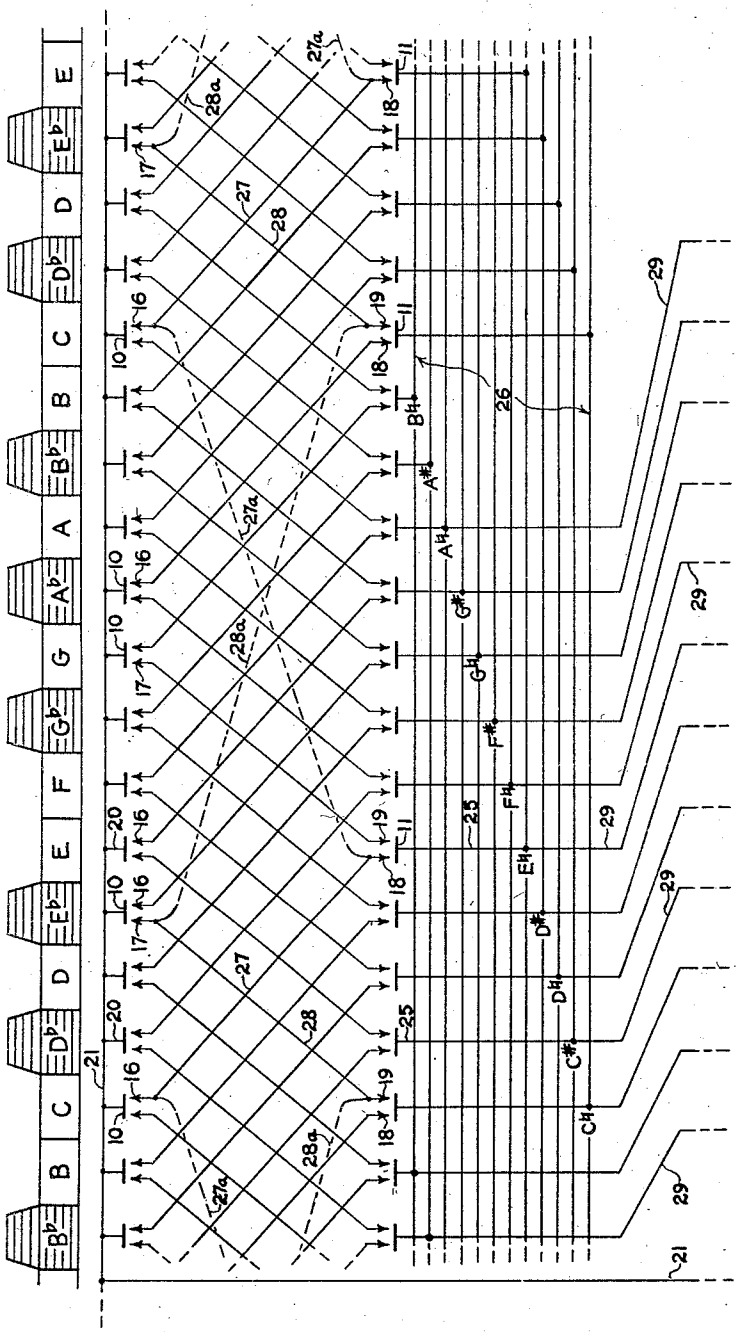
June 24, 1947. H. M. WAAGE 2,422,940

MUSICAL INSTRUMENT

Filed Oct. 9, 1945 4 Sheets-Sheet 1

Fig. 1



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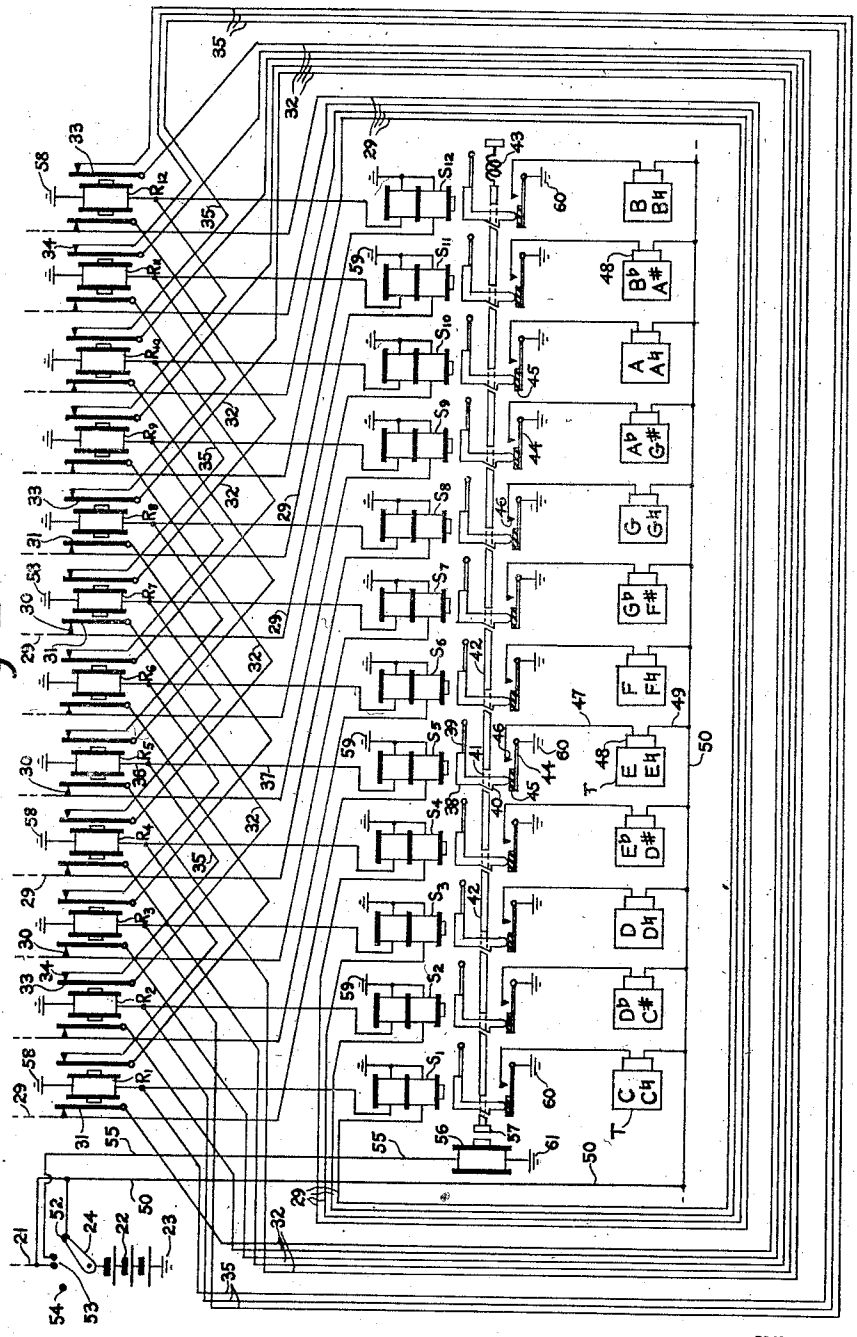


Fig. 2

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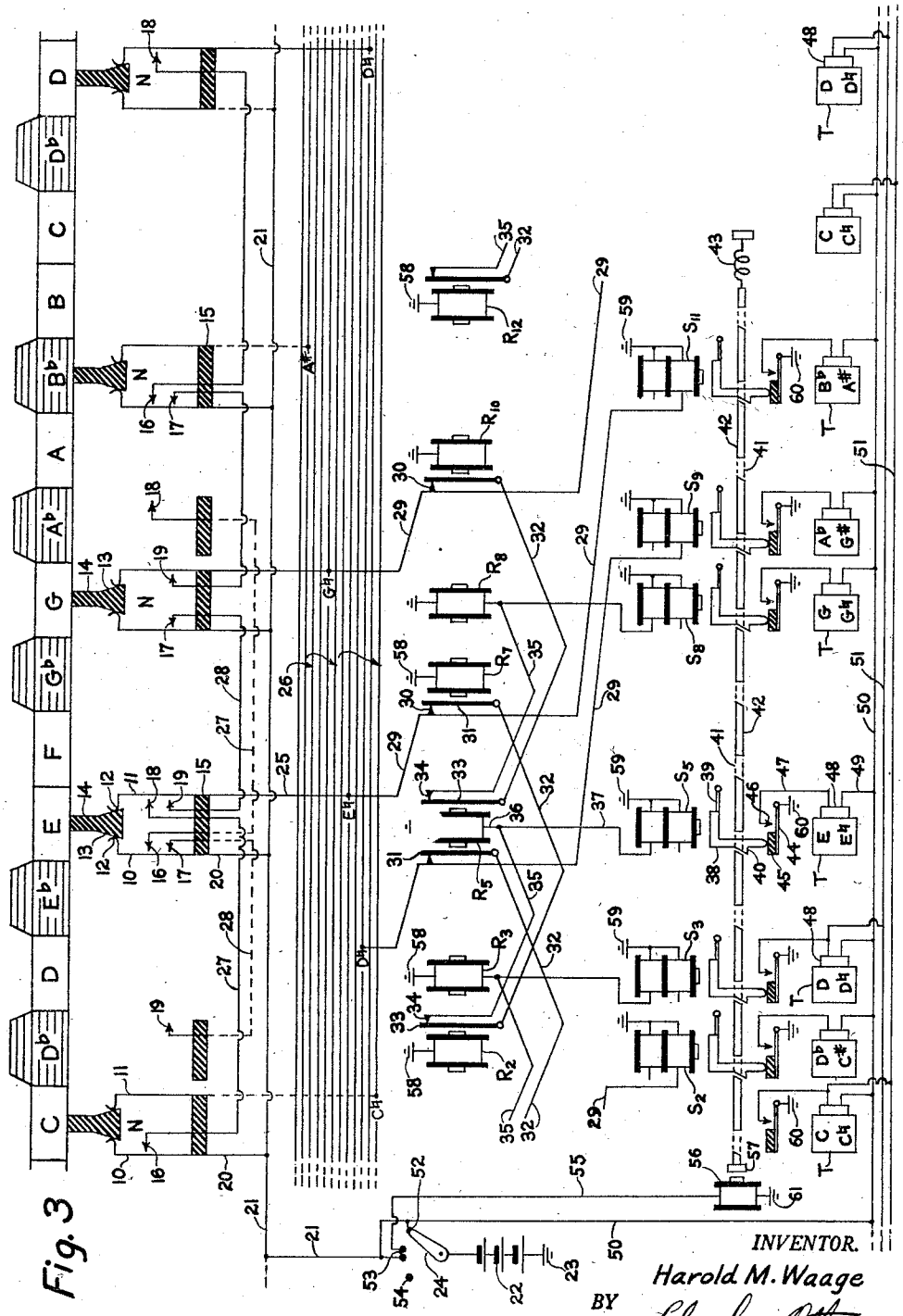


Fig. 3

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Fig. 4

	C	$D^\flat$	D	$E^\flat$	E	F	$G^\flat$	G	$A^\flat$	A	$B^\flat$	B	C
Scale P	1.0000	1.0595	1.1225	1.1892	1.2599	1.3348	1.4142	1.4983	1.5874	1.6818	1.7818	1.8877	2.0000
	264	279.70	296.33	319.95	332.62	352.40	373.35	395.55	419.07	443.99	470.39	498.37	528
Scale J	1.0000		1.1250		1.2500	1.3333		1.5000		1.6667	1.7500	1.8750	2.0000
	264		297		330	352		396		440	462	495	528
Scale S	.9921	1.0511	1.1136	1.1798	1.2500	1.3243	1.4031	1.4865	1.5749	1.6685	1.7678	1.8729	1.9843
	261.92	277.50	294.00	311.48	330	349.62	370.41	392.44	415.77	440.50	466.69	494.44	523.84
	$C^\natural$	C^*	$D^\natural$	D^*	$E^\natural$	$F^\natural$	F^*	$G^\natural$	G^*	$A^\natural$	A^*	$B^\natural$	$C^\natural$

Fig. 5

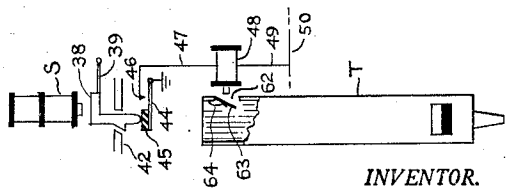
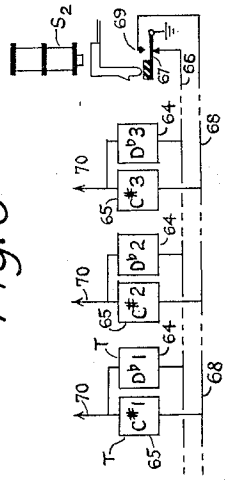


Fig. 6



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Patented June 24, 1947 2,422,940

UNITED STATES PATENT OFFICE

2,422,940

MUSICAL INSTRUMENT

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Application October 9, 1945, Serial No. 621,238

7 Claims. (Cl. 84—1.01)

1

This invention relates to musical instruments provided with improved means for automatically changing the pitches of tone producing elements thereof normally tuned to the equal tempered scale so that said elements produce tones in just intonation when chords are played.

Heretofore attempts have been made to attain perfect attunement in a plurality of musical keys by provision of complex keyboards which enabled the player to select the most concordant tone combinations among a large number of tone producing elements for each octave. In order to simplify the keyboards use has been made of auxiliary scale selector pedals or keys associated with mechanism for obtaining selective control of a large number of enharmonic tones. These structures required the mastery of new fingering technique or pedal operation and the additional mental effort of a proper selection of tones.

In order to avoid these objections, the present invention primarily comprehends the provision of means responsive to the actuation of the keys of the keyboard whenever chords are played thereon during the rendition of a musical composition to thereby control the tone producing elements of the instrument for automatically changing the tones of said chords normally produced in the equal tempered scale to tones of just intonation in all octaves of the instrument.

The invention further provides means of the indicated character which may be incorporated in a musical instrument employing the conventional organ or piano keybard and which will enable musicians accustomed to such standard keyboard to play in the usual manner musical compositions of considerable complexity with true intonation.

With the foregoing and other objects in view reference is now made to the following specification and accompanying drawings in which is illustrated the preferred embodiment of the invention.

In the drawings:

Fig. 1 is a fragmentary schematic view illustrating a portion of the keyboard of an organ and a portion of the electrical wiring constructed in accordance with the invention.

Fig. 2 is a similar view illustrating a continuation of the electrical wiring shown in Fig. 1 and illustrating the same in association with instrumentalities for carrying out the invention.

Fig. 3 is a fragmentary schematic view illustrating the electrical wiring and instrumentalities associated therewith which is typical for any one key and showing the same for the key E.

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Fig. 4 is a graphic representation of two equal tempered scales and a perfect or just intonation scale.

Fig. 5 is a fragmentary schematic view illustrating an organ pipe tone producing element for producing a prime tone and a sub tone.

Fig. 6 is a similar view illustrating two separate tone producing elements for producing a prime tone and a sub tone for each key.

In order to demonstate the theory upon which the invention is based, a graphic representation of two equal tempered scales differing slightly in pitch and of a perfect or just intonation scale interposed between the equal tempered scales is illustrated in Fig. 4 of the drawings, the representation of the scales including the tones in an octave from middle C to the C above.

The uppermost scale consisting of prime tones indicated by the reference character P illustrates an equal tempered scale in which the tones thereof are separated by intervals corresponding to a common multiple factor of 1.0595, the low C in the octave being represented by 1.0000 and the upper C by 2.0000.

The lowermost scale consisting of sub tones indicated by the reference character S illustrates an equal tempered scale in which the tones thereof are likewise separated by intervals corresponding to a common multiple factor of 1.0595. As the tones in this scale are slightly lower in pitch than the tones in scale P, the low C♮ in the octave is represented by .9921 and the upper C♮ by 1.9843.

The intermediate scale indicated by the reference character J is a just diatonic scale in which six common intervals are represented, namely, a major second from 1.0000 to 1.1250, a major third from 1.0000 to 1.2500, a perfect fourth from 1.0000 to 1.3333, a perfect fifth from 1.0000 to 1.5000, a major sixth from 1.0000 to 1.6667, and a major seventh from 1.0000 to 1.8750. An additional interval from 1.0000 to 1.7500, known as the natural or harmonic seventh, is also represented in scale J. The low C of scale J is represented by 1.0000 the same as scale P and the upper C by 2.0000.

All tones in scales P, J and S are represented by decimal ratios which may be thought of as the number of vibrations produced by the various tones thereof in the same interval of time that the low C of scales P and J executes one vibration. The relative pitches or number of cycles per second of all tones are also given in relation to tone A in scale J when the same is tuned

to the American standard pitch of 440 cycles per second. It will be noted that the pitches of all tones in scale J are expressed in whole numbers as is also the case with each C in scale P and E♮ in scale S.

The rationale of the notation used to represent notes in scales P and S will appear from the following: When modulating from the key of C major into the key of G major, F is raised to F sharp. F is the fourth note in the scale of C major while F sharp is the seventh note in the scale of G major. In scale J the fourth note is closely approximated by a prime tone in scale P, while the leading tone seventh in scale J is closely approximated by a sub tone in scale S. The prime tones are, therefore, represented by plain letters and the sub tones by sharped letters. When modulating from the key of F major into the key of C major, B flat is raised to B natural. For similar reasons the flats and naturals are used to represent prime tones and sub tones respectively. By means of this arrangement of conventional symbols the enharmonic notes of scales P and S may be clearly differentiated. However, it will be apparent that this notation is accurate only within the eight key signatures from A flat major through A major and that additional symbols would have to be provided in order to avoid ambiguous note designations of just intonation scales in other musical keys.

The faults of the equal tempered scale may be readily seen by comparing the relative sizes of intervals in scale P with the corresponding intervals in scale J of just intonation. The major third CE and major sixth CA of scale P are too wide in comparison with the corresponding intervals in scale J while the minor third EG and the minor sixth EC are too narrow in comparison with scale J for perfect consonance. The minor seventh CB♭ used in the dominant seventh chord CEGB♭ is considerably wider than the harmonic seventh interval between 1.0000 and 1.7500 in scale J. The equal tempered fourths and fifths such as CF and CG respectively are mistuned by about one-fiftieth of an equal tempered semitone and are, therefore, harmonically equivalent to just fourths and fifths. The octave is the only perfect interval within the equal tempered scale.

By providing a second equal tempered scale such as scale S of slightly lower pitch the imperfect intonation of the thirds and sixths of equal temperament can be corrected by proper substitution. The scale S is tuned flatter than scale P by a comma equal to one third of the great diesis, which is the interval by which three superimposed just major thirds are short of an octave. In general, the comma is the interval by which four superimposed fifths exceed two octaves and a just major third. Since just fifths are wider than equally tempered fifths, it follows that the comma of perfect intonation is larger than that required for the system of commatic equal temperament provided by the scales P and S. The former comma is .215 of an equal tempered semitone while that of the commatic equal temperament is .137 of an equal tempered semitone. When music involving complex modulations and progressions is played in perfect intonation, frequent shifts of a comma are bound to occur. Because of the small comma required in the system of temperament here described, these shifts will be less noticeable than in a mathematically perfect intonation.

In the commatic equal temperament all major thirds and their inversions, the minor sixths, are in perfect tune. Thus the interval between C in scale P and E♮ in scale S coincides with the interval from 1.0000 to 1.2500 in scale J. All other major thirds such as D♭F♮, DF♯, E♭G♮, etc., being of the same size as CE♮ are also perfect. The minor thirds and their inversions, the major sixths, are very slightly out of tune but hardly enough to make them distinguishable from the corresponding perfect intervals. Thus E♮G is slightly narrower than the just minor third between 1.2500 and 1.5000 in scale J because G is slightly flat. The same is true of all the other minor thirds such as F♯A♭, F♯A, G♯B♭, etc.

It is possible to introduce a slight modification in the above arrangement whereby the minor thirds are perfectly tuned and the major thirds are tuned slightly flat but the total harmonic effect of such a system would be practically identical with the one here described.

Since all major and minor chords contain various combinations of major and minor thirds and sixths the said chords may be rendered in almost perfect intonation in all musical keys by selection of the proper tones from scales P and S. In scale J the tones 1.0000, 1.1250, 1.2500, 1.5000 and 1.7500 form a justly intoned dominant ninth chord within the limits of one octave. A good approximation to this ideal chord may be attained by employing the tones C, D, E♮, G and A♯ from scales P and S. The superfluous sixth CA♯ which is the only appreciably mistuned interval in the chord serves as a satisfactory substitute for the natural seventh interval from 1.0000 to 1.7500 in scale J. In a similar manner highly consonant dominant seventh and dominant ninth chords are obtained in all tonalities by deriving their roots, fifths and ninths from scale P and their thirds and sevenths from scale S.

Referring to the drawings by characters of reference the keyboard is diagrammatically illustrated by a portion of the keys thereof which are lettered according to the notes of the scale. The means responsive to the actuation of the keys of the keyboard for automatically correcting the intonation of chords includes for each key a switch means indicated generally by the reference character N, a solenoid S adapted to be energized by the simultaneous actuation of at least two of the keys to thereby control the pitch of a tone producing element T of at least one of the keys and a double armature relay R adapted to be actuated when certain chords are struck to break the circuit with certain of the solenoids so that the pitches of the tone producing elements T corresponding thereto will remain unchanged.

The relays R are twelve in number irrespective of the number of the keys of the keyboard and the same are numbered respectively R1–R12. Likewise the solenoids S are twelve in number and are numbered respectively S1–S12. The tone producing elements T of the instrument correspond in number to the keys of the keyboard and the tone producing elements are normally tuned to the notes of the equal tempered scale P and are constructed to produce tones of the scale S when the tuning elements 48 thereof are energized by the playing of certain chords.

The switch means N may be of any preferred construction and as illustrated by the wiring diagram in Figs. 1 and 3 of the drawings and more particularly in Fig. 3 thereof each switch means N includes a pair of oppositely disposed spring

switch elements 10 and 11 formed with rolled inwardly directed free upper ends 12 which slidably engage against oppositely inclined cam faces 13 provided on the flared lower end of a switch actuator lug 14 fashioned of insulation material, one such lug being secured to and depending from the underside of each key. The switch elements 10 and 11 of each switch means N are secured to opposite side edges of an insulation strip 15 affixed to the instrument frame, the upper end of each switch element 10 and 11 being normally tensioned against the actuator lug 14 for movement inwardly upon depression of the key. Protruding through the strips 15 are pairs of fixed switch terminals 16 and 17, and 18 and 19 respectively, disposed adjacent to the switch elements 10 and 11 and adapted to make contact therewith upon the actuation of the keys to permit of the normal inward movement of elements 10 and 11.

The switch elements 10 of the switch means N are respectively connected by conductor wires 20 to common conductor 21 which extends throughout the length of the keyboard and is connected to a source of current 22 and to a ground 23 through a three-way switch 24. The opposite switch elements 11 of the switch means N of all keys of the same note denomination in each octave are connected by conductor wires 25 to a common bus wire 26, there being twelve bus wires 26 respectively lettered according to the subtone series and which extend throughout the length of the keyboard while the twelve keys in each octave are lettered according to the prime tones.

The switch terminal 16 of each key throughout the keyboard is connected by a conductor wire 27 to the switch terminal 18 of the fourth key to the right while the switch terminal 17 of each key is connected by a conductor wire 28 to the switch terminal 19 of the third key to the left. Each switch terminal 16 is also connected by a conductor wire 27A to the switch terminal 18 of the eighth key to the left while each switch terminal 17 is also connected by a conductor wire 28A to the switch terminal 19 of the ninth key to the right. For instance, beginning at the left of Fig. 1, the switch terminal 16 of key C is connected by a conductor wire 27 to the switch terminal 18 of key E, which terminal is also connected by a conductor wire 27A to the switch terminal 16 of key C in the next octave above, and the last mentioned terminal in like manner is connected by a conductor wire 27 to the switch terminal 18 of key E in the next octave above, and so on throughout the length of the keyboard. Similarly, switch terminal 19 of the first key C is connected by a conductor wire 28 to the switch terminal 17 of the key Eb, which terminal is also connected by a conductor wire 28A to the switch terminal 19 of the key C in the next octave above, which latter terminal in like manner is connected by a conductor wire 28 to the switch terminal 17 of the key Eb in the next octave above, and so on throughout the length of the keyboard. Thus, by means of the conductor wires 27 and 27A the switch terminals 16 and 18 of keys separated by intervals of a major third or any inversion thereof, are coupled together, and by means of the conductor wires 28 and 28A the switch terminal 17 and 19 of keys separated by intervals of a minor third or any inversion thereof, are coupled together. It follows that upon the simultaneous depression of the low key C at the left side of the diagram Fig. 1 and the upper key E at the right side of the diagram, a circuit is completed from

the common conductor 21 to the bus wire E♮ through the switch terminal 16 of the key C, the switch terminal 18 of the key E a major third above, the switch terminal 16 of the key C an octave above and thence through the switch terminal 18 of the key E a major tenth above. Similarly, upon the simultaneous depression of the low key C at the left side of the diagram and the upper key Eb at the right side of the diagram a circuit is completed from the common conductor 21 to the bus wire C♮ through the switch terminal 19 of the low key C, the switch terminal 17 of the key Eb a minor third above, the switch terminal 19 of the key C an octave above, and thence through the switch terminal 17 of the key Eb a minor tenth above.

The bus wires 26 are connected by conductor wires 29 to fixed contacts 30 respectively, which contacts are normally engaged by the left-hand armatures of the relays R1 to R12 respectively. The conductor wires 29 are also connected to the lower windings of the solenoids S1 to S12 respectively. The left-hand armature 31 of each relay is connected by a conductor wire 32 to the right-hand armature 33 of the fifth relay to the left respectively, the right-hand armature thereof being normally in engagement with a fixed contact 34. The fixed contacts 34 are each connected by a conductor wire 35 to branch wires 36 and 37 leading respectively to the winding of the third relay to the right thereof and to the upper winding of one of the solenoids S.

It is to be understood that the energizing of a particular solenoid S is dependent upon the note denominations represented in any pair of simultaneously depressed keys and is independent of any possible inversion of the interval thereof. When two keys forming an interval of a major third or a major sixth such as AbC or EbC, respectively, are depressed, a circuit is completed between the switch element 10 of the lowermost key and the switch element 11 of the uppermost key. Conversely, when two keys forming an interval of a minor third or a minor sixth such as EG or EC, respectively, are depressed, a circuit is completed between the switch element 10 of the uppermost key and the switch element 11 of the lowermost key. In every case of a completed circuit between the switch elements 10 and 11 of two keys, the switch element 10 is associated with a key which theoretically should elicit a prime tone and the switch element 11 is associated with a key which theoretically should elicit a sub tone in order that the interval be rendered in just intonation.

The twelve solenoids S1 to S12 are arranged in horizontal alignment and are provided with armatures 38 swingably mounted on spring elements 39 respectively. The armatures 38 are formed with depending latch elements 40 protruding through longitudinally spaced detent openings 41 in a slidably mounted latch bar 42 which as illustrated is retractably disposed in position for engagement with the latch elements 40 by the action of a coiled contractile spring 43. Disposed below each of the armatures 38 is a spring switch element 44 having its free end located below the lower end of the latch element 40 and which is spaced therefrom by an insulation block 45. As illustrated the downward tension of the armature 38 normally acts to overcome the upward tension of the spring switch element 44 so that the same moves upwardly with the armature 38 when the solenoid thereof is energized. A fixed contact element 46 is provided for each

spring switch element 44 which is adapted to be engaged thereby when the corresponding armature 38 is moved upwardly, the contact elements 46 being connected by conductor wires 47 to the windings of tuning elements 48 associated with each tone producing element T. The opposite ends of the windings of the tuning elements 48 are connected by conductor wires 49 to a common conductor 50. The windings of all tuning elements 48 associated with the tone producing elements T of the same note denomination in each octave are connected by bus wires 51 for control by a single solenoid S. The tone producing elements T may be of any type and any suitable key controlled means for sounding the same may be employed. The design of the electrically controlled tuning elements 48 will depend upon the particular types of tone producing elements T used, but it is desirable that the time lag between the initial operation of the switch means N and the operation of the tuning elements 48 be small compared to the time lag between the initial movement of the key levers and the sounding of the corresponding tone producing elements T controlled thereby. The tone producing elements T which are normally tuned to the scale P are lowered in pitch to produce tones of the scale S when the windings of the tuning elements 48 thereof are energized.

In the right hand position the three-way switch 24 engages a contact 52 which is connected to the common conductor 21 and to the common conductor 50. In the middle position the said switch 24 engages a double contact 53, one contact of which is connected to the common conductors 21 and 50 and the other of which is connected by a conductor wire 55 to the winding of a solenoid 56. The left hand or open circuit position of the said switch is provided by a contact 54.

The solenoid 56 is disposed in alignment with and adjacent to one end of the latch bar 42 and is provided with an armature 57 mounted on the adjacent end of the latch bar 42 which armature is adapted to be engaged by the solenoid 56 for shifting the latch bar 42. The opposite end of the latch bar 42 has the coiled contractile spring 43 attached thereto and adapted to tension the latch bar for retracting the same when the solenoid 56 is deenergized. The source of current 22, the windings of the relays R, the upper and lower windings of the solenoids S, the spring switch elements 44, and the winding of the solenoid 56 are respectively connected to a common ground as indicated at 23, 58, 59, 60 and 61.

When the three-way switch 24 is set in the right hand position the solenoid 56 is deenergized and the latch bar 42 is free to engage with the armatures 38 of solenoids S. The general purpose of the latching feature of the switches actuated by the solenoids S is to allow the corrected intonation of each chord to be retained so that the same chord may thereafter be played as a succession of notes in arpeggio fashion without altering the intonation thereof. Also if the instrument is provided with sustained tones which may sound after the keys are released, as in a piano, the latching of switches actuated by solenoids S will insure that the intonation of the chord will not change upon releasing the keys. For each new chord played a new combination of solenoids S will be energized and as the armatures 38 thereof engage the latch bar 42 they will simultaneously act to disengage those previously latched armatures 38 of a prior combination which are foreign to the new combination as is characteristic of structures of this kind.

When the three-way switch 24 is in the middle position the solenoid 56 is energized to shift the latch bar 42 so that the armatures 38 no longer latch therewith, and the switches controlled thereby remain closed only while the corresponding solenoids S are energized. For certain types of music in which the chords follow one another in rapid succession, and particularly if the tones of the instrument sound only during the depression of the keys, it may be more advantageous to render the latch bar 42 inoperative by setting the three way switch 24 in the middle position.

In order to play music in equal temperament the three-way switch is set in the left hand or open circuit position and all solenoids S as well as all tuning elements 48 are deenergized and all tone producing elements T of the instrument are then tuned to scale P or equal temperament. Also after the three-way switch has once passed through the middle position before a final setting in the left hand position the latch bar 42 is momentarily shifted to disengage all previously latched armatures 38 and thus producing the same effect as the deenergizing of all the tuning elements 48.

It will be understood that the conductor wires 29 connected respectively with the contacts 30 of the relays R9 to R12 inclusive are connected with the lower windings of the solenoids S1 to S4 inclusive as illustrated in Fig. 2 of the drawings. Similarly the conductor wires 32 connect the right-hand armatures 33 of the relays R8 to R12 inclusive with the left-hand armatures 31 of the relays R1 to R5 inclusive. The conductor wires 35 leading from the contacts 34 of the relays R10 to R12 inclusive are connected with the conductor wires 37 leading from the relays R1 to R3 respectively.

The use of the instrument will be set forth in conjunction with the playing of chords which are typical of the chords requiring corrected intonation. Since most of the chords which require corrected intonation contain notes either 3, 4, 8 or 9 keys apart, one or more circuits will be completed upon the playing of a chord due to the spacing of the notes thereof so that the circuits with one or more of the bus wires 26 will be completed to thereby actuate tuning elements 48 of certain tone producing elements T to produce tones of just intonation.

One of the chords which will be changed when played on the keyboard is the major chord having the notes CEG. With particular reference to Fig. 3 the depressing of the keys C and E of the keyboard will close the circuit with the bus wire 26 which bears the notation E♮. In like manner when the keys E and G of the keyboard are struck a circuit will be closed with the bus wire 26 likewise bearing the notation E♮.

The said bus wire 26 with the notation E♮ is connected by means of the conductor wire 29, contact 30, left-hand armature of the relay R7, conductor wire 32, the right-hand armature of the relay R2, contact 34, conductor wire 35 and conductor wire 37 connected with the winding of the relay R5 and the upper winding of the solenoid S5 whereby the said relay and solenoid will be energized upon the playing of said chord so that the armature 38 will be attracted by the solenoid S5 to close the circuit with the conductor wire 47 so that the tone producing element T normally producing the tone E will func-

tion to produce the tone E♮. The chord thus changed will be CE♮G.

Another chord which will be changed when played on the keyboard is the minor chord GB♭D. Depressing the keys GB♭ and the keys B♭D of the said chord will close the circuits with the bus wires bearing the notation G♮ and D♮. The circuit with the said bus wire 26 bearing the notation G♮ is completed through the left-hand armature of the relay R10 and the right-hand armature of the relay R5 into the winding of the relay R8 and the upper winding of the solenoid S8 so that the tone producing element T normally producing the tone G will function to produce the tone G♮. Similarly the circuit with the bus wire 26 bearing the notation D♮ is completed through the left-hand armature of the relay R5 and the right-hand armature of the relay R12 into the winding of the relay R3 and the upper winding of the solenoid S3 so that the tone producing element T normally producing the tone D will function to produce the tone D♮. The minor chord CB♭D with its intonation thus corrected will be G♮B♭D♮.

Due to an anomaly in the structure of the dominant ninth chord CEGB♭D when the same is rendered in just intonation the constituent minor chord GB♭D thereof will no longer have its tones G and D lowered in pitch to G♮ and D♮ but instead the pitches of these tones will remain unchanged and the pitch of the tone B♭ will be lowered to A♯. The same is true of the dominant seventh chord CEGB♭. As set forth hereinbefore depressing the keys CE and/or depressing the keys EG will close the circuit with the bus wire 26 which bears the notation E♮ to thereby energize the winding of the relay R5 and the upper winding of the solenoid S5 so that the tone producing element T producing the tone E will function to produce the tone E♮. Simultaneously a circuit with the said bus wire bearing the notation E♮ is also completed through conductor wire 29 into the lower winding of solenoid S11 so that the tone producing element T normally producing the tone B♭ will function to produce the tone A♯. The depressing of the keys GB♭ of the chord CEGB♭D and the keys B♭D of the said chord will close the circuits with the bus wires 26 bearing the notation G♮ and D♮. These bus wires are respectively in circuit with the right-hand armature 33 and the left-hand armature 31 of the relay R5. As this relay is energized by the playing of the notes CE and/or EG, the right and left-hand armatures thereof will be attracted thereto so as to break the circuits with the bus wires bearing the notation G♮ and D♮ whereby the tone producing elements T producing the tones G and D will be unchanged in pitch. The dominant ninth chord CEGB♭D with its intonation thus corrected will be CE♮GA♯D.

It will be apparent from the foregoing description that the automatic corrections of the intonation of these and other chords will be exactly analogous when they are transposed into any musical key and also that the desired corrections of intonation will be equally effective for all possible inversions of each chord.

In Figs. 2 and 3 of the drawings the tone producing elements T and tuning elements 48 are illustrated diagrammatically. In Fig. 5 of the drawings however the same is illustrated more in detail. As illustrated therein the tuning element 48 consists of an electro-magnet one terminal of which is connected to the fixed contact element 46 by the conductor wire 47 while the opposite terminal thereof is connected to the common conductor 50 by the conductor wire 49 as is also shown in Figs. 2 and 3 of the drawings. In this embodiment the tone producer T consists of an organ pipe which is open at its upper end in the usual manner and is provided with an aperture 62 adjacent the upper end thereof and which is adapted to be closed or restricted by a swingably mounted vane 63 of magnetic material when the electro-magnet 48 is energized. The vane 63 is normally maintained by a spring 64 in open relation with reference to the aperture 62, it being understood that when the same is in open relation the tone producing element or organ pipe T will produce a prime tone or a tone in scale P and when the vane is closed by the energizing of the electro-magnet 48 the tone producing element T or organ pipe will produce a sub tone or a tone in scale S.

In Fig. 6 of the drawings a plurality of octave related tone producing elements T are shown by way of illustration. For each key throughout the length of the keyboard a tone producing element is provided which in this instance consists of two tone producing devices, one for emitting a prime tone such as D♭ designated by the reference character 64 and the other for emitting a sub tone such as C♯ as indicated by the reference character 65. The tone producing devices 64 for the octave related keys throughout the keyboard are connected by means of a common conductor wire 66 to a contact normally engaging the spring switch element 67 similar to the spring switch element 44 in the previous form of the invention. The opposite tone producing devices 65 of the same octave related keys are respectively connected to a common conductor wire 68 leading to a fixed contact 69 normally out of contact with the spring switch element 67 and adapted to be engaged thereby when the corresponding solenoid S in this instance the solenoid S2 is energized in the manner hereinbefore described which also functions to disengage the contact with the common conductor wire 66. The tone producing devices 64 and 65 are any standard electric key control type and are connected in the usual manner by conductor wires 70 to the key actuated means of the organ. The tone producing device 64 is adapted to emit a prime tone or a tone in scale P while the tone producing device 65 is adapted to emit a sub tone or a tone in scale S.

As hereinbefore set forth the drawings illustrate a portion of the keyboard of a musical instrument which is illustrative of the switch arrangement and wiring connection for each key throughout the keyboard. In some organs several keyboards are provided and for such construction common conductor wires 21 and the bus wires 26 may be extended throughout the extent of the additional keyboards in which event also the conductor wires 27 and 28 and 27*a* and 28*a* would be extended throughout the additional keyboards.

Having thus described the invention, it will be apparent that the same is not limited to the particular embodiments illustrated, but that numerous modifications thereof may be made without departing from the more fundamental principles of the invention.

What is claimed is:

1. A musical instrument of the type having a keyboard, a tone producing element for each key thereof and an action for effecting the sounding of the tones of said tone producing elements when

the keys are actuated respectively, in combination with an electrical switch for each key, each switch having two terminal elements and two pairs of contacts normally spaced therefrom respectively, an electrical circuit connected with a source of current, one of the terminal elements of each switch being connected to one of the wires of said circuit, circuit wires respectively connecting one pair of contacts of each switch with contacts of the switches of keys located four semitones above and three semitones below respectively, circuit wires respectively connecting the other pair of contacts of each switch with contacts of switches of the keys located three semitones above and four semitones below respectively, means carried by the keys respectively for effecting engagement of said contacts with the terminal elements upon depressing of the keys, double armature relays corresponding in number to the number of the keys in an octave of the keyboard with the corresponding notes of the octaves having the same relay, double coil solenoids corresponding in number to the number of keys in an octave of the keyboard with the corresponding notes of the octaves having the same solenoid, circuit wires connecting the opposite terminal element of each switch with a winding of the solenoid of the key separated six semitones therefrom and with one of the armatures of the relay of the key separated two semitones therefrom whereby switches of corresponding keys of each octave are in circuit with the same solenoid and are normally in circuit with the same armature, circuit wires connecting said relays in circuit with the other winding of the solenoids respectively and with the relays normally in circuit with the other armature of the relays of the keys separated three semitones therefrom respectively and with one armature of each relay with the opposite armature of the relay of the keys separated five semitones therefrom, said tone producing elements each being connected with the other wire of the first named electrical circuit and each having means for emitting an enharmonic tone lower in pitch than the normal tones thereof, and normally open electrical switch means connected with said last named means and adapted to be closed by the movements of the armatures of the solenoids when the same and the relays are energized by the actuation of the keys when a chord is played on the keyboard to thereby effect the sounding of the enharmonic tones of lower pitch of at least one of the tone producing elements corresponding to the keys actuated.

2. A musical instrument of the type having a keyboard, a tone producing element for each key thereof and an action for effecting the sounding of the tones of said tone producing elements when the keys are actuated respectively, in combination with an electrical switch for each key, each switch having two terminal elements and a pair of contacts for each terminal element normally spaced therefrom respectively, one contact of one of the terminal elements of each key being in circuit with contacts of the other terminal elements of octave related keys located four semitones above and eight semitones below respectively, the other contact of the first named terminal element of each key being in circuit with contacts of the other terminal elements of the octave related keys located nine semitones above and three semitones below respectively, one contact of the other terminal element of each key being in circuit with contacts of the first named terminal elements of octave related keys located eight semitones above and four semitones below respectively, the other contact of the other terminal element of each key being in circuit with the contacts of the first named terminal elements of octave related keys located three semitones above and nine semitones below respectively, means carried by the keys respectively for effecting engagement of the said contacts with the terminal elements upon depression of the keys, double armature relays corresponding in number to the number of keys in an octave of the keyboard with the corresponding keys of each octave having the same relay, double coil solenoids corresponding in number to the number of keys in an octave of the keyboard with the corresponding keys of each octave having the same solenoid, one of the terminal elements of each switch being connected in circuit with a source of current, the opposite terminal element of each switch being connected in circuit with a winding of the solenoid of the key separated six semitones therefrom and each of the said opposite terminal elements being normally in circuit with one of the armatures of the relay separated two semitones therefrom whereby the switches of corresponding keys of each octave are in circuit with the same solenoid and are normally in circuit with the same armature, the said relays each being connected in circuit with the other winding of a corresponding solenoid respectively and the relays also being normally connected in circuit with the other armature of the relays of the keys separated three semitones therefrom respectively and one armature of each relay being connected in circuit with the opposite armature of the relay of the key separated five semitones therefrom, said tone producing elements each having means for emitting an enharmonic tone lower in pitch than the normal tones thereof and normally open electrical switch means connected in circuit with octave related groups of the said last named means, each of said electrical switch means adapted to be closed by the movements of the armatures of corresponding solenoids when the same and the relays are energized by the actuation of the keys when a chord is played on the keyboard to thereby effect the sounding of the enharmonic tones of lower pitch of at least one of the tone producing elements corresponding to the keys actuated.

3. A musical instrument of the type having a keyboard, a tone producing element for each key thereof and an action for effecting a sounding of the tones of said tone producing elements when the keys are actuated respectively, in combination with an electrical switch for each key, each switch having two terminal elements and two pairs of contacts normally spaced therefrom respectively, the contacts of one switch being connected in circuit with the contacts of other switches of keys located three and four semitones thereabove and therebelow, means carried by the keys respectively for effecting engagement of said contacts with the terminal elements upon depressing of the keys, a plurality of double armature relays, a plurality of double coil solenoids, one of the terminal elements of each switch being connected in circuit with a source of current, the opposite terminal element of each switch being connected in circuit with a winding of one of the solenoids and being normally in circuit with one of the armatures of one of the relays with the terminals of the switches of the corresponding keys in the several octaves of the keyboard

being connected with the same solenoid and normally in circuit with the same armature, said tone producing elements each having means for emitting an enharmonic tone lower in pitch than the normal tones thereof and normally open electrical switch means connected with said last named means and adapted to be closed by the movements of the armatures of the solenoids when the same and the relays are energized by the actuation of the keys when a chord is played on the keyboard to thereby effect the sounding of the enharmonic tones of lower pitch of at least one of the tone producing elements corresponding to the keys actuated.

4. A musical instrument of the type having a keyboard, a tone producing element for each key thereof and an action for effecting the sounding of the tones of said tone producing elements when the keys are actuated respectively, in combination with an electrical switch for each key, each switch having two terminal elements and two pairs of contacts normally spaced therefrom respectively, an electric circuit connected to a source of current, one of the terminal elements of each switch being connected to one of the wires of said circuit, circuit wires respectively connecting the contacts of one switch in circuit with the contacts of other switches of keys located three and four semitones thereabove and therebelow, means carried by said keys respectively for effecting engagement of said contacts with the terminal elements upon depressing of the keys, circuit wires connecting the opposite terminals of said switches in circuit with tuning control devices of said tone producing elements respectively, said tone producing elements having means for emitting enharmonic tones lower in pitch than the normal tones thereof, and electrically actuated means in the circuits between said opposite terminals and said last named means and adapted to be actuated when a chord is played on the keyboard to thereby effect the sounding of the enharmonic tones of lower pitch of at least one of the tone producing elements corresponding to the keys actuated.

5. In a keyboard type polyphonic musical instrument having tone producing elements normally tuned to the equal tempered scale, the combination of electrically actuated means associated with each tone producing element for effecting an enharmonic shift of pitch to correct the grosser errors of the said scale, an electrical switch for each key, a network of coupling wires interconnecting said switches to provide circuit paths upon the simultaneous actuation of keys separated by musical intervals of major and minor thirds and all inversions thereof by octaves and all transpositions of each interval by semitones, latching armature solenoids equal in number to the keys in an octave of the keyboard and adapted to control octave related groups of said electrically actuated means, circuit cut out relays adapted to render inoperative certain latching armature solenoids associated with anomalous notes of a chord, an electrical circuit including a source of current and adapted to extend through any one of said circuit paths and connected with the armatures of two of said circuit cut out relays and with the winding of one of said cut out relays and with the winding of one of said latching armature solenoids, latching means having detent elements engaging the latch elements of all of the armtaures of said latching armature solenoids, electrically actuated means for shifting said latching means out of engagement with all of said latch elements, and a three way switch provided with a contact connecting said current source with said electrical circuit and a double contact connecting said current source with said electrical circuit and with the last named electrically actuated means and having an open circuit position for disconnecting said current source whereby the instrument is retuned to the equal tempered scale.

6. In a keyboard type polyphonic musical instrument having tone producing elements normally tuned to the equal tempered scale, electrically controlled means for lowering the pitches of octave related groups of said tone producing elements to correct the grosser errors of the said scale, an electrical switch for each key, networks of coupling wires between said switches for producing equivalent circuit paths upon the simultaneous actuation of a plurality of keys of distinct note denominations constituting a chord irrespective of all inversions thereof and octave repetitions of the notes thereof, the arrangement of said coupling wires following the same repeated pattern among all of said switches to provide analogous circuit paths for all transpositions of a given chord whereby the simultaneous actuation of any two keys forming an interval classed as major effects the closure of one of said circuit paths feeding said electrically controlled means associated with the upper of the two keys of the said major interval and whereby the simultaneous actuation of any two keys forming an interval classed as minor effects the closure of one of said circuit paths feeding said electrically controlled means associated with the lower of the two last named keys of the said minor interval, said electrically controlled means including solenoids for controlling the tuning elements of said octave related groups and being connected to respond in pairs corresponding to notes a tritone apart for providing corrected sevenths in addition to corrected thirds in dominant seventh and dominant ninth chords, and a circuit cut out relay for each key of an octave of the keyboard and being connected to operate in unison with a solenoid of said electrically controlled means and adapted to render inoperative the solenoids of others of said electrically controlled means associated with the fifth and with the ninth of dominant seventh and dominant ninth chords.

7. In a keyboard type polyphonic musical instrument, the combination of two tone producing elements of fixed pitch for each key respectively tuned to two equal tempered scales differing in pitch by an enharmonic interval, an action for effecting the sounding of one of a pair of said tone producing elements when the corresponding keys are actuated respectively, an electrical switch for each key, a network of coupling wires interconnecting said switches to provide circuit paths upon the simultaneous actuation of keys separated by musical intervals of major and minor thirds and all inversions thereof by octaves and all transpositions of each interval by semitones, latching armature solenoids equal in number to the keys in an octave of the keyboard, said latching armature solenoids adapted to select which of two sets of octave related enharmonic tone producing elements shall be able to sound, circuit cut out relays adapted to render inoperative certain latching armature solenoids associated with anomalous notes of a chord, an electrical circuit including a source of current and adapted to extend through any one of

said circuit paths and being connected with the armatures of two of said circuit cut out relays and with the winding of one of said cut out relays and with the winding of one of said latching armature solenoids, a latching means having detent elements engaging latch elements of all of the armatures of said latching armature solenoids, electrically actuated means for shifting said latching means out of engagement with all of said latch elements, and a three way switch

provided with a contact connecting said circuit source with said electrical circuit and a double contact connecting said current source with said electrical circuit and with the last named electrically actuated means and having an open circuit position for disconnecting said current source whereby the instrument is tuned only to the equal tempered scale of higher pitch.

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