Jan. 23, 1951 M. GRUDIN 2,539,130

ELECTRICAL MUSICAL INSTRUMENT

Filed March 4, 1948 4 Sheets-Sheet 1

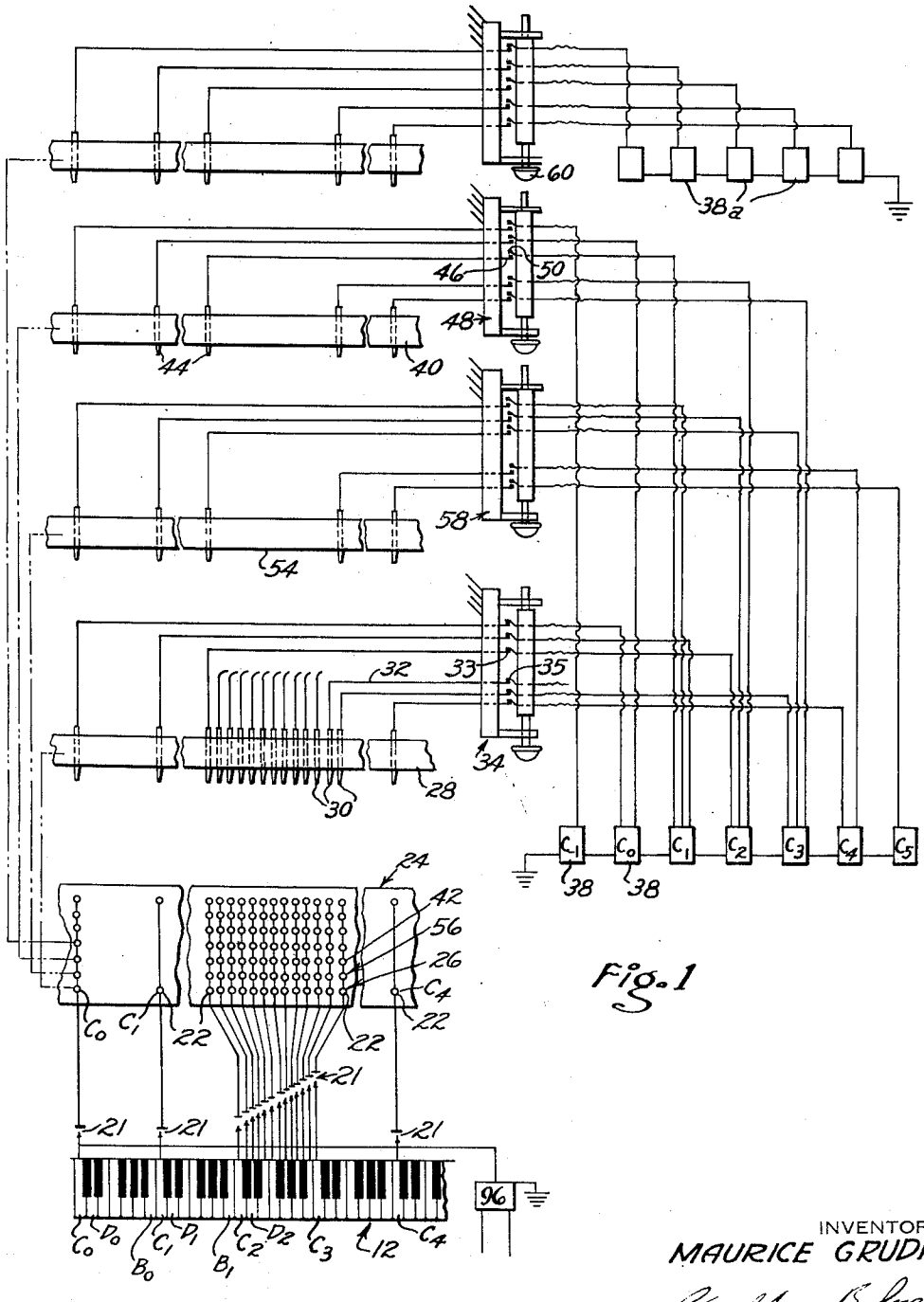

Fig. 1

INVENTOR.
MAURICE GRUDIN

BY Godfrey B. Speir

ATTORNEY.

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ELECTRICAL MUSICAL INSTRUMENT

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Fig. 2

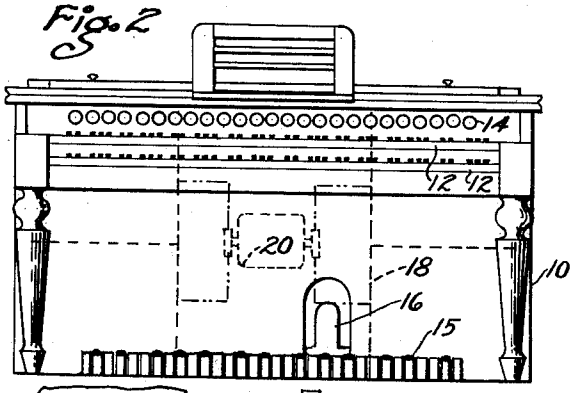
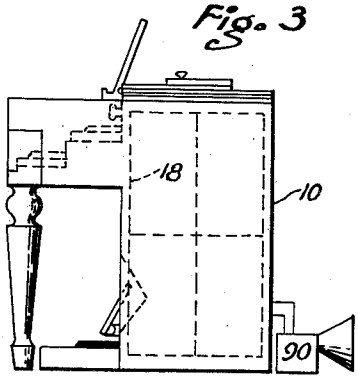


Fig. 3



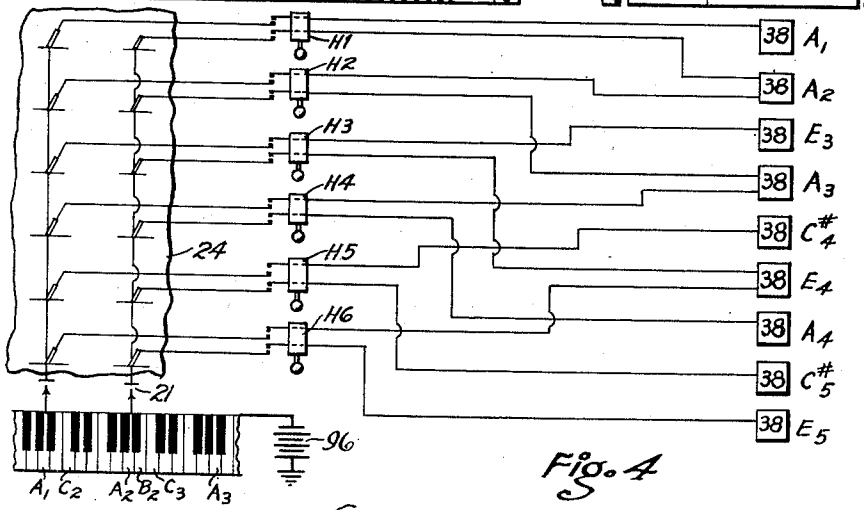


Fig. 4

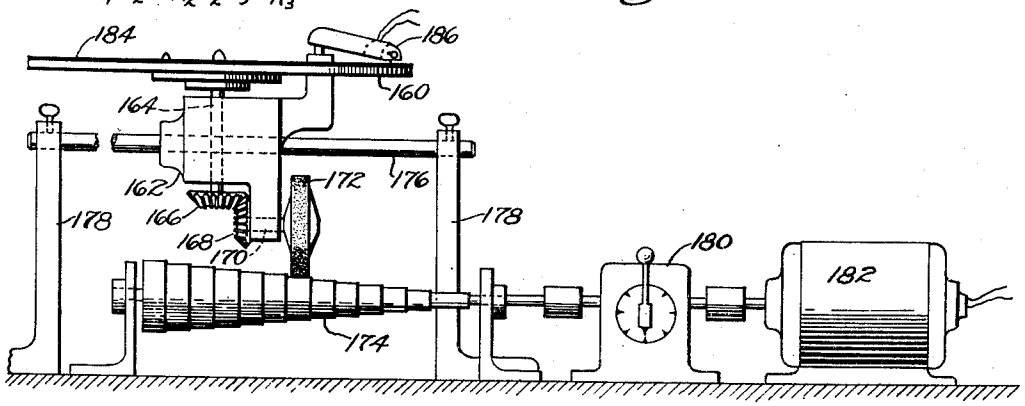


Fig. 14

INVENTOR.
MAURICE GRUDIN

BY Godfrey B. Spein

ATTORNEYS.

Jan. 23, 1951 M. GRUDIN 2,539,130

ELECTRICAL MUSICAL INSTRUMENT

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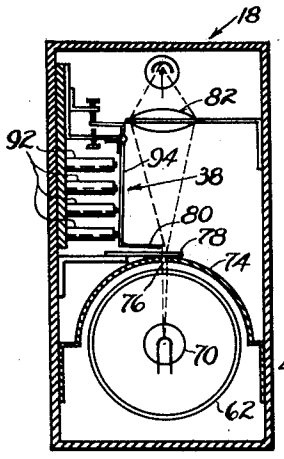

Fig. 5

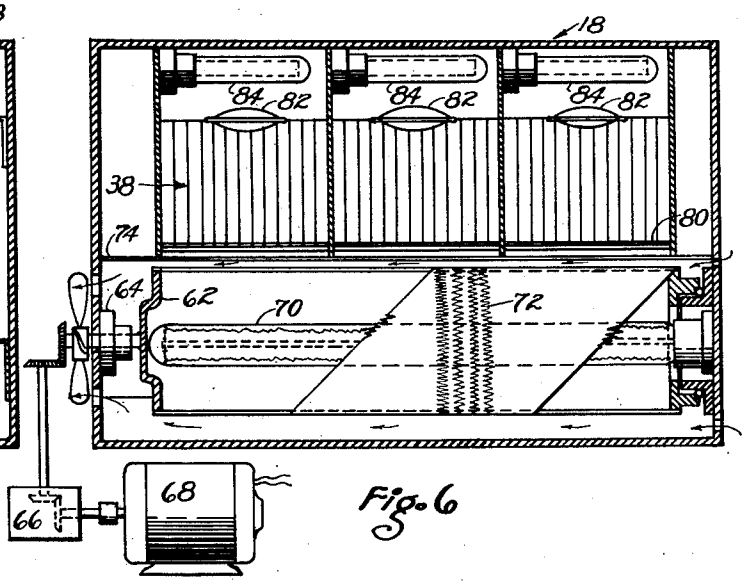

Fig. 6

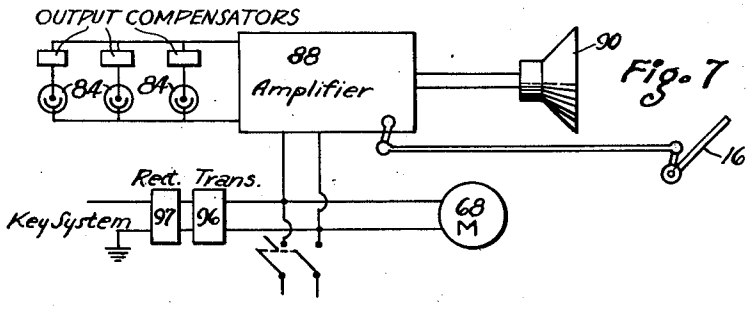

Fig. 7

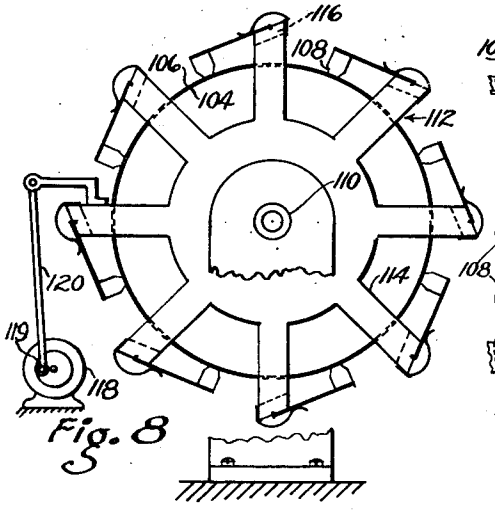

Fig. 8

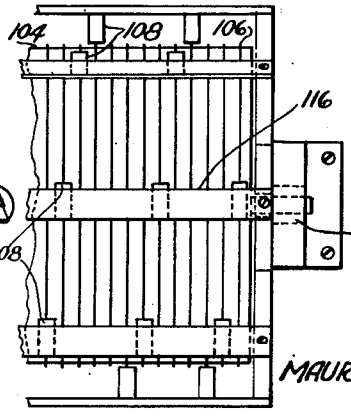

Fig. 9

INVENTOR.
MAURICE GRUDIN

BY Godfrey & Spencer
ATTORNEYS.

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ELECTRICAL MUSICAL INSTRUMENT

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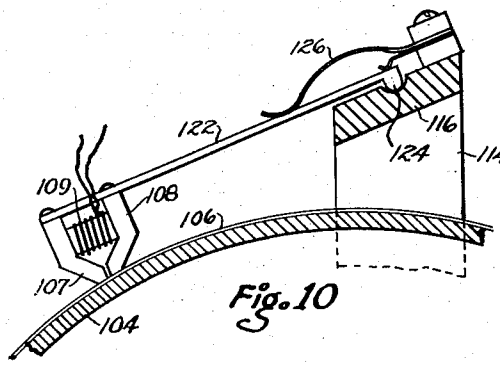

Fig. 10

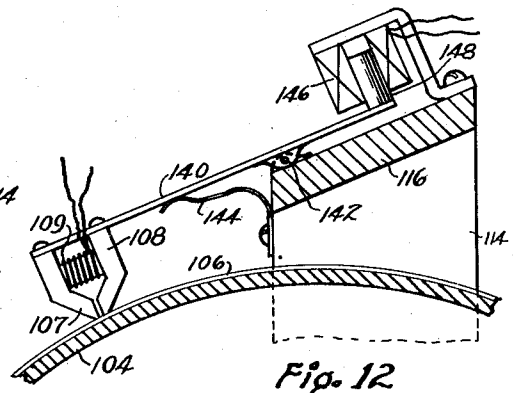

Fig. 12

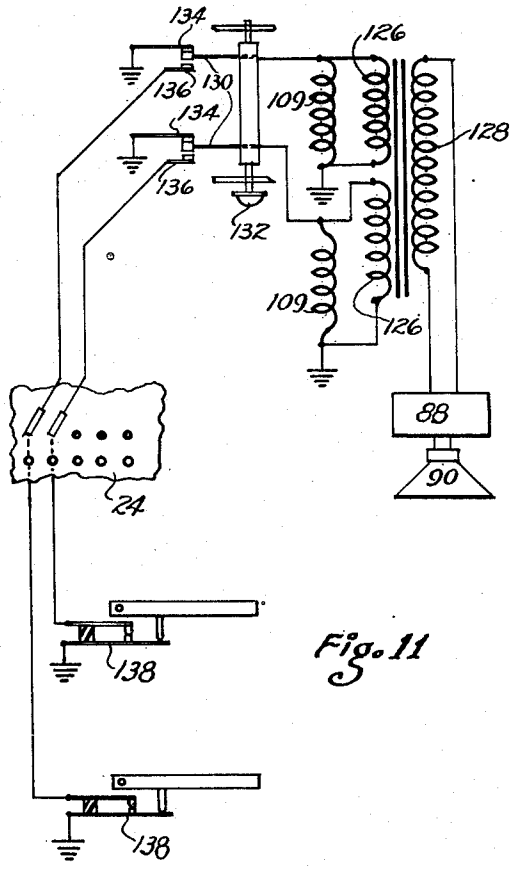

Fig. 11

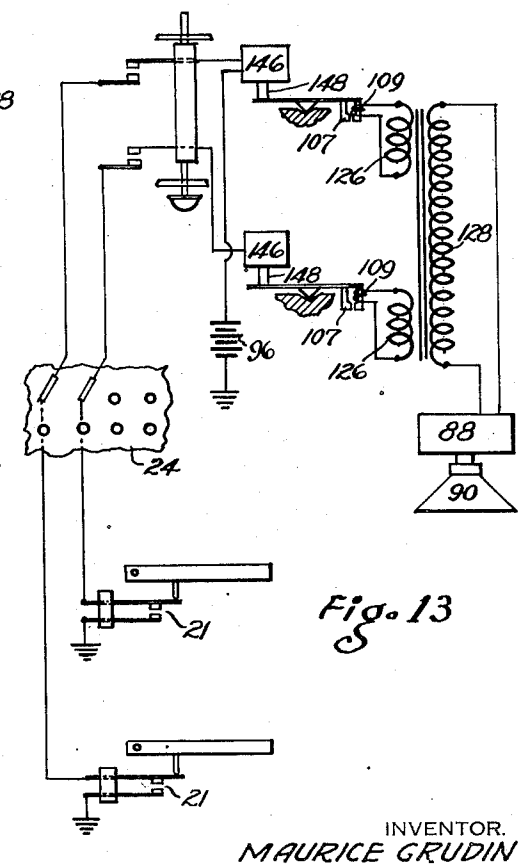

Fig. 13

INVENTOR.
MAURICE GRUDIN

BY Godfrey D. Green

ATTORNEYS.

Patented Jan. 23, 1951 2,539,130

UNITED STATES PATENT OFFICE

2,539,130

ELECTRICAL MUSICAL INSTRUMENT

Maurice Grudin, Paterson, N. J.

Application March 4, 1948, Serial No. 13,028

21 Claims. (Cl. 84—1.18)

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This invention relates to playable electrical musical instruments, by the playing of which, musical compositions may be rendered by a musician, and wherein the sounds are produced by electrical phenomena, as distinguished from sounds produced by natural instruments, strings, pipes, reeds or the like.

In broad terms, the invention comprises a playing console, equipped with stops or slabs, and one or more keyboards controlling the initiation and termination of musical sounds. The sounds are produced by a loud speaker, and are derived by electromagnetic or electro-optical means from a plurality of sound tracks, tapes or wires, there being a separate track for each pitch and timbre within the scope and range of the instrument. The invention further includes arrangements by which tones of different pitch and timbre may be registered with each of the several playing keys of the instrument, so that each key of the instrument may be caused to produce the nominal pitch represented thereby, in any one of several timbres, and also to produce the pitches of tones one or more octaves away from the nominal pitch, again in any one of several timbres. The invention further provides for the production of a plurality of complex tones simultaneously, with each tone retaining its inherent fidelity and timbre characteristics.

A general object of the invention is to provide an organ-like instrument having a conventional console, the instrument being substantially self-contained and semi-portable in character, wherein the key manuals, pedals and stops have both an arrangement and scope which will enable a skilled organist to use the instrument without special training or indoctrination. Thus, the playing technique of the instrument, being like that of the more or less conventional organ, enables the player to use the instrument interchangeably with a fixed type of organ. This playing interchangeability greatly facilitates both practice and training for organists. Another object is to provide an instrument whose scope is selectively unlimited, and to permit the use of any appropriate number of independent voices, including conventional organ voices and a large selection of orchestral instrument voices and special and unconventional voices, if the latter may be desired. A further object is to provide an instrument which keeps each produced tone, voice or timbre independent, so that when various voices and tones are used coincidentally, each retains its own timbre with complete fidelity, as does a full organ or orchestra. Another object of the invention is to provide selective registry of different voices and their pitches on the keyboard, and to provide for selective registration or production of several voices and pitches thereof by depression of a single key of a manual. A further object is to provide for the selective registration of one or more voices and pitches on several keyboards, one of which may comprise pedals.

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Another object is to provide an instrument in which tones of desired timbre and pitch are produced electrically, either by photoelectric or magnetized wire or tape means, the electrical impulses derived from such means being amplified, and converted to sound by a loudspeaker or the like. Preferably, the instrument is unitary in construction, the speaker unit being embodied in the instrument, or being separate therefrom as desired.

A further object of the invention is to provide means for producing sound track or sound wire or tape elements from a single tone of desired timbre to embrace a pitch range appropriate to the timbre, for use in the electrical musical instrument.

It is known that various playable electrical musical instruments have been proposed wherein the tones are synthesized from their fundamentals and harmonics, to produce any timbre desired, either of a conventional instrument, or of an unusual quality which may not ordinarily be found in a natural instrument. However, such instruments have serious limitations when chords are played or when several octave pitches are registered by the same key, for the fidelity of component tones of chords is sacrificed due to the coincidence of synthesized frequencies in several tones of the chord and the consequent aberration of the timbre desired. The harmonics of one tone may coincide with fundamentals or harmonics of another, whereby the timbre of both is materially modified. Only by compromising the true timbre of tones may pleasing chordal effects be produced, and these are only tolerable by virtue of the courtesy or insensitivity of the player or listener.

Further objects of the invention will become apparent in reading the annexed detailed description in connection with the drawings, which show the essential provisions of the invention in one or more preferred forms. These forms are, however, exemplary, and are not to be construed as limiting the scope of the invention.

In the drawings, in which similar reference numbers indicate similar parts, and in which

certain symbols are used for assisting understanding of the invention;

Fig. 1 is a schematic diagram of a portion of a keyboard of one embodiment of the instrument and associated registry and sound actuating circuits;

Fig. 2 is a front elevation of an entire instrument showing the general disposition of the components therein;

Fig. 3 is an end elevation of the entire instrument;

Fig. 4 is a partial schematic diagram of a modification or addition to the instrument to produce fundamental and harmonic tones;

Fig. 5 is a side sectional elevation of one of the sound track units;

Fig. 6 is an end sectional elevation of the sound track unit of Fig. 5;

Fig. 7 is a general wiring scheme of one embodiment of the instrument;

Fig. 8 is an end elevation of a sound track unit utilizing electromagnetic pickups;

Fig. 9 is a plan of a portion of the unit shown in Fig. 8;

Fig. 10 is an enlarged end elevation, partly in section, of one of the pickup units of Fig. 8;

Fig. 11 is a schematic wiring diagram of the circuit system utilized with the pickups of Fig. 8;

Fig. 12 is an enlarged end elevation partly in section of an alternative electromagnetic pickup unit;

Fig. 13 is a schematic wiring diagram of a circuit system utilized with the pickup of Fig. 12; and

Fig. 14 is a schematic arrangement of a sound transposing machine.

Referring briefly to Figs. 2 and 3, I show an entire instrument in the form of an organ console **10**, including a plurality of key manuals **12**, a panel for stops or slabs **14**, pedals **15**, and swell pedal **16**. The console contains a plurality of demountable box units **18** each comprising a "voice," such as flute, string, oboe, horn, diapason, etc., all driven if desired by a common motor **20**. The "voices" may be of any desired number, eight being shown as a number suitable, for average needs, to produce musical effects over a wide range. The "voice" boxes may be inserted into the ends of the console, leaving the middle part free for incorporating junction panels, amplifiers, speakers, and necessary auxiliaries which will be described.

Now referring to Fig. 1, I show a key manual portion **12**, embracing 5 octaves, wherein the keys are identified by their pitch symbols C_0, C_1, C_2, etc., some of the intervening keys of each octave being similarly symbolized. Each key operates a S. P. S. T. switch **21** which is connected to a contact **22** bearing the key symbol, on a main contact panel **24**. This panel includes a plurality of horizontally shown contact rows, each row comprising contacts for all keys of the keyboard; all contacts on vertical lines are inter-connected with each other and with the key switches for the keys having the same key symbols.

Into all contacts of the first contact row **26** may be plugged a bar **28** carrying contacts **30**, each engaged with one of the contacts **22**, the several contacts **30** being connected by conductors **32** to the points **33** of one member of a multi-point stop switch **34**, actuated by a stop button or slab constituting one slab of the panel **14** (Fig. 2). The other member of the stop switch **34** carries a plurality of points **35**, respectively connectible or disconnectible relative to the first set

of points **33** by operation of the stop. Conductors lead individually from each point of the set **35** to each of a series of solenoid units **38**, said solenoid units being operable to open and close a sound track to a pickup as will be described. The stop **34** when operative, gives nominal registry of the keys with the solenoid units **38**, so that, for instance, depression of key C_3 produces the pitch C_3 by operation of the solenoid unit **38** corresponding to pitch C_3 of the "voice" represented by the stop **34**. This yields "8 foot" pitch registry. In addition to nominal key registry, it is highly desirable to use, at times, registries of one or more octaves higher or lower than nominal, to give richness of tone and additional volume, and also to register high or low tones on the manuals for convenience in playing the instrument. Also, different voices in different parts of the tonal range may be played simultaneously by single keys. Provision is made for different registries in the manner described below.

A contact bar **40** is plugged into the row of contacts **42**, on the panel **24**, the contacts **44** of the bar being connected to fixed contacts **46** of a stop switch **48**. Movable contacts **50** of the stop switch are connected to separate windings incorporated in the solenoid units **38**, but in an order such that, when the stop switch **48** is closed, depression of key C_3 operates the solenoid unit corresponding to pitch C_2, and depression of any other key will actuate the solenoid unit corresponding to a pitch one octave lower than the nominal key pitch. This yields "16 foot" pitch registry.

A contact bar **54**, plugged into a row of contacts **56** on the panel **24**, connects said contacts to a stop switch **58**, which in turn connects to solenoid units **38** in an order such that, when the stop **58** is operative, depression of key C_3 operates the solenoid unit corresponding to pitch C_4, and depression of any other key actuates a solenoid unit corresponding to a pitch one octave higher than the nominal key pitch. This yields "4 foot" pitch registry.

In the same manner, registries of 32 foot pitch and 2 foot pitch—that is, two octaves lower or two octaves higher than nominal, may be secured by providing additional contact bars and stops.

The same contact panel **24** may be utilized, in conjunction with additional stop switches such as **60**, to connect other sets of solenoid units **38***a* to the keyboard, such other solenoid units being associated with other voices of the instrument. Offset tone registries may also be effected in the manner described to secure fifths, seventeenths, or any other desired interval from the nominal tone. That is, the playing of key C_1, for instance, may produce tone G_1 (for the fifth) or E_3 (for the seventeenth) with corresponding intervals for other keys. Furthermore, registries may be changed at the discretion of the organist, by lifting out a bar, such as bar **28**, from its contacts **26**, and reinserting it into the row of contacts **26** in such relation as to shift the coincidence of contacts **30** and **26** from the original registry to an octave higher or lower, or offset for fifths, seventeenths, nineteenths or any other desired interval.

The contact panel **24** is associated with a single keyboard or manual **12**. If additional manuals or pedals are used, each has a panel, like **24**, to enable a plurality of connections to be made to the available voices of the instrument. In this connection, the solenoid units such as **38** may not only be connected to one manual through

several stop switches to secure different octave registries, but may also connect to one or more additional manuals or pedals, either for single or multiple octave registry with each.

From the preceding description, it is apparent that stops **58**, **48**, **34** may be actuated individually or jointly, to secure desired octave registrations on the one manual shown.

In Fig. 4, I show a connection arrangement for one "voice" of the instrument to provide a plurality of pure tone qualities over the pitch range desired, such tones being produced from sound tracks of pure sine wave character without the overtones which characterize usual organ or instrumental timbres. These pure tones are, at times, very useful, either to synthesize tones of unusual quality, to play by themselves, or to fortify and augment tones of complex composition by superimposition thereon. The Fig. 4 arrangement is shown for exemplary purposes for two pitches A_1 and A_2 and enables the combination of any one or all of the first six harmonics of the fundamental pitches. In practice, the connections are carried out for all semitone pitches of the range desired. The manual keys as previously described operate key switches **21** connected to the panel **24**. Several horizontal rows of contacts in the panel are reserved for harmonic connector bars whose plugs are respectively connected to stop switches respectively designated **H1**, **H2**, **H3**, **H4**, **H5** and **H6**. These stop switches, when in the active position respectively set up the solenoid units of the first to sixth harmonics. The harmonics of the fundamental or first harmonic pitches A_1 and A_2 correspond with other fundamentals in the tempered scale as shown in the tabulation below, and the connections from the harmonic stop switches H1 to H6 are made to the solenoid units corresponding to such other fundamentals, as shown. As previously described, the solenoid units have a separate winding associated with the appropriate sound track for each connection from a stop switch, to avoid shadow circuits and cross-talk.

Nominal Pitch	Harmonic	Equivalent Fundamental
A_1	fundamental or 1st harmonic	A_1
A_1	2nd harmonic	A_2
A_1	3rd harmonic	E_3
A_1	4th harmonic	A_3
A_1	5th harmonic	$C_4\#$
A_1	6th harmonic	E_4
A_2	fundamental or 1st harmonic	A_2
A_2	2nd harmonic	A_3
A_2	3rd harmonic	E_4
A_2	4th harmonic	A_4
A_2	5th harmonic	$C_5\#$
A_2	6th harmonic	E_5

I am aware that in order to produce timbres solely by synthesis of partials or harmonics it is more desirable to have available more than six harmonics in more than one degree of intensity. However, I have found that for a practical instrument of the type herein described, the use of the first six partials in but one degree of intensity offers by synthesis and by alteration of stock stops a more than sufficient number of timbres for the production of usable and highly desirable musical effects. The addition of harmonics opens up a vast field of tone colors, inasmuch as these harmonics in their numerous combinations create new timbres, and the addition of one or more harmonics to a stock stop or combination of stops produces a still greater number of new timbres. Thus, (1) the admixture of harmonics alone, (2) the addition of one or more harmonics to an individual stop or combination of stops, (3) the use of one or more independent stops, make available to the player a number of timbres which may well nigh be described as limitless.

Referring now to Figs. 5 and 6, details of a typical "voice" unit **18** are shown, in conjunction with a series of associated solenoid units **38**. In one arrangement of the invention, each voice unit **18** comprises a cylindrical transparent drum **62** secured for rotation in end bearings **64**, and driven at constant speed through a transmission **66** by a motor **68**. Within each drum is a light source **70**, and suitable provisions may be made for ventilating and cooling the unit by circulating air through the drum. Around the drum are secured a plurality of axially spaced sound tracks **72**, there being one such track for each pitch over the range desired, all tracks preferably representing tones of the same timbre. These sound tracks may represent an organ timbre, an orchestral instrument timbre, or any other, including the fundamentals and harmonics indigenous to each. There need be no particular phase relationship between the waves of each track, and each track produces its own monotone of full fidelity and timbre. I have found little or no need for matching wave patterns at the ends of each track at it is wrapped around and secured to the drum, as the interruption caused by mismatched wave patterns, at the one point in the drum circumference, where the track ends meet, is so minute as not to be noticeable even to the most critical ear.

Around the drum **62** is disposed a light shield **74** having a longitudinal narrow slit **76** therealong, or a plurality of holes one opposite each track. Either above or below the shield **74** may be disposed a plurality of individual tapered light filters **78**, one for each track, to enable adjustment of the sound level produced by each track. Either another long tapered filter may be introduced to adjust the sound level of the entire unit, or the filters **78** could be adjustable jointly, as well as individually, to attain the same result. Spaced beyond the slit and filter is a shutter **80** for each track **72**, the shutter normally masking the slit and being movable to uncover the slit by the associated solenoid unit **38** of which the shutter is a part. Beyond the shutters are a plurality of lenses **82** for focusing the beams from open sound tracks onto one of a set of interconnected photocells **84**. These receive light signals from the lamp **70** within the drum as modulated by the sound track **72**.

Photocell output is conducted to an amplifier **88** (Fig. 7), and amplifier output controlled as to overall sound level by the swell pedal **16**, is transmitted to a speaker **90**.

Accordingly as one or more shutters **80** are operated, one or more true individual tones are produced in the speaker, blending to produce harmonious music without distortion or aberration.

The solenoid units **38** (Fig. 5) each comprise a plurality of solenoid windings **92**, and an armature **94**, carrying the shutter **80**, which is operable by the energization of any one winding **92**. One end of each winding **92** connects to a common ground, while the other end connects to one contact of one of the stop switches such as **34**, **48** and **58** (Fig. 1). This arrangement of multiple solenoids in each unit **38** has been found to give excellent results, and to avoid any possi-

bility of shadow circuits or cross-talk between different stops, keys, and "voice" units. Other interconnecting arrangements are no doubt feasible, and I do not necessarily wish to confine the scope of the invention to the connection system shown. In the solenoid units **38**, windings from one to seven or more may be employed. If but a single tone registry on a single manual is needed, the single winding is adequate. Seven windings are desirable when the tone is to be producible in one registry on the pedals and in three registries (4', 8' and 16') on each of two manuals.

As noted in Fig. 7, a common power supply may energize the amplifier **88**, motor **68** and key system, the latter preferably operating at low D. C. voltage through a transformer **96** and a rectifier **97**.

It is contemplated that selective tremolo effects may be produced by periodically raising and lowering the overall sound frequencies. There are known methods for producing the tremolo, such as by varying the speed of the motor **68** at cyclic intervals of 5 to 9 per second. Another arrangement is to insert a selectively operable cyclically varying drive between the motor **68** and the drums **62**.

An alternative sound track system is shown in Figs. 8 to 13, wherein an insulating or non-magnetic drum **104** is driven, as before, by the motor **68** and transmission **66**. Preferably, the peripheral speed of the drum is of the order of 120 to 250 feet per minute to attain high fidelity sound production. Around the drum are secured a plurality of magnetic wires or tapes **106**, one for each tone over the range desired, each wire or tape being magnetized to produce, when associated with a pickup and speaker system, a tone of desired pitch and timbre. The several wires or tapes provide the desired range of pitch. The wires or tapes are spaced apart to avoid cross-talk, and with each wire or tape is associated one or more magnetic pickups **108** which are analogous in function to the solenoid units **38** of the electro-optical system previously described. The pickup comprises pole pieces **107** having a winding **109**, whose ends lead to an amplifier and speaker system.

The wire-carrying drum **104** is rotated in bearings **110**, and at each end of the drum is a spider **112** having a plurality of spoke-like arms **114** across the ends of which are secured members **116** upon which the pickups **108** are mounted. The spiders **112** are selectively oscillatable about the center of the drum, at a frequency of between 5 to 9 cycles per second, while the drum is rotating at constant speed, to attain tremulant effects. Such oscillation may be attained by a small motor **118** having a crank **119** connected to one end of a spider arm **114** by a connecting rod **120**. When the drum oscillates the frequency of impulses picked up by the devices **108** varies slightly and cyclically, to yield the tremolo.

Referring to Figs. 10 and 11, based on the general arrangement of Figs. 8 and 9, I show one arrangement and circuit system for using the magnetic pickups. The pickup **108** is mounted on a bar **122** pivoted at **124** to one of the members **116**. A light spring **126** holds the bar **122** in place, and urges the poles of the pickup **108** into light, continuous engagement with the magnetized sound wire **106**. The pickup pole pieces and the wire are preferably highly polished to minimize wear and distortion of the impulses picked up from the wire (or tape). Fig. 11 shows a fragmentary typical circuit diagram, wherein two keys and two pickups are showns. It will be apparent that an entire key system will be arranged in generally the same fashion. Each pickup coil **109** connects to a transformer primary **126** at all times, the two primaries being related to a joint secondary **128**. The secondary provides the input to the amplifier **88** and speaker **90**. One end of each pickup is grounded, the other end of each leading to center points **130** of a stop switch **132**. When the stop switch is "off" or up, as shown, the pickups are short-circuited through ground as at **134** whereby they do not transfer energy to the transformer **126—128**. When the stop switch is "on," the pickup coil ends are connected to points **136**, through the junction panel **24** of normally closed grounded key switches **138**. When the key is at rest, the pickup coil **109** is ground-shorted, but when the key is pressed, the short is broken and the pickup coil **109** feeds energy to the transformer and sound system.

In an alternative system shown in Figs. 12 and 13 each pickup **108** is mounted on an arm **140**, pivoted at **142** to the member **116**, and normally urged away from contact with the wire **106** by a spring **144**. A solenoid **146**, mounted on the member **116**, serves when energized to move the pickup into contact or pickup relationship to the wire **106**, the arm **140** having secured thereto an armature **148** entering the solenoid. Cushioning means, such as felt, is provided to prevent bouncing of the pickup on the wire when the solenoid is energized, and additional cushioning means may be applied to prevent pickup bounce when it is disengaged from the wire. The solenoids **146** operate in the same kind of key system as is shown in Fig. 1, and are comparable to the solenoid units **38**. The key switches **21**, junction panel **24**, and stop switches are similar. In this arrangement the pickup coils **109** are constantly connected to their respective transformer primaries **126**, but the solenoid circuits are normally open.

To enable relatively close spacing of wires **106** on the drum **104**, and to provide for an adequate number of pickups **108**, the latter may be spaced circumferentially around the drum as shown in Figs. 8 and 9. By this arrangement a plurality of pickups may be associated with each wire **106**, each pickup being connected to one of the several stop switches to enable playing of a single tone from a plurality of manuals, pedals and key positions. The pattern for the multiple playing of a single note follows, in general, the same principles as were outlined heretofore in connection with the sound-track optical system.

The magnetized wire system shown may yield augmented musical effects, since a specific pitch and timbre may be produced by several pickups each operated by a different key, the sound produced by each key depression being additive to the similar sounds produced by other key depressions. This has the same effect as though there were duplicated, triplicated or multiplied voices in the organ system. This is desirable but usually impractical in the natural organ or electrical organ analogue.

In the foregoing description I have used the terms solenoid, and solenoid units, to designate, in general, electromagnetically actuated light gates or magnetic pickup actuators. The particular form of these units is not necessarily germane to the invention herein disclosed, there being many desirable mechanical arrangements of parts to fulfill the function required. I find that

the general arrangements shown minimize the possibility of "key click" in the speaker system of the instrument, since the pickups or photocells are always connected during playing, and are rendered active by optical or mechanical connection to the sound tracks or wires. Were the photocell or pickup circuits to be made and broken each time a note is played, obnoxious "key click" would be almost inevitable.

Further, in either the optical or magnetic pickup systems described, tones are initiated or terminated smoothly, without objectionable suddenness. If desired, the speed of tone initiation and termination may be varied by varying the response speeds of the solenoid units. In the magnetic wire systems, I prefer to use a sequence of wires on each drum which will minimize the possibility of discordant cross-talk—that is, pickup of dissonant frequencies by a pickup unit from wires which are neighbors of the wire with which the unit is directly associated. To this end, all of the C pitch wires are neighbors, and comprise the first group. The next group comprises all the G pitch wires, then in sequence, groups of D, A, E, B, F♯, C♯, G♯, D♯, A♯, F are arranged. The intervals between all groups are fifths, and the intervals between wires in a group, octaves, so that any cross-talk which may occur will always be harmonious.

The sound wire on the drums (tape being considered equivalent to wire) may be wound as a plurality of separate spaced turns, or the wire may be wound continuously to form a multi-turn helix. In the latter form, the helix turns may be offset sharply from one turn to the next to enable each wire to run predominantly centrally under its pickups. The magnetization of the wires to represent appropriate pitches and timbres may be accomplished before or after the wire is placed upon the drum.

It will be noted that in the optical system, a single light gate may be operated by any one of several solenoids associated therewith to secure pickup from a single sound track, while in the electromagnetic system, a separate pickup is preferred for each key and stop combination with the result that there are several pickups associated with each sound wire. The wire or tape system comprehends their assembly as "voice" units such as **18**, as previously described in connection with the optical system, all "voices" being energized by the same drive motor, and all sound being reproduced by the same amplifier and speaker, with coincidental volume regulation by the swell pedal **16**.

For the purpose of securing true pitch sound tracks either as translucent tracks for use with the electro-optical system of reproduction or with the electromagnetic tape or wire system, I have evolved a mechanism which may produce an entire range of pitches of certain timbre from a recording of a single pitch of the desired timbre. This mechanism is shown in Fig. 14. It comprises a turntable **160** borne in a housing **162** by a shaft **164**, the shaft having a bevel gear **166** meshed with a bevel gear **168** whose shaft **170** is also borne in the housing. The shaft carries a wheel **172** faced with friction material, the wheel being engageable with any one of a plurality of pulley faces on a stepped pulley **174**. The housing **162** is mounted for tilt and sliding on a horizontal rod **176** carried by brackets **178**, so that the housing, with its turntable and drive mechanism, may be shifted along the pulley **174**. The brackets **178** and the shaft **176** are spaced from the pulley **174**, lying behind the pulley and the axis of the turntable **184**. Thereby, the entire housing **162** may be tilted up and down on the shaft **176** as it is slid therealong, to allow engagement of the friction wheel **172** with any one of the steps on the pulley. The weight of the housing and its associated parts is sufficient to load the wheel **172** into firm frictional driving engagement with the pulley **174**.

The pulley **174** is driven through a change-speed gearset **180** from a constant speed motor **182**, successive ratios of the gearset having 2:1 relationship. That is, the pulley **174** may be driven at, say, a minimum speed of 25 R. P. M. Successive ratio steps would be 50, 100, 200, 400 and 800. The 13 steps of the pulley increase progressively in diameter by the ratio 1.05946 driving the turntable at similar R. P. M. ratio increments. For example if the smallest pulley face is .500 inch in diameter successive faces will have diameters .5297, .5612, .5946, .6299, .6674, .7071, .7492, .7937, .8409, .8909, .9439, and (13) 1.0000. If a monotone record **184** of desired timbre is placed on the turntable, and the pickup **186** is connected to a suitable reproducer, any desired range of all notes of several octaves of the tempered scale may be reproduced by changing the driven speed of the turntable, by shifting the wheel on the step pulley **174** for semitone intervals within an octave, and by shifting the gearset **180** for octave intervals. The output of the pickup **186** is connected to known apparatus to produce optical sound tracks (**72** in Fig. 6) or magnetized sound wires or tapes (**106** in Figs. 8–12). Such tracks may be produced for use on the drums forming parts of the "voice" units **18** of Figs. 2 and 3. Any appropriate tone timbre may be secured by the use of appropriate monotone records **184**.

Though several embodiments illustrating the invention have been shown and described, it is to be understood that the invention may be applied in other and various forms. Changes may be made in the arrangements, without departing from the spirit of the invention. Reference should be had to the appended claims for definitions of the limits of the invention.

What is claimed is:

1. In an electrical musical instrument, a plurality of sound tracks having the same and complex timbre and different pitch, at least one pickup energizable by the tracks, a sound producer responsive to pickup energization, means to translate the tracks relative to the pickup, selectively operable means associated with each track to place the track in energizing relationship to the pickup and to place the track in inoperative relation to the pickup, a keyboard, a key switch for each key of the keyboard, and means to connect each key switch to one and more of said selectively operable means, whereby key switch operation may place one and more tracks of the same timbre but of different pitch in operative relation with said pickup.

2. In an electrical musical instrument, a plurality of sound tracks having the same and complex timbre and different pitch, at least one pickup energizable by the tracks, a sound producer responsive to pickup energization, means to translate the tracks relative to the pickup, selectively operable means associated with each track to place the track in energizing relation to the pickup and to place the track in inoperative relation to the pickup, a keyboard, a key switch for each key of the keyboard, means to

connect each key switch to one and more of said selectively operable means, whereby key switch operation may place one and more tracks of the same timbre but of different pitch in operative relation with said pickup, said sound tracks comprising filaments magnetized in accordance with pitch and timbre of the tone to be produced, and said pickup comprising means magnetically engageable with said filament and producing electrical impulses in conformance with the magnetization of said filament.

3. An electrical musical instrument comprising a plurality of selectively operable key switches each closable to produce a nominal tone, a plurality of multi-point stop switches each including two sets of points, connections from said key switches to respective points of one set of each of said stop switches, a plurality of actuators, connections from said other sets of stop switch points to said actuators in a plurality of combinations, a full-timbred sound track operatively associated with each actuator, and sound producing means responsive to energization of said actuators individually and in groups to produce the same full-timbred sound corresponding to the one or more tracks brought into operation by energization of respective actuators.

4. An electrical musical instrument comprising a plurality of selectively operable key switches each closable to produce a nominal tone, a plurality of multi-point stop switches each including two sets of points, connections from said key switches to respective points of one set of each of said stop switches, a plurality of actuators, connections from said other sets of stop switch points to said actuators in a plurality of combinations, a full-timbred sound track operatively associated with each actuator, and sound producing means responsive to energization of said actuators individually and in groups to produce the same character of full-timbred sound corresponding to the one or more tracks brought into operation by energization of respective actuators, said actuators comprising electro-magnetically operated devices operable to render said tracks active and inactive.

5. An electrical musical instrument comprising a plurality of selectively operable key switches each closable to produce a nominal tone, a plurality of multi-point stop switches each including two sets of points, connections from said key switches to respective points of one set of each of said stop switches, a plurality of magnetic pickups, actuating means to render said pickups active, connections from said other sets of stop switch points to said actuating means in a plurality of combinations, a full-timbred sound track operatively associated with each pickup, and sound producing means responsive to energization of said pickups individually and in groups to produce the same character of full-timbred sound corresponding to the one or more tracks brought into operation by energization of respective actuators, said actuators comprising electro-magnetically operated devices operable to render said tracks active and inactive relative to their pickups, and said tracks comprising magnetized filaments.

6. In an electrical musical instrument, a light modulating sound track, a light source, a photocell responsive to light from the source as modulated by the track, a light shutter in the path of light from said source to said photocell selectively operable to pass and not to pass said light, said shutter comprising a movable shutter element, a plurality of solenoids individually and jointly energizable to move said shutter, a plurality of playing key switches connected with and selectively closable to energize respective shutter solenoids, and stop switching means, selectively operable, and interposed in the connections from said key switches to said shutter solenoids.

7. In an electrical musical instrument, a plurality of signal producing units each comprising a series of tracks having characteristics of similar complex timbre over a certain pitch range, a sound producer responsive to the signals of the several producing units, a plurality of playing key switches, and means selectively operable to connect each key switch to one and more of said producing units simultaneously, in octave intervals, to produce sound signals from said tracks and sound producer upon key switch closure.

8. In an electrical musical instrument, a plurality of signal producing units each comprising a series of tracks having characteristics of similar complex timbre over a certain pitch range, a sound producer responsive to the signals of the several producing units, a plurality of playing key switches, and means selectively operable to connect each key switch to one and more of said producing units simultaneously in octave intervals, to produce sound signals from said tracks and sound producer upon key switch closure, said selectively operable means including connections to afford a plurality of octave registries of said key switches with the sound tracks of said units.

9. For use in preparing a plurality of sound tracks of similar timbre for an electrical musical instrument, a turntable for a record of a monotone of desired timbre, a record pickup, sound track recording means responsive to said pickup, a drive shaft, and a transmission from said drive shaft to said turntable comprising a stepped drum having a plurality of steps having a diameter increment ratio of substantially 1.05946 driven by said drive shaft, a follower wheel selectively engageable with the drum steps, and means for driving the turntable from the follower wheel.

10. For use in preparing a plurality of sound tracks of similar timbre for an electrical musical instrument, a turntable for a record of a monotone of desired timbre, a record pickup, sound track recording means responsive to said pickup, a drive shaft, a transmission from said drive shaft to said turntable comprising a stepped drum having a plurality of steps having a diameter increment ratio of substantially 1.05946 driven by said drive shaft, a follower wheel selectively engageable with the drum steps, means for driving the turntable from the follower wheel, and means for changing the speed of said drive shaft in the ratio 2:1.

11. For use in preparing a plurality of sound tracks of similar timbre and different pitch, for an electrical musical instrument, a record of monotone pitch and desired timbre, pickup means for said record, means to re-record sound tracks responsive to pickup output, a drum having a plurality of steps of different diameters, a wheel drivably engaged with said drum, the drive between drum and wheel varying in the ratio of substantially 1.05946 between steps of increasing diameter, said wheel and drum comprising input and output members, not necessarily respectively, means to drive said input member at constant

speed, and means to drive said single pitch record from said output member.

12. In an electrical musical instrument, a plurality of playing keys each including a switch, a plurality of full-timbred voice units, each unit having a range of full-timbred tones of the same voice, a contact panel having a plurality of lines of contacts, means connecting each line with a key switch, each voice unit having a plurality of control conductors each representing one note of its voice unit, and means operable to connect the said control conductors from one voice unit simultaneously and in tonal sequence, to the lines of contacts of said panel.

13. In an electrical musical instrument, a plurality of playing keys each including a switch, a plurality of full-timbred voice units, each unit having a range of full-timbred tones of the same voice, a contact panel having a plurality of lines of contacts, means connecting each line with a key switch, each voice unit having a plurality of control conductors each representing one note of its voice unit, means operable to connect the said control conductors from one voice unit simultaneously and in tonal sequence to the lines of contacts of said panel and means to shift said control conductors as a unit to cause registries of said conductors, in tonal sequence, with different lines of contacts of said panel.

14. In an electrical musical instrument, a plurality of playing keys each including a switch, a plurality of full-timbred voice units, each unit having a range of full-timbred tones of the same voice, a contact panel having a plurality of lines of contacts, means connecting each line with a key switch, each voice unit having a plurality of control conductors each representing one note of its voice unit, means operable to connect the said control conductors from one voice unit simultaneously and in tonal sequence, to the lines of contacts of said panel and means to shift said control conductors as a unit to cause registries of said conductors, in tonal sequence, with different lines of contacts of said panel whereby at a player's option, registry of a C_1 key, for example, may be effected with a C_0, C_1 and C_2 tone of any one of said voice units.

15. In an electrical musical instrument, a plurality of playing key switches, a connection panel having a plurality of contact elements rectilinearly disposed in lines and rows, the elements in each line being interconnected and connected to one of said key switches, a plurality of bars each having a plurality of contact elements engaged with the panel contact elements of one row, said bars being interchangeable between rows and being adjustably shiftable along a row, a plurality of sound signal generating units, one for each bar, each having a range of musical tone signals and each having conductors, one for each tone, energizable to produce respective signals, selectively operable multiple contact stop switch units, the conductors of said generating units being connected in order to the respective contacts of said stop switch units, and means connecting other contacts of said stop switch units, respectively, to the contact elements of said several bars.

16. In an electrical musical instrument, a plurality of playing key switches, a connection panel having a plurality of contact elements rectilinearly disposed in lines and rows, the elements in each line being interconnected and connected to one of said key switches, a plurality of bars each having a plurality of contact elements engaged with the panel contact elements of one row, said bars being interchangeable between rows and being adjustably shiftable along a row, a plurality of sound signal generating units, one for each bar, each having a range of musical tone signals and each having conductors, one for each tone, energizable to produce respective signals, selectively operable multiple contact stop switch units, the conductors of said generating units being connected in order to the respective contacts of said stop switch units, and means connecting other contacts of said stop switch units, respectively, to the contact elements of said several bars, said bars and generating units being replaceable, and said bars being position-shiftable along the rows of said panel to alter the key registration relative to the nominal tones available from said generating units.

17. In an electrical musical instrument, a plurality of playing key switches, a connection panel having a plurality of contact elements rectilinearly disposed in lines and rows, the elements in each line being interconnected and connected to one of said key switches, a plurality of bars each having a plurality of contact elements engaged with the panel contact elements of one row, said bars being interchangeable between rows and being adjustably shiftable along a row, a plurality of sound signal generating units, one for each bar, each having a range of musical tone signals and each having conductors, one for each tone, energizable to produce respective signals, selectively operable multiple contact stop switch units, the conductors of said generating units being connected in order to the respective contacts of said stop switch units, and means connecting other contacts of said stop switch units, respectively, to the contact elements of said several bars, said generating units each having a single musical timbre for the range of tones producible thereby.

18. In an electrical musical instrument, a plurality of playing key switches, a connection panel having a plurality of contact elements rectilinearly disposed in lines and rows, the elements in each line being interconnected and connected to one of said key switches, a plurality of bars each having a plurality of contact elements engaged with the panel contact elements of one row, said bars being interchangeable between rows and being adjustably shiftable along a row, a plurality of sound signal generating units, one for each bar, each having a range of musical tone signals and each having conductors, one for each tone, energizable to produce respective signals, selectively operable multiple contact stop switch units, the conductors of said generating units being connected in order to the respective contacts of said stop switch units, and means connecting other contacts of said stop switch units, respectively, to the contact elements of said several bars, said stop switch units being of a number corresponding to more than the number of generating units, and being connected for different registries of said key switches with the tones of said several generating units as well as for nominal registry.

19. In an electrical musical instrument comprising a selectively operable keyboard, a pickup, and a speaker energized by said pick-up, a movable sound track-carrying member having a plurality of tracks thereon, said pickup being associated operably with said tracks, means responsive to key operation to energize said pickup for signal production resulting from key operation, said plurality of tracks being arranged in a sequence of groups, each group containing tracks having

octave intervals therebetween, and said groups having fifth intervals therebetween.

20. In an electrical musical instrument comprising a selectively operable keyboard, a pickup, and a speaker energized by said pickup, a movable sound track-carrying member having a plurality of tracks thereon, said pickup being associated operably with said tracks, means responsive to key operation to energize said pickup for signal production resulting from key operation, there being fifth intervals between certain individual adjacent tracks of said plurality.

21. In an electrical musical instrument comprising a selectively operable keyboard, a pickup, and a speaker energized by said pickup, a movable sound track-carrying member having a plurality of tracks thereon, said pickup being associated operably with said tracks, means responsive to key operation to energize said pickup for signal production resulting from key operation, there being octave intervals between certain individual adjacent tracks of said plurality.

MAURICE GRUDIN.

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