group relay associated with each group of keys, circuits for

energizing the group relays in response to the operation of any of the keys in its associated group, a source of electrical tone signals, means controlled by the slow-operating note relays to cause said source to provide tone signals of octavely related frequencies, an output system including an amplifier and electroacoustic translating means, and means controlled by the group relays to cause the amplifier to transmit the tone signals provided by the source.

4. In an electrical musical instrument having an output system including an amplifier and electroacoustic translating means, the combination of a keyboard comprising a plurality of keys, a plurality of switches, one for each of the keys and operable thereby, a plurality of first relays and a plurality of second relays energized upon the operation of the switches, circuits connecting the switches and relays to cause one of the first relays to be energized upon depression of corresponding note designation keys in different octaves and to cause one of the second relays to be energized upon operation of any of the keys in a given octave, said first relays being of slow release type and the second relays being of the fast release type, an electrical tone signal generating system, means controlled by the first relays to determine the pitch of the tone signal produced by the generating system, means operated by the second relays to control the gain of the amplifier to cause it to transmit the tone signals with a predetermined decay, whereby when a key is released the tone signal will continue to be supplied to the amplifier during its decay period.

5. In an electrical musical instrument having a tone signal generating system, a pair of output channels each including an amplifier and a speaker, playing keys, means controlled by the playing keys to cause tone signals from the generating system of the lowest frequencies to be transmitted to one of the amplifiers and signals of higher frequencies to be transmitted to the other amplifier, a tone intensity envelope controlling means associated with each of the amplifiers, the envelope controlling means for the amplifier of the lowest frequencies producing a relatively slow decay while that for the higher frequency amplifier produces a rapid decay, and means controlled by the keys for rendering effective both of the tone intensity envelope controlling means.

6. In an electrical musical instrument, the combination of an oscillator, a plurality of cascaded frequency halving stages coupled to the output of the oscillator, a second group of cascaded frequency halving stages, a pedal clavier comprising several octaves of pedals, means operable upon depression of one of the pedals to tune the oscillator to a frequency corresponding with the pedal in note designation but not necessarily in the same octave range, means operable upon depression of a pedal to couple the output of either the oscillator or of one of its associated frequency halving stages to the input of the second group of frequency halving stages, an output system including an amplifier and electroacoustic translating means, and means for selectively coupling the outputs of said second group of frequency halving stages to the output system.

7. The combination set forth in claim 6 in which means are provided to maintain the oscillator tuned to the frequency to which it was tuned by a depressed pedal until the depression of a second pedal which requires that it be tuned to a different frequency.

8. In an electrical musical instrument, the combination of an oscillator, a plurality of cascaded frequency halving stages coupled to the output of the oscillator, a second group of cascaded frequency halving stages, a pedal clavier comprising several octaves of pedals, means operable upon depression of one of the pedals to tune the oscillator to a frequency corresponding with the pedal in note designation but not necessarily in the same octave range, means operable upon depression of a pedal to couple the output of either the oscillator or of one of its associated frequency halving stages to the input of the second group of frequency halving stages, an output system including two amplifiers and two electroacoustic translating means, means for selectively coupling the lowest frequency output of said second group of frequency halving stages to one of the amplifiers of the output system and for coupling the higher frequency output to the other amplifier, slow decay control means forming a part of the amplifier for the lowest frequencies, relatively rapid decay control means for the other amplifier, and means controlled by the depression of a pedal to render effective both of said decay control means.

9. An electrical musical instrument for the production of organ bass tones and having an output system including an amplifier and electroacoustic translating means, the combination of a pedal clavier having pedals extending through more than one octave range, a switch associated with each of the pedals and operated thereby upon depression of the pedal, an electrical tone signal generating system having means for tuning it to generate any musical tone signal within the range of an octave together with a signal an octave lower in pitch, an octave series of tuning relays each having a holding circuit and connected to be energized upon the closure of a pedal switch of corresponding note designation in any octave of the pedal clavier, said tuning relays including means operative to tune the generating system, an octave selecting relay for each octave of pedals connected to be energized upon the operation of any of the pedal switches in its associated octave of pedals, circuits associated with said octave relays to prevent energization of more than one of them at one time, said octave relays operating rapidly with respect to the speed of operation of the tuning relays, whereby the tuning relays will remain in energized condition after the octave relays have released, and means controlled by the octave relays to cause transmission of the signal to the output system with controlled attack and decay.

10. In an electrical musical instrument having a pedal clavier consisting of a plurality of octaves of pedals, an electrical tone signal generating system providing a plurality of signal frequencies in octave relationship and tunable to frequencies of the notes of the musical scale throughout ranges of an octave, note relays operated upon depression of a pedal in any octave to tune the generating system to a pitch corresponding in note designation with that of the depressed pedal, octave relay means associated with each octave of pedals and operable to select the proper octave tone signal from the generating system, an output system including an amplifier and electroacoustic translating means, and means operable by the octave relays to couple the generating system to the output system and

to render the amplifier capable of transmitting the signal.

11. In an electrical musical instrument having a pedal clavier consisting of a plurality of octaves of pedals, an electrical tone signal generating system providing a plurality of signal frequencies in octave relationship and tunable to frequencies of the notes of the musical scale throughout ranges of an octave, note relays operated upon depression of a pedal in any octave to tune the generating system to a pitch corresponding in note designation with that of the depressed pedal, a holding circuit for each of the note relays, octave relays associated with each octave of pedals and operable to select the proper octave tone signal from the generating system, means associated with the octave relays to prevent energization of more than one of them at a time, an output system including an amplifier and electroacoustic translating means, and means operable by the octave relays to couple the generating system to the output system and to render the amplifier capable of transmitting the signal.

12. In an electrical musical instrument, the combination of a frequency source capable of producing the frequencies of the notes of the musical scale throughout the range of an octave, a series of cascaded frequency halving stages, a pedal clavier comprising several octaves of pedals, means operable upon depression of one of the pedals to cause the frequency source to impress a frequency, corresponding with the depressed pedal in note designation but not necessarily in the same octave range, upon the input to the series of frequency halving stages, an output system including an amplifier and electroacoustic translating means, and means for selectively coupling the outputs of said series of frequency halving stages to the output system.

13. In an electrical musical instrument, the combination of a frequency source capable of producing the frequencies of the notes of the musical scale throughout the range of several octaves, a series of cascaded frequency halving stages, a pedal clavier comprising several octaves of pedals, means operable upon depression of a pedal to cause the frequency source to impress a frequency corresponding with that of the note designation of the depressed pedal upon the input of the series of frequency halving stages, an output system including a normally cut-off amplifier and electroacoustic translating means, means for selectively coupling the outputs of said series of frequency halving stages to the output system, and means controlled by the depressed pedal to render the amplifier capable of transmitting a signal.

14. A bass tone producing system for organs comprising a pedal clavier, an electrical bass tone signal generating system capable of simultaneously producing complex wave signals of several pitches octavely related to the nominal pitch of a pedal of the clavier upon depression thereof, said generating system having a first output circuit for the lower pitch bass tone signals and having other output circuits for the intermediate and higher pitched bass tone signals, a high power output amplifier for the bass tone signals of lower pitches, a speaker coupled to the output of the amplifier and constructed for efficient radiation of the lowest frequencies, a second amplifier and speaker constructed for efficient amplification and sound radiation of the intermediate and higher pitched bass tone signal, and a plurality of tone quality modifying meshes for coupling the first output circuit of the tone signal generating system to the high power amplifier and for coupling the other output circuits to the second amplifier.

15. A bass tone producing system for organs, comprising a pedal clavier, an electrical bass tone signal generating system capable of simultaneously producing complex wave signals of several pitches octavely related to the nominal pitch of a pedal of the clavier upon depression thereof, said generating system having a first output circuit for the lower pitched bass tone signals and having other output circuits for the intermediate and higher pitched bass tone signals, a high-power output amplifier for the bass tone signals of lower pitches, a speaker coupled to the output of said amplifier and constructed for efficient radiation of the lower pitched signals, a second amplifier and speaker constructed for efficient amplification and radiation of the intermediate and higher pitched bass tones, selectively operable means effective to couple the first output circuit of the generating system to the high-power amplifier and to couple the other output circuits of the tone signal generating system to the second amplifier, and means connected with said amplifiers and operable upon the release of a depressed pedal to cause slow decay of the tone signals transmitted by the first amplifier and relatively rapid decay of the tone signals transmitted by the second amplifier.

16. In an electrical bass tone generating musical instrument, the combination of a plurality of pedals constituting a pedal clavier, a tone signal generating system capable of simultaneously producing tones of different octavely related pitches, a first amplifier for the lower pitched bass tone signals, a second amplifier for the higher pitched bass tone signals, the first of said amplifiers having a slow attack and slow decay control circuit associated therewith, said second amplifier having a relatively fast attack and fast decay circuit associated therewith, means controlled by the depression of a pedal to effect transmission of the lower pitched bass tone signals to said first amplifier and transmission of the higher pitched tone signals to the second amplifier, and means controlled respectively by the depression and release of a pedal to render effective the attack and decay control circuits of both amplifiers.

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