May 10, 1949. E. M. SPIELMAN 2,469,850

ELECTRIC MUSICAL INSTRUMENT

Filed March 14, 1944 4 Sheets-Sheet 1

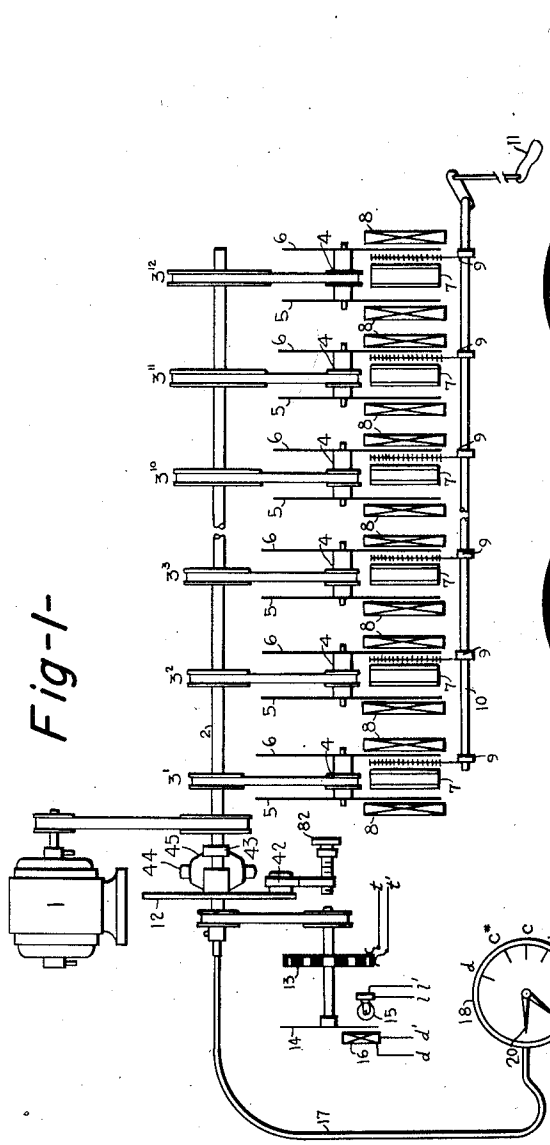


Fig-1-

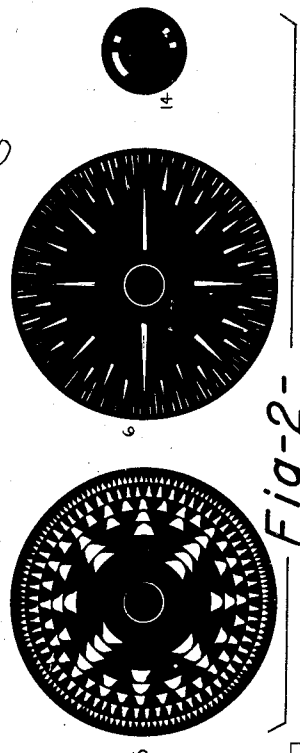


Fig-2-

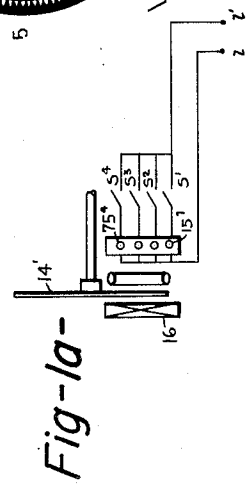


Fig-1a-

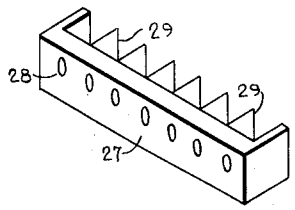
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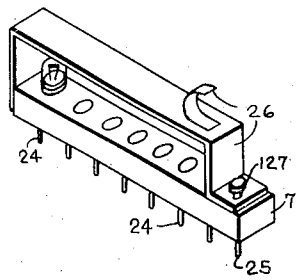
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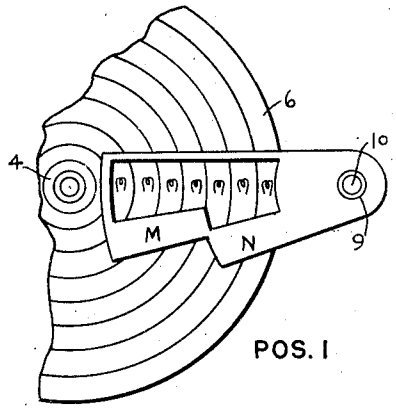
ELECTRIC MUSICAL INSTRUMENT

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Fig-3-

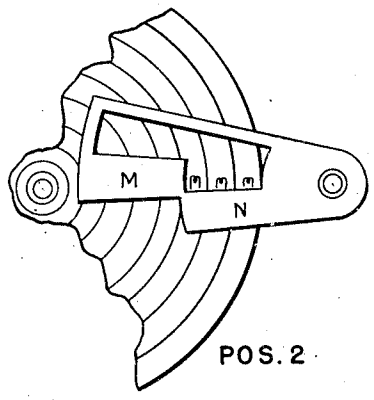






POS. 1

Fig-5a-



POS. 2

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ELECTRIC MUSICAL INSTRUMENT

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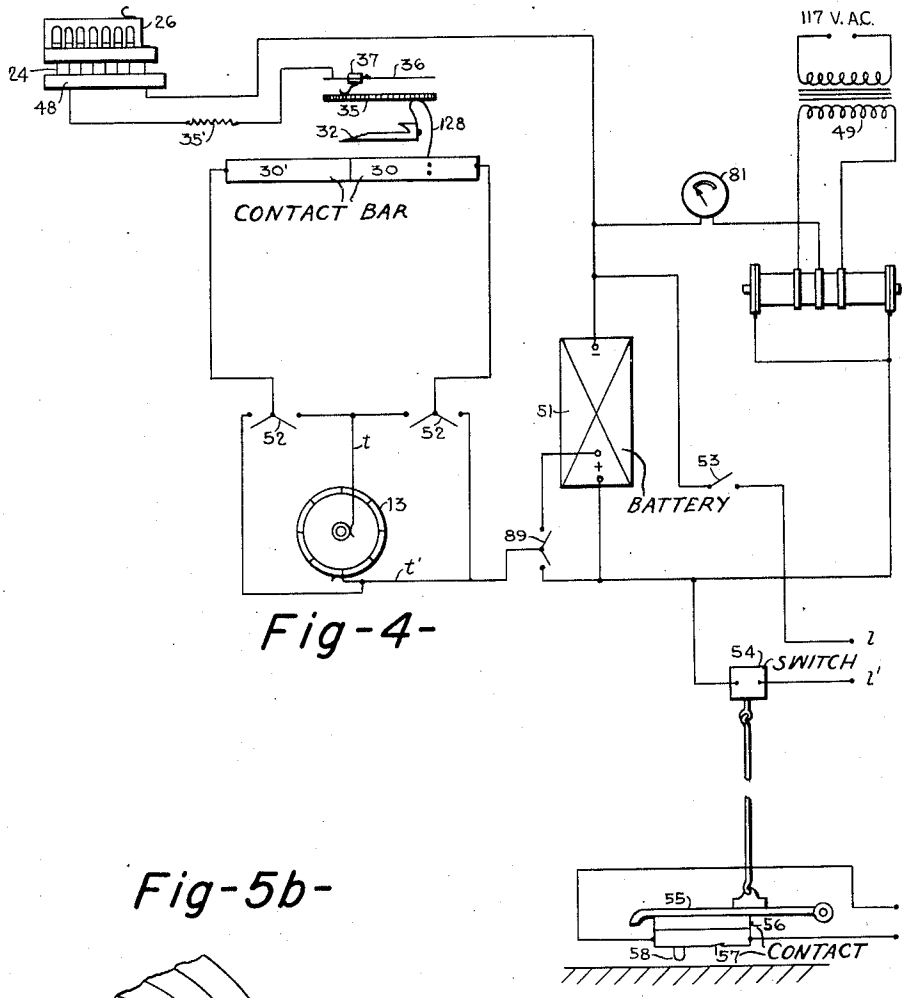
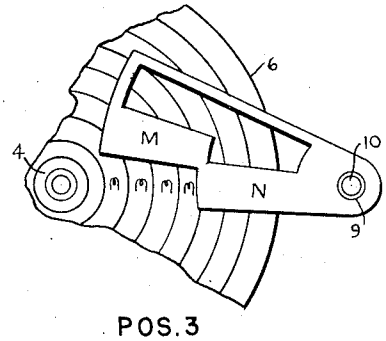


Fig-4-

Fig-5b-



POS. 3

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ELECTRIC MUSICAL INSTRUMENT

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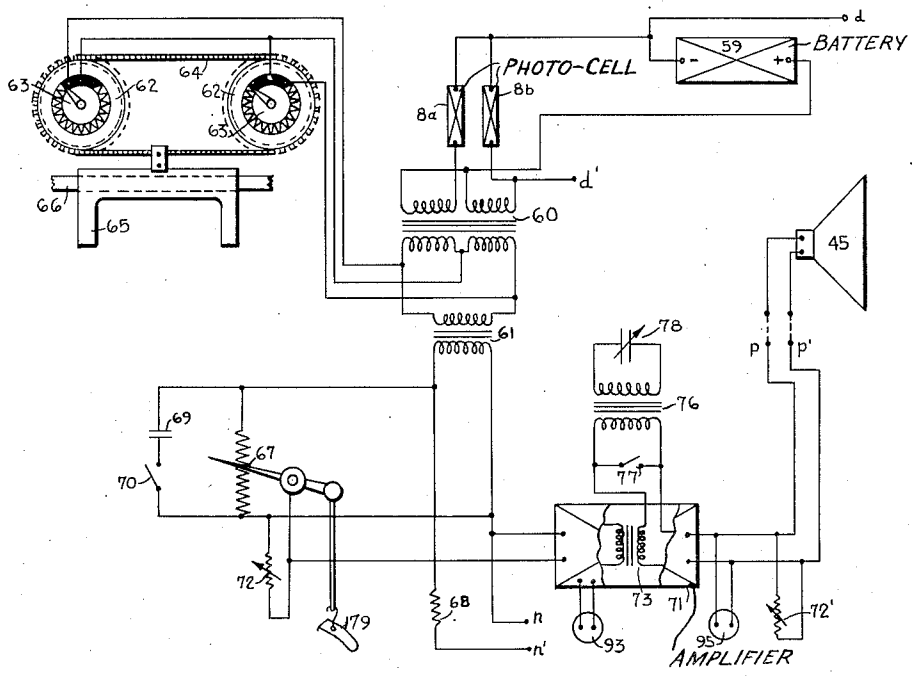


Fig-6-

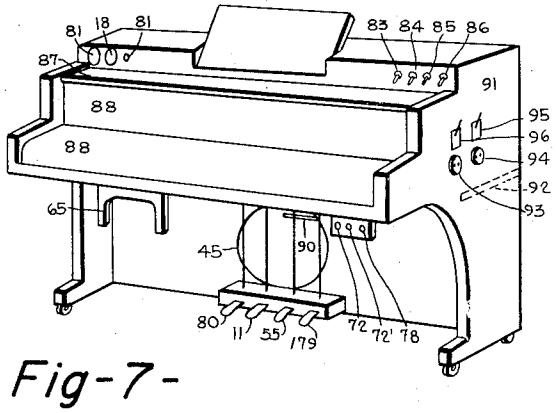


Fig-7-

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Patented May 10, 1949 2,469,850

UNITED STATES PATENT OFFICE

2,469,850

ELECTRIC MUSICAL INSTRUMENT

Emeric M. Spielman, New York, N. Y.

Application March 14, 1944, Serial No. 526,408

1 Claim. (Cl. 84—1.18)

1

The present invention consists in improvements and new devices for electric musical instruments which produce tone frequencies by rotating members, particularly of the type described in my former U. S. Patent No. 1,778,374.

The invention consists in a device for execution of accents by pedals.

The invention further consists in a modification and new application of a device described in my U. S. Patent No. 1,977,095, in order to produce orchestral effect.

I have to interpret the meaning of orchestral effect. We speak of orchestral effect when a band of performers on various instruments executes polyphonous music. The resulting sound appears as a mixture of voices, each played in different tone colors. The mixture of different tone colors alone does not exhaust the characteristic of orchestral effect; it is indispensable that each voice within the mixture sounds with independent accents, dynamically varying. Therefore, we contrast music of an organ which performs upon several keyboards an accentless mixture of different tone colors to orchestra music with its matchless abundance of accents. According to these considerations a keyboard instrument will produce orchestral effect if it is furnished with means which unite the possibility of performing accentuated music and variable mixture of tone colors. From the standpoint of musical progress it is clear that a keyboard instrument which fulfills these conditions cannot have the task of imitating or replacing an orchestra; besides, a better substitute of an orchestra than a record player with power amplifier cannot be imagined. But if such an instrument should be used to give the possibility of innovating an orchestra composition by new tone colors in an adequate instrumentation chosen by the performer, new avenues for musical performance could be opened.

The instrumentation of an orchestral work comprises a great number of different instruments which, however, can be grouped in three categories, namely stringed, wood wind and brass instruments, each category having its own distinct characteristic of sounding. This phenomenon is utilized in a modification of my photoelectric instrument, described on page 3 of U. S. Patent No. 1,778,374 which could correspond to the mentioned conditions of producing orchestral effect quite well. But as it uses three keyboards and requires more than average skill from its player, it could never replace the piano as a home instrument. With respect to this aim the problem is to produce orchestral effect upon one single keyboard.

The present invention solves this problem by grouping all tone colors in only two categories,

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one category comprising tones rich, the other comprising tones poor in harmonics.

The first category represents the sound of stringed and brass, the second category the sound of wood wind instruments; the mixture of both categories is analogous to full orchestra. The division of tone colors in only two categories makes it possible to apply the method of tone color variation, described in my U. S. Patent No. 1,977,095 in combination with the instrument described in my U. S. Patent No. 1,778,374. Upon this combination the present device for producing orchestral effects on one keyboard is based.

The invention also consists in a device which gives the possibility to play in bass and treble of the same keyboard simultaneously different timbres.

The invention also consists of a device which enables the player to apply a method of performing simultaneously an undefined number of voices.

Other objects of my invention will be apparent from the following description and the accompanying drawings in which:

Fig. 1 is a diagrammatical view of the apparatus producing photo-electric current of tone frequency in changeable timbre,

Fig. 2 shows different types of tone discs,

Fig. 3 illustrates the arrangement of flash light bulbs used for producing the same note in seven octaves,

Fig. 4 is a diagram of the flash light bulb circuit,

Fig. 5 shows one of the screens for varying the tone colors,

Fig. 6 is a diagram of the photocell circuit, and

Fig. 7 is an outside view of the instrument.

In order to more clearly demonstrate the manner of working of the instant improvements and new devices I am going to delineate the entire instrument; therefore, a restricted repetition of some constructional details disclosed in my former patents will be inevitable.

I. *Apparatus*

An electromotor 1 (Fig. 1) is connected by means of a transmission to a shaft 2 on which twelve pulleys 3^1–3^{12} are arranged, only six being shown in the drawing. Each of these pulleys rotates by means of belts one of twelve pulleys 4 of equal diameter, each being arranged on separately bedded shafts. The speed of the pulleys 4 depends on the different diameters of the pulleys 3^1–3^{12}, the dimensions of which increase in the same ratio as the frequencies of twelve consecutive notes increase within an octave. On each of the pulleys 4 two opaque circular tone discs are fixed. These discs 5 and 6 have in annular zones the same number of regularly distributed transparent areas or apertures. Between the

discs **5** and **6** light bulbs **30** are arranged in a row. Opposite at the other side of each disc photo-cells **8** are placed. Light beams coming from the light bulbs strike the photo-cells after having passed through the apertures of the discs. When the discs rotate, the light beams become intermittent with a frequency which corresponds to the number of apertures crossing the way of the light beams per second. In the same sequence as light and darkness changes on the photo-cells **8** their electric resistance varies. If these variations follow in tone frequency the photo-cells will produce a fluctuating current of tone frequency which may be made audible on a phone or a loud speaker. The discs **5** and **6**, preferably made of transparent acetate sheets, are made opaque by printing thereon light impervious areas, as illustrated in Fig. 2. In this manner seven concentric rings of transparent areas or apertures are created, the innermost ring having two transparent apertures, the second ring four, the third ring eight, the fourth ring sixteen, the fifth ring thirty two apertures, following the rule that the larger ring has always double the number of apertures appearing on the preceding one.

Accordingly, the intermittences of light produced by the same rotating disc have the ratio 1:2:4:8:16, which is the same ratio the frequencies of the same note have in five consecutive octaves. However, the sixth and seventh ring is given more than double the number of apertures following the rule that the number of apertures increases from the innermost to the outermost zone according to the ratio 1:2 in the inner zones, in the ratio 1:2.1 in the outer zones. The reason for this deviation is to correct the sounding of the higher octaves according to the sensibility of human hearing which demands the higher octaves to be sharp. As each couple of tone discs synchronously rotating produces the same note in seven consecutive octaves and 12 couples or units are provided, each producing another note within an octave, the tone discs produce eighty four different intermittences corresponding to the tone frequencies of the notes of a chromatic scale covering seven octaves from c^1 to b^4.

The number and distribution of the tone areas are on both discs **5** and **6** alike, but the shape is different. The apertures on disc **5** are chosen for producing sound poor in harmonics analogous to wood wind instruments, the apertures on disc **6** are chosen for producing sound rich in harmonics analogous to stringed and brass instruments. As indicated in the preamble in this way orchestral effect may be obtained. Many variations of known shapes are adapted to fulfill the requirements of producing sound containing more or less harmonics, particularly when the apertures are scanned by beams of light optically formed into a light line, a device which is fundamentally used in sound motion picture machines. But an adequate result can also be accomplished by less complicated means. Fig. 2 shows apertures on disc **5** resembling sine waves recorded by an oscillograph and apertures on disc **6** in shape of straight lines; both shapes are specifically appropriate for creating one of the mentioned timbres.

Eighty four light bulbs are arranged in groups of seven between the discs **5** and **6**. Fig. 3 and Fig. 5 illustrate this arrangement. A strip **48** suitably fixed to the apparatus holds eight jacks. The bulb carrier **7** is provided with eight plugs seven of the plugs **24** being attached to bulb sockets to fit into the mentioned jacks; one plug **25** is connected with the input of the bulb current and one pole of the above mentioned seven bulb sockets, whereas the other pole of the sockets transmits the output of the bulb current over the plugs **24**. The distance between the plugs **24** is equal to the width of the rings on the tone discs; therefore, each bulb is coordinated to one ring, the same in both discs **5** and **6**. In order to facilitate the replacement of bulbs, the carrier **7** is removable by means of a handle **26** which can be pivoted around the screw **127**.

Placed under the handle **26** a combination of screens is provided; Fig. 3 shows them removed. The opaque strip **27** supports a row of screens **29**; each of them separates optically two adjacent bulbs. Strip **27** contains seven holes **28**. Passing through these holes the beams of light, directed to disc **5**, form light spots on the rings, each spot not larger than one ring; therefore, the light of each bulb passes through the apertures of only one ring, namely the opposite ring. On the other side of strip **27** the screens allow the beams of light to form light spots larger than the rings; therefore, the light of one bulb passes not only through the apertures of the opposite ring, but partly also through those of the next two rings. In this case not only the note of the opposite ring, but also the same note in the next higher and lower octaves will be audible in consonance; in this way the disc **6** also is supported in its destination of creating sound with numerous harmonics.

The light of each bulb strikes both discs **5** and **6** simultaneously; therefore, a mixture of the timbres produced by the tone discs is heard. In order to make audible either the timbre of disc **5** or that of disc **6** the simplest way is to cover the disc of the not demanded timbre by a movable opaque screen. This procedure is utilized in a device which makes it possible to play on the same keyboard in bass and treble different timbres simultaneously.

For this purpose a bar **10**, Fig. 1, is provided parallel to shaft **2** holding twelve specifically shaped screens **9**, each placed between disc **6** and one group of bulbs. By means of a pedal **11** all screens are movable together vertically up and down.

In Fig. 5 one of the screens is to be seen in its normal position which allows the light passing to the disc **6** indicated in the drawing by the site of the filaments. This is the position for playing full orchestra. The pedal **11** is connected with a suitable mechanism which makes it possible to turn and hold the screens **9** in two other positions shown in Fig. 5. In the position II, following the normal position I, the part M of the screens covers the four rings of the disc **6** which produce the notes of the four bass octaves; in the position III the part N covers the three rings of the disc **6** which produce the notes of the three treble octaves. Therefore, when the screens are turned to position II all notes of the four bass octaves will sound in the timbre of disc **5** analogous to wood wind instruments and simultaneously all notes of the treble octaves analogous to full orchestra. In position III the bass will sound analogous to full orchestra and the treble analogous to wood wind instruments. Other combinations of timbres, different in bass and treble, can be made, using on the same bar **10** another row of twelve similarly shaped screens between the bulbs and disc **5**. But all devices based on the method which uses screens for varying tone colors have the same deficiency; they change tone colors only in steps and not continuously. The continuous

passing from one timbre to another within one and the same note contributes very much to the art of musical expression. A singer possesses this timbre changeability by passing from chest register to head register; a violinist can alter the timbre by using the bow either on its lower end or on the point.

Fig. 6 shows a diagram of the photo-cell circuit and the means by which continuous variation of tone color can be accomplished. The battery 59 provides direct current to the photo-cells 8 by two circuits each of them including in parallel twelve photo-cells either on the side of disc 5 or disc 6. The drawing Fig. 6 shows only one cell of each group 8a and 8b. Each circuit leads to one of the split primary windings of a transformer 60. The secondaries of this transformer are center tapped; each half of the secondaries is shunted by one of the potentiometers 63 the rotating arms of which are secured to two toothed wheels 62. Both wheels can be moved together by a driving chain 64, one link of which is attached to a frame 65 which is adapted to glide horizontally along a rail 66. This rail is fastened underneath the keyboard and placed in a manner that the gliding of the frame can be accomplished by the left knee of the player, moving the knee from left to right or vice versa. Fig. 7 shows the frame in connection with the keyboard. The secondary windings of the transformer 60 are connected with the primary windings of transformer 61 the secondaries of which lead to the input terminals of the amplifier 71. The currents produced by the photo-cells 8a and 8b flow through the primaries of the same transformer 60; therefore, its secondaries deliver a mixture of both. It is possible gradually to check the flow of one of the currents by turning the arms of the potentiometers, whereby only the other will be audible.

The frame 65 is seen in Fig. 8 in a position in which the rotating arm of one potentiometer 63 short-circuits the shunt pertaining to the circuit of photo-cell 8a while the arm of the other potentiometer provided maximum value of resistance of the shunt pertaining to the circuit of photo-cell 8b. In this position of the frame only tones rich in harmonics will be sounded. When it is moved to a middle position a mixture of both timbres, and to a position at the right end of the rail tones poor in harmonics will be heard in continuous passing from one timbre to another.

The described method of shunting the photo-cell currents improves the method described in U. S. Patent No. 1,977,095 by the arrangement of only one transformer in order to enhance the mixture of timbres and by the use of a gliding frame which can be handled by the knee easier than by a pivoted lever.

Uniform speed of the motor 1 is essential for the invariability of the produced tone frequencies. Although the ratio of tone frequencies is secured by the ratio of the pulleys 3^1–3^{12} once for all the pitch of the notes depends upon a strictly defined speed of the shaft 2. In order to secure an equal constant speed it is advisable to employ a synchronous brushless induction motor, but in this case the instrument can be exclusively used on A. C. current.

In order to make the instrument playable on A. C. or D. C. current an universal motor may be provided the speed of which is controllable by a power rheostat. Within certain limits the speed of any brush motor can be adjusted by applying a brake. In accordance with this method a brake device is fixed on shaft 2. A brake disc 12 is fastened to the fixed ring 43 by means of flexible steel tapes 45. When rotating the weights 44 attached at the tapes rotation of the weights contracts the tapes because of the acting centrifugal force in this way passing the brake disc 12 gliding on shaft 2 against brake block 42. By means of the screw 82 the pressure of the block can be adjusted and in this way a precise number of revolutions per second obtained and maintained. The correct number of revolutions is adjusted when the discs fixed to pulley 3^1 produce the note *c* in standard pitch. The described brake device makes it possible to transpose the whole scale by turning the screw 82. The correct adjustment of a chosen pitch, respectively of a chosen number of revolutions per second is indicated by the pointer 20 of a speedometer 18 connected with shaft 2 by means of a flexible shaft 17. The dial of the speedometer (tachometer) 18 is not marked to gauge the number of miles or revolutions but to indicate the speed necessary to create certain pitches. It shows several marks; a red one indicates the speed necessary to produce the note *c* in standard pitch by depressing the *c* keys and some black marks indicate transposition two half tones higher or lower. In order to signify a mark for a pitch which should be chosen deviating from the standard pitch an adjustable pointer is fixed on the outside of the glass covering the dial. The instrument will play in standard pitch when the pointer of the speedometer coincides with the red mark on the dial.

The quality of the tones produced photo-electrically by rotating members is modifiable by the means which transmit the rotation. When the belts transmitting the rotation of the pulleys 3^1–3^{12} to the pulleys 4 are made endless and of cotton, leather or another nonelastic material the produced tones are not sweet and euphonic enough. To eliminate this deficiency the belts employed in the improved instrument are composed of a longer portion of nonelastic material and a shorter portion of elastic material. These portions are connected to form an endless belt either by sewing them together or preferably by hooks and eyes. By this combination the speed of the pulleys 4 is rendered variable, that is slower or faster within very narrow limits, making the quality of tones resembling to tones of stringed instruments when the player rocks his finger on the string, in this way altering the length of the string within very narrow limits. The described combination belts produce analogous tiny fluctuations of frequency in this way creating tones full of life and euphony.

II. *Keyboard and action*

Each of the eighty-four light bulbs is assigned to one key of a keyboard comprising seven octaves. The pressure of a key transferred to a special mechanism, i. e. action, effects not only switching on the light, but also increases and decreases the light intensity according to the depth of the key pressure. In the improved instrument fundamentally the construction of the keyboard and action is the same as described in U. S. Patent No. 1,778,374.

III. *Circuits*

In Fig. 4 the circuit of one bulb is to be seen connected with the input of 117 volt A. C. In order to eliminate photo-electric pick-up of the tone of the A. C. input the bulbs must carry filtered direct current. Therefore, a filament transformer 49 is provided which delivers A. C. current of suitable voltage to a metal rectifier 50, the D. C. cur-

rent of which charges a storage battery 51. The battery serves as voltage regulator and hum filter. The minus terminal of the battery is connected with the jack on strip 48 which has the plug 25. This plug is the common pole of the seven bulb sockets arranged on carrier 1. On the storage battery 51 two plus terminals are provided, one for the full output of the battery voltage, the other for an output of a lower voltage resulting by omitting the last battery cell, 1.2 volt less using an Edison battery. These two terminals are connected with a two circuit push switch 89 which can be acted on by a lever 90, Fig. 7, for a purpose explained hereinafter. Normally the terminal of the lower voltage is switched on so the battery current passes from this terminal over the lead t' through the rotating interrupter 13 to the lead t and from there over one or both of two two-way switches to one or both bars 30 and 30'. Each of these bars, insulated from each other, bears forty two spring tapes 128. When the corresponding key is pressed down, the bulb attached to the socket 24 in Fig. 5 receives periodically interrupted current, effecting tremolo. By means of the switches 52 and their bilateral connection with t and t' it is possible to short-circuit the interrupting process either in the circuit leading to the bar 30 or the bar 30'. In this way tremolo can be made audible either on the side of bar 30', i. e. bass or on the side of bar 30, i. e. treble, or on both sides according to the chosen position of the switches 52.

When the adjustment of the contact 37 coincides with the extreme point which the spring tape 128 by rolling on the resistor 35 may reach, the full voltage of the connected plus terminal of the battery reaches a bulb. It is obvious that all notes of the keyboard must sound at the same strength when the keys are fully pressed down. But for this purpose it is ineffective to adjust the contacts 37 of all notes alike at the mentioned extreme point, because on the one hand eighty four light bulbs usually have different effectiveness of light emission so producing at the same voltage tones of not exactly the same loudness; on the other hand, twenty four photo-cells of exactly the same sensitivity are difficult to manufacture. In order to compensate the different effectiveness of bulbs and photocells the voltage set at the bulbs exceeds the normal voltage the bulbs are built for. The voltage surplus is reduced separately for each bulb by a fixed resistor 35' and an additional variable resistance resulting by adjusting the contact 37 beyond the extreme point which the spring tape 128 touches on the resistor 35. By choosing the right value of the additional resistance the maximal tone intensity according to the deepest key position can be equalized. By this procedure to be controlled by the ear automatically equal strength of intermediate tone intensities are secured because the resistors 35 are all of the same value.

Performing crescendo and decrescendo extended over a musical phrase may be obtained by using a variable resistor parallel to the input terminals of an amplifier.

The whole tone character of the instrument can be made darker and softer by connecting a condenser 69 parallel to the primaries of the input transformer 61 and closing the switch 70. In order to make the tone character lighter and sharper, the secondaries of a transformer 76 are arranged in series with one of the secondary windings of an intermediate transformer 73 provided between any consecutive stages within amplifier 71. This effect can be altered by changing the impedance of the transformer 76; for this purpose the primaries of this transformer are connected parallel to a variable condenser adjustable by the knob 78, see Fig. 7. When the switch 77 is closed, this device becomes ineffective.

IV. *Pedals*

Fig. 7 shows the exterior view of the instrument and the arrangement of the pedals.

There are four pedals 80, 11, 55 and 179 provided to be trodden by the foot, and two devices 65 and 90 operated by the left and the right knee of the player. The mode of operation of the frame 65 and the pedals 80, 11 and 179 has been previously described. The lever 90 and the pedal 55 make it possible to perform sforzando. The lever 90, when pressed upward by the knee, controls the switch 89, Fig. 5, in a way that the lead t' becomes connected with the battery terminal of the higher voltage. Swift input of higher voltage effects suddenly increased intensity of light respectively suddenly increased loudness, i. e. accent. This sforzando becomes particularly impressive when the lever 90 is moved while keys are fully pressed down, so the resistance in the bulb circuit is a minimum, because then the overcharged filaments have the greatest light emissivity. Overcharging the filaments diminishes the lifetime of bulbs. But as it is possible nowadays to manufacture bulbs enduring 25% voltage increase overcharging has lost a great deal of its injuriousness.

While by the described device fortissimo sforzando can be executed within forte played passages, the pedal 55 makes it possible to perform forte accents within piano or mezzoforte played passages. By the same pedal an effect may be created.

The constructional principle of the pedal 55 is apparent from Fig. 4. The treadle 55 bears on its underside two metal strips 56 and 57, insulated from each other. These strips form a normally closed contact in the circuit nn'. The treadle can be operated in two steps. On the deeper step the knob 58 touches the floor and breaks the contact. The circuit nn' comprises a resistor 68 shunting the windings of the volume control 63, i. e. the input of the amplifier. Therefore, when the pedal 55 is moved two steps down, the parallel resistance 68 disappears and the instrument sounds suddenly louder in every position of the volume control.

The other side of the treadle 55 is connected by a rod with a normally open switch 54 which controls the circuit 11' when the switch 53 is closed. The circuit 11' carries current for the bulb 15, Fig. 1. Opposite this bulb a photo-cell 16 is arranged which, receiving current by the circuit dd', Fig. 6, lies in the circuit of the input transformer 61. Between bulb 15 and photocell 16 a tone disc 14, Fig. 2, is fixed on the same shaft which bears the rotating interruptor 13. The apertures of the tone disc 14 are shaped for producing sound resembling drumbeats; therefore, when the pedal 55 is trodden halfway, while switch 53 is closed, drum sound will be audible either as accent or roll. The switch 54 is necessary in order to make the pedal 55 usable for two purposes.

Fig. 2 shows a tone disc 14 with 4 concentric zones each of which is provided with photographic registration of the sound of another percussion instrument. The disc is arranged between a photocell and a carrier of 4 bulbs 15^1—15^4,

one opposite of each ring. By means of switches s^1–s^4 which connect each of the bulbs with the bulb current it becomes possible to turn on the light bulbs singly or together by the same pedal.

V. *Assemblage*

The case of the instrument 91, Fig. 7, is horizontally divided by a shelf the position of which is illustrated by the dotted lines 92. The upper compartment holds the apparatus, the lower contains the amplifiers, the speaker and the battery. The shelf 87 and the keyboard lid 88 are removable so the action becomes fully visible for adjustment, if necessary. The ammeter 81 indicates the charging condition of the battery. Beside the screw 82 which controls the speed of the motor the speedometer 18 is situated; 83, 84, 85 and 86 designate the switches of motor, rectifier, amplifier and photo-cell battery; 72 and 72′ are volume controls acting on the input and output of the amplifier. 93 is an outlet box connected with the input of the amplifier over the switch 94; 95 is an outlet box connected with the output of the amplifier over the switch 96. These two outlets constitute the device which enables the player to apply a method of performing simultaneously an undefined number of voices.

The scores of orchestral works mostly comprise a large number of voices; therefore, piano transcriptions of these works must be arranged for two players to render the entire polyphony audible. The hereinafter described method enables one player alone to perform piano music arranged for two players simultaneously on the same keyboard.

The method consists in the following procedure which is applicable also in combination with nonelectrical musical instruments. The player plays first one part of the voices of a composition, at the same time making a record of his playing on a recording unit; then he plays the other part of the voices together with the recorded one; two fundamental conditions must be fulfilled to secure the effectiveness of this method; first the number of rotations per minute of the turntable must constantly be the same, secondly the instrument must have constantly the same pitch or must be tuneable to a predetermined pitch, which has to be exactly equal while the two parts are played. For instance, a violinist who wants to play a concerto written for two violins can successfully apply the method using a recording unit which mostly will suit the first condition because such units are chiefly equipped with brushless induction motors and devices which secure the standard speed of 78 R. P. M. He has only to pay full attention to the pitch of his violin which has to be exactly the same when he plays the first and the second part of the composition, otherwise difference of pitch when playing together with the record becomes inevitable.

The method applied in combination with nonelectric instruments has the disadvantage that the recorded part becomes audible on a loudspeaker, so the quality of its sounding does not perfectly match that of the other part. When used in combination with electric musical instruments this disadvantage disappears because both parts sound on the same loudspeaker in thorough blending.

The two mentioned outlets 93 and 95 make possible the connection of the recording unit with the instrument; 93 connects the play-back with the input, preferably the second stage of the

amplifier, because sound reproduction by a phonograph does not require the full amplification photo-cells require. Outlet 95 connects the cutting head with the output of the amplifier, which preferably is provided with a universal output transformer to match the impedance of different types of cutting heads.

It will be understood by those skilled in the art that modifications of my present invention, applicable to non photo-electric instruments can be made without departing from the spirit of this invention or the scope of the subjoined claim. I, therefore, claim as my invention modifications whereby substantially the same effect may be obtained in a substantially analogue way.

I claim:

An electric musical instrument for the performance of multivoiced music with orchestral effect comprising twenty four tone discs having transparent areas regularly arranged in concentric annular zones, the number of which increases from the innermost of the outermost zone according to the ratio 1:2 in the inner zones, in the ratio 1:2.1 in the outer zones, the said twenty four tone discs arranged in twelve groups of tone disc couples, the transparent area of one tone disc of each couple shaped to produce tone frequencies having a timbre poor in harmonics, the transparent areas of the other tone disc of the couple shaped to produce the same tone frequencies having a timbre rich in harmonics, a plurality of light bulbs and photo cells situated in combination with the tone disc couples to produce each note in a mixture of said two timbres, means to adjust the relation of harmonic poor and harmonic rich tone frequencies within the mixture, a key board, means to control the intensity of the light of each bulb according to the depth the coordinated key is depressed, a motor, means to rotate the twelve groups of tone disc couples with different speed increasing in the same ratio as the tone frequencies of twelve consecutive notes increase within an octave, means to control the speed of the motor, a speedometer indicating the pitch, current supply for the light bulbs, current supply for the photocells, an amplifier, a resistance shunting the input of said amplifier and a pedal to disconnect said shunt, two outlets one of which connected with the input, the other connected with the output of said amplifier, and a speaker.

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