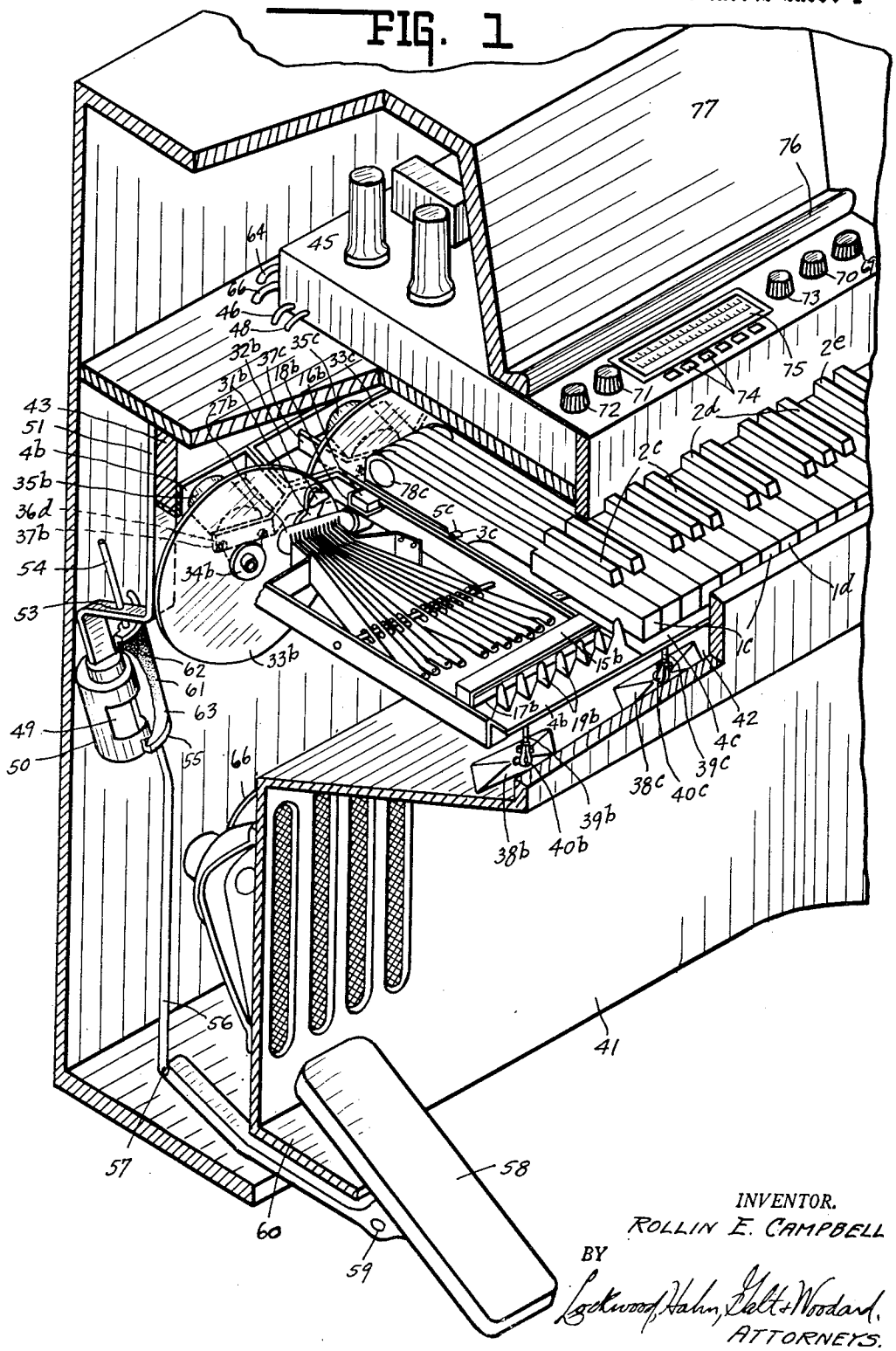
July 3, 1951 R. E. CAMPBELL 2,559,276

PHOTOELECTRIC MUSICAL INSTRUMENT

Filed May 9, 1947 4 Sheets-Sheet 1

FIG. 1



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PHOTOELECTRIC MUSICAL INSTRUMENT

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FIG. 2

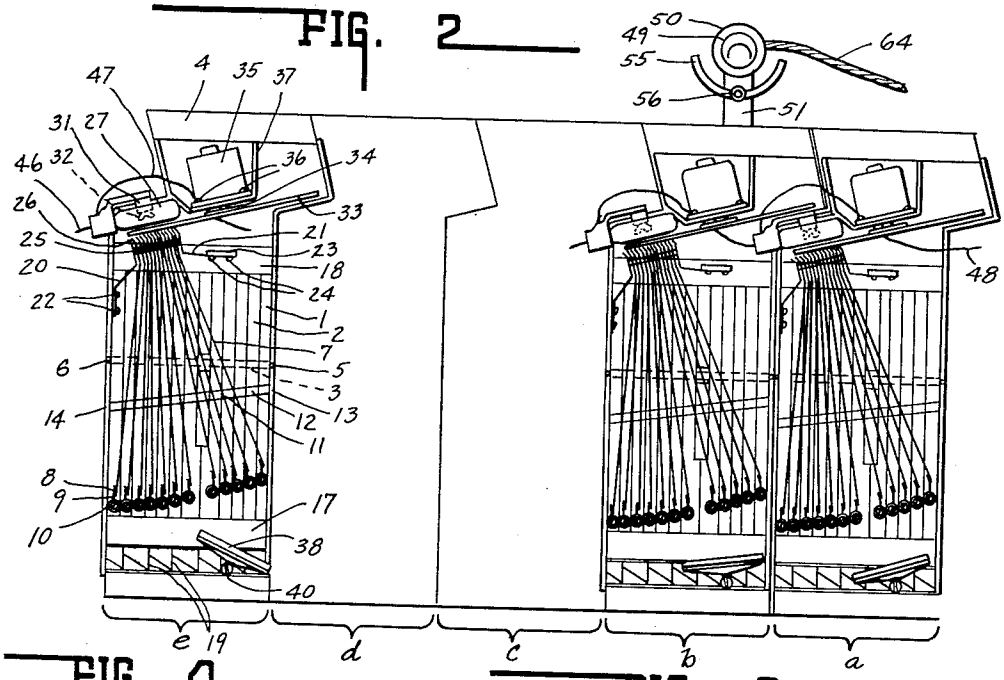


FIG. 4

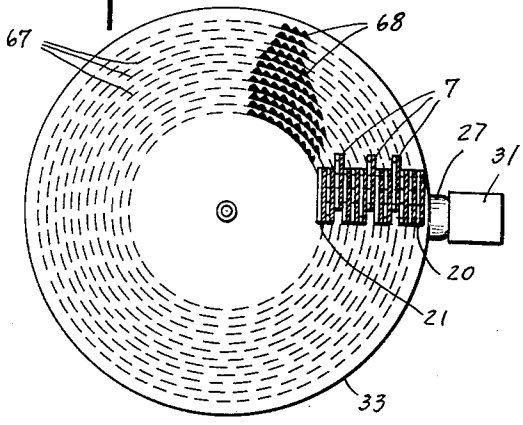


FIG. 3

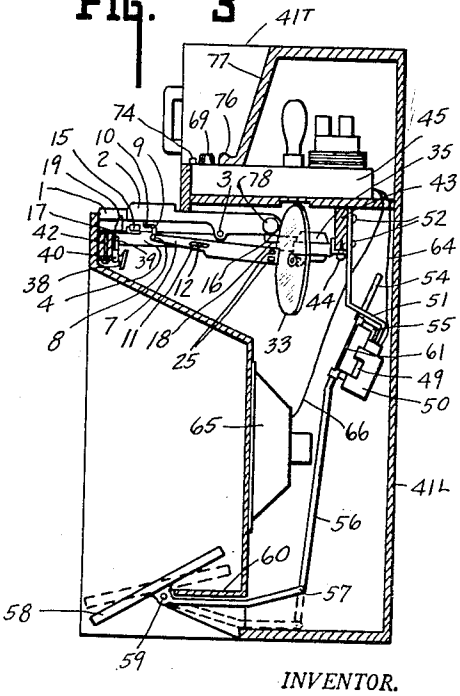
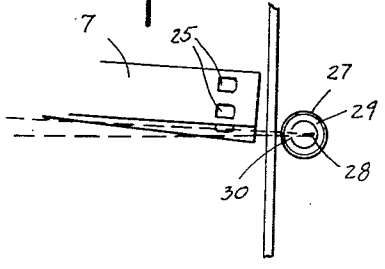


FIG. 5



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FIG. 6

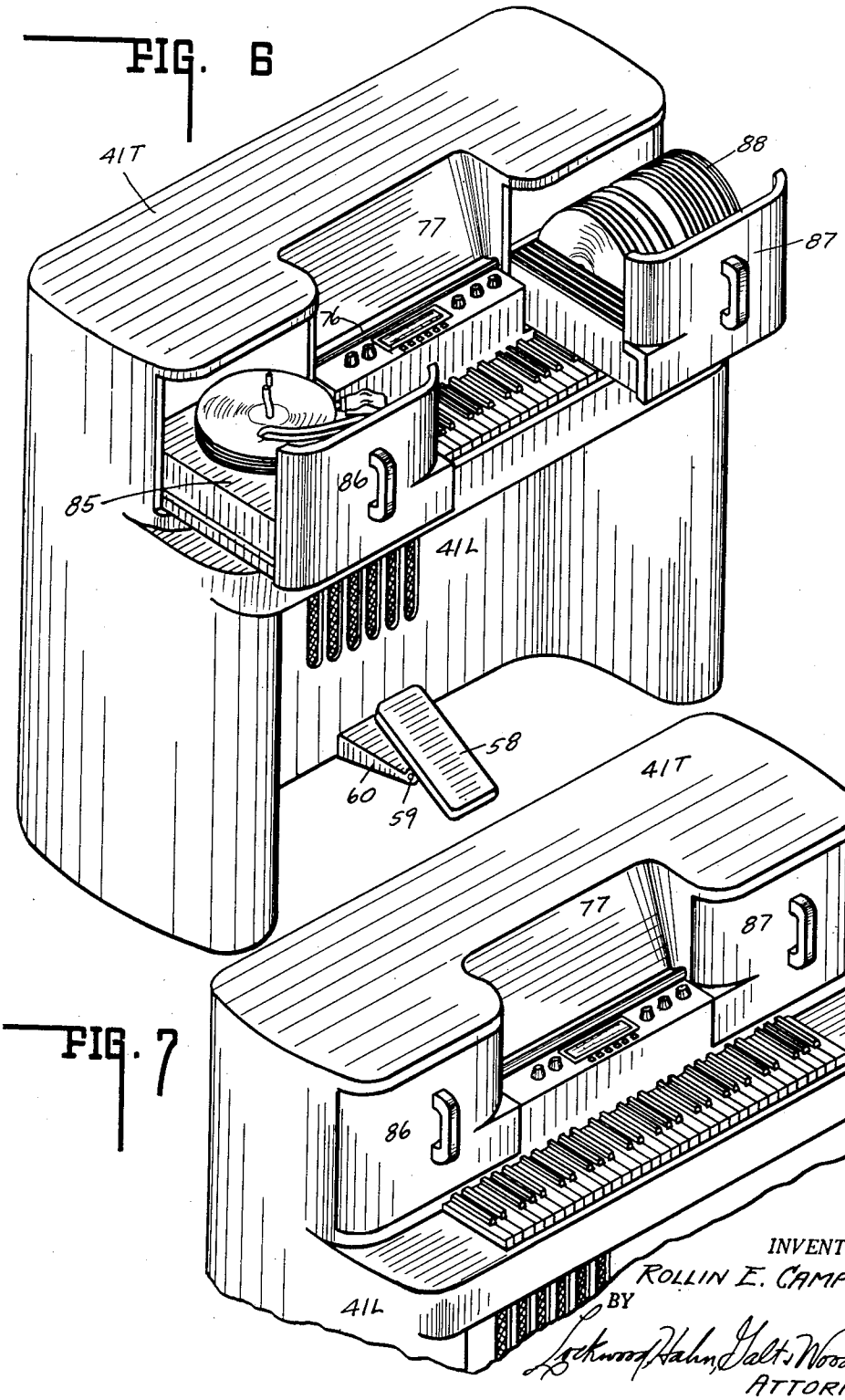


FIG. 7

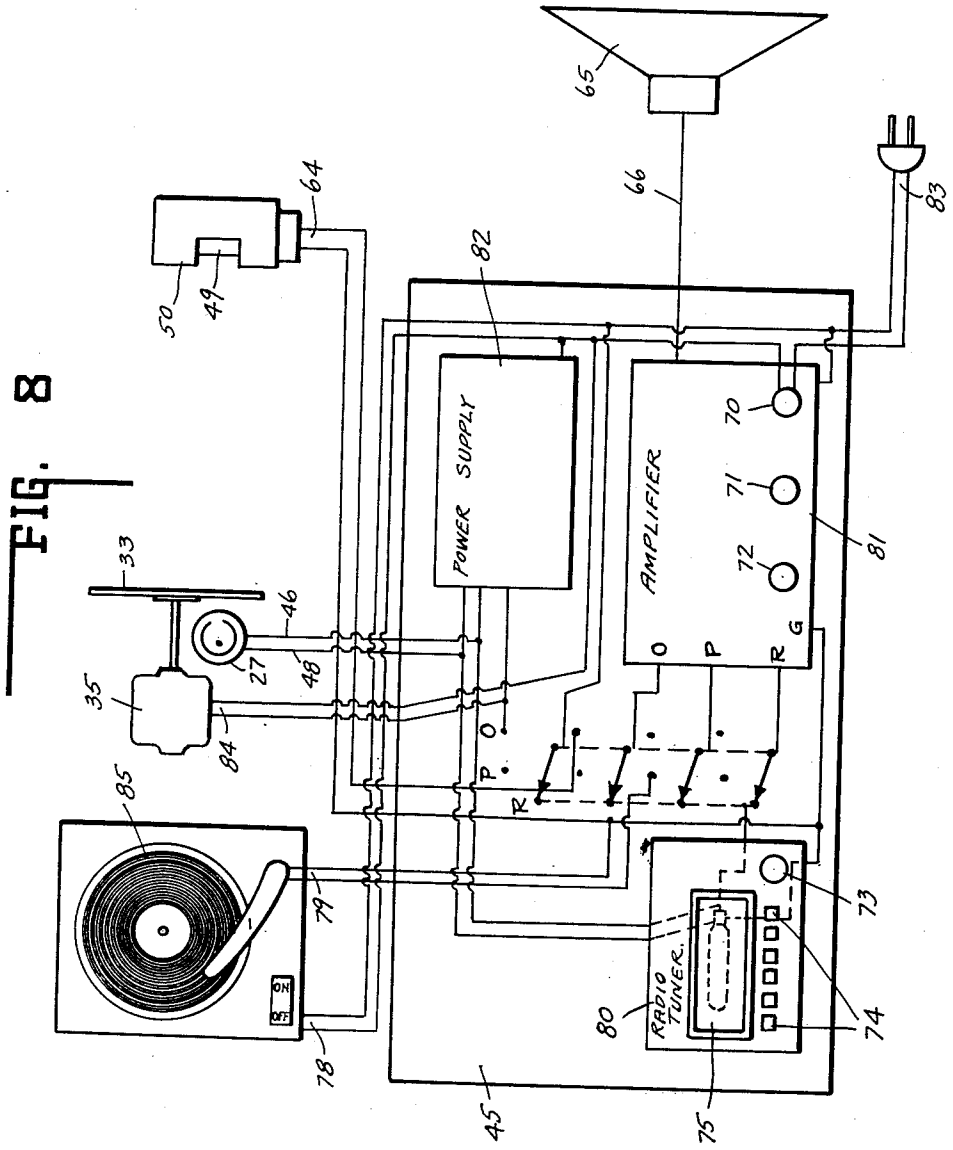
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PHOTOELECTRIC MUSICAL INSTRUMENT

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FIG. 8



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UNITED STATES PATENT OFFICE

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PHOTOELECTRIC MUSICAL INSTRUMENT

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Application May 9, 1947, Serial No. 747,073

8 Claims. (Cl. 84—1.18)

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My invention relates to musical instruments of the type whereby the tone frequencies are produced by the rotation of a sound track or series of tone patterns between a source of power and a pickup device for further amplification. Though the many novel features and improvements have a wide field of application, this invention deals primarily with those instruments wherein the tone patterns revolve between a light source and a photocell. This system of photoelectric tone generation, when combined with a keyboard and suitable controls may be referred to as an organ. My invention comprises such an organ and its combination with a radio receiver and phonograph.

Musical notes, tones, and chords are produced by the repetition of a distinct single cycle. The cycle, whether simple or complex, is complete within itself. Several instruments have been devised for producing these notes and tones by interrupting a light beam with a series of patterns representing the desired tone. This has been accomplished by making endless bands of patterns or by recording sound on emulsified surfaces of cylinders and disks. The success of these devices has been limited by a number of factors. In cases where a cylinder is used, the number of patterns must be increased in each succeeding band to produce a note of a higher frequency. The size of the pattern decreases proportional to the increase in the number of patterns to the extent that in one octave of music the pattern must be reduced to one half and in a range of five octaves, the pattern decreases to one sixteenth its original size. This would necessitate a rather intense light through a narrow aperture to obtain proper reproduction. To obtain such an intense light on all the bands would require a large source of power as well as the use of condensing lenses. If a different light intensity were used on the various bands, the aperture would have to vary accordingly, or the variations be compensated by other means. The photocell used in combination with the cylinder would have a length equal to all the sound tracks combined; the cell being located lengthwise of the cylinder. In use, a photocell of that type would have only a small fraction of its target area activated by light through the sound tracks at any one time. Thus the efficiency of the photocell and of the complete apparatus would be reduced thereby. As to recording of the tone patterns in endless concentric rings on flat disks, the recording has been done without regard to proportional spacing of the tone patterns making it necessary to vary

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the light intensity on each of the separate rings to get a uniform response. In instances where a plurality of disks have been used it has been necessary to use a photocell for each disk and a complicated mixer circuit to interlock these cells with the amplifier.

The object of my invention is to apply these familiar principles, through the use of new and novel means to produce an instrument of the type; namely a photoelectric organ suitable for manufacture. To accomplish this I propose to eliminate many faults and disadvantages in earlier instruments of this type by new means and improvements with these objects; first, to have patterns of equal size throughout the frequency range; second, to expose these patterns to a light source of minimum intensity; third, to make the light from any one or combination of notes or frequencies to fall uniformly over the entire target area of a single photocell; fourth, to interpose between the light source and the photocell means for controlling the volume of sound produced; and fifth, to provide a method whereby the frequency range may be increased or decreased without changing the size or structure of the tone generating elements. An additional object is an instrument of simple and compact design suitable for combination with a radio receiver and phonograph.

That I have obtained many advantages and improvements as well as the specific objectives outlined will be apparent from the accompanying drawings and the following specification, in which a typical construction is described.

Figure 1 is a section view in isometric with a portion of the keyboard removed to more clearly illustrate the underlying mechanism.

Figure 2 is a view of the tone generating mechanism and keyboard from underneath.

Figure 3 is a section view of the instrument taken in the opposite direction from Figure 1.

Figure 4 is a view of the tone wheel with the shutters superimposed in section.

Figure 5 is an end view of the tone wheel, light source and shutters.

Figure 6 is an external view in isometric showing the record player and record compartment in the loading position.

Figure 7 is an external view in isometric of the upper portion of the instrument with the record drawers closed.

Figure 8 is a block wiring diagram.

Referring to the drawings, Fig. 1 to Fig. 5: The keyboard and tone generating mechanism is composed of several duplicate units or sections.

These units are composed of duplicate parts which have been given a common numeral, but carry a subscript to identify the sections *a*, *b*, *c*, *d*, and *e*. See Fig. 2. The keys 1 and 2 are pivotably supported on shaft 3 which in turn is rigidly attached to the chassis 4 by screws 5 and 6. To keys 1 and 2 are pivotably connected the shutter 7 by rivet 8 and connector 9 which is securely attached to the keys 1 and 2 by screw 10. The slot 11 in shutter 7 allows the shutter to rock freely over shaft 12 which is supported through holes in the chassis 4 at points 13 and 14. Felt pads 15 and 16 supported on cross members 17 and 18 of chassis 4 restrict and cushion the movement of the keys 1 and 2. The keys move between guides 19 affixed to chassis 4. The shutters 7 group together between the shutter guides 20 and 21. The guide 20 is attached to the chassis 4 by screws 22. The guide 21 is attached to the extension 23 from the cross member 18 by screws 24. The shutters 7 have a raised spot 25 to form a bearing with the adjacent shutters and a bend 26 near their ends to overlap slightly the adjacent shutter thereby forming a barrier to the light from bulb 27. The bulb 27 has a long straight filament 28 surrounded by a reflector 29 having an aperture 30 as shown in Fig. 5. The bulb 27 is supported in socket-bracket 31 adjustably mounted by thumbscrew 32 to the chassis 4. The tone wheel 33 with the hub 34 is driven by the motor 35 which is supported on the chassis 4 by means of screws 36 and bracket 37. A mirror 38 is mounted on an extension rod 39 from the chassis 4 by a ball and socket clamp 40. All of the aforementioned parts form a unit mechanism supported in the cabinet 41 on a ledge 42 and rib 43, being attached thereto by screws 44.

The unit mechanism previously described contains twelve keys and shutters for controlling the twelve sound tracks on the tone wheel. These twelve sound tracks have the related frequencies for producing an octave of music. As each unit or section covers an octave, an extended scale may be formed by placing a number of these units together. Fig. 2 illustrates an instrument combining five such units. The impulses and frequencies generated by the various units are controlled and amplified by devices common to all the various units. The amplifier-power supply 45 is located on a shelf over the mechanism. The lights 27*a*, 27*b*, 27*c*, 27*d*, and 27*e* are excited by a current free of audible variations. The current is produced by power supply 45 and fed through the lead 46 to bulb 27*a*, to bulb 27*b* by lead 47*a*, to bulb 27*c* by lead 47*b*, to bulb 27*d* by lead 47*c*, to bulb 27*e* by lead 47*d*, and back to the power supply 45 by lead 48. The photocell 49 is enclosed by shield can 50 and is supported by arm 51 which is attached to rib 43 by screws 52. The arm 51 is pierced by a hole 53 to form a bearing for the extension rod 54 of the swell pedal control. The swell pedal control consists of the extension rod 54 rigidly attached to a frame 55 which is rigidly supported on rod 56 which in turn is pivotally connected by pin 57 to an extension of the pedal 58. Pedal 58 is rockably mounted on pin 59 and supported on an extended portion of the cabinet 41L. Frame 55 retains a diffuser 61 having an opaque portion 62 at one end and a transparent portion 63 at the other end with a gradual shading in between. The photocell is connected to the amplifier 45 by a shielded cable 64. The speaker 65 is connected to the amplifier 45 by lead 66.

The tone wheel 33 consists of a transparent

disk having endless tracks 67. These tracks 67 are made up of a number of tone patterns 68. The pattern 68 is a graphical representation of a note tone or chord. This pattern or graph may represent another instrument or be purely imaginary.

The method of obtaining these patterns is as follows. When the tones of a known instrument are desired, that instrument is played or a recording of it is played through a suitable device connected to an oscilloscope. During the time the desired note is played there will be formed on the screen of the oscilloscope a still pattern or trace graphically representing the relation of the amplitude of the sound with respect to the time, at any instant from the beginning to the end of the cycle. A similar graph may be made by enlarging a section of motion picture sound track film having the desired tone. It is also feasible to mathematically calculate the relation of the higher frequencies to the fundamental and to draw a graph to represent them. The next step is to alter the dimensions of the graph to fit the space allowed for it on the tone wheel. This altered graph then becomes a template and a set of patterns for the full wheel are cut according to it. The patterns are arranged on a suitable backing in twelve concentric rings with the number of patterns in each ring being related as are the twelve frequencies of an octave of music in the tempered scale. It is advisable that the graph template and tone wheel be made on an enlarged scale and then be reduced by photographic means to a suitable size. The diameters of the various rings must hold substantially the same relationship to each other as do the frequencies. The tone wheels may be of the variable density type. They can be made by shifting a tone wheel disk coated with a photographic material with respect to a mask having narrow slits while being exposed to a light source which varies in intensity corresponding to the variations of the desired tone. One ring of patterns would be exposed at a time with the number of slits in the mask being equal to the frequency desired.

As each wheel represents an octave of music, five or more wheels will produce five or more octaves of music if each succeeding wheel is driven twice as fast as the preceding one. Thus an unlimited range of frequencies can be produced without any changes in lights, apertures, or patterns, if the rate of travel of the various patterns is proportional to their respective frequencies.

Operation of the instrument is as follows. The keys and shutters are counterbalanced by slug 78 which will maintain them in the raised position shown in Fig. 3 except when depressed by the musician or operator. When any one of the keys 1 or 2 is depressed down against the felt bumper 15, the shutter 7 will be lifted to the position shown in Fig. 5. In that position, light from bulb 27 is free to pass through the tone wheel 33 to the mirror 38, to be reflected through the diffuser 61 onto the photocell 49. The beam of light originating in bulb 27 and passing through the tone wheel then beneath the raised shutter and between the adjacent shutters tends to increase in height and width until on reaching the cell it covers the whole target area of the cell. Variations in the light falling on the cell produced by the motion of the tone patterns produce corresponding variations in the current passing through the photocell. These variations in cur-

rent are suitably amplified by means 45 and changed to sound by speaker 65. If several keys are depressed at the same time the light beams from the several sound tracks superimpose on one another to produce a compound or complex impulse in the cell. Any number of keys in a single octave may be depressed at one time. Fig. 4 represents a major triad. The light from the sound tracks thus exposed are reflected to the cell by the mirror for that octave. The mirrors 38*a*, 38*b*, 38*c*, 38*d*, and 38*e* are adjusted by means of their respective ball and socket clamps to focus the light from their respective bulbs 27*a*, 27*b*, 27*c*, 27*d*, and 27*e* onto the photocell 49. Any number of keys in all the octaves combined may be depressed at the same time. The light beams originating in any one or all of the octave sections would be reflected by their respective mirror to the photocell. A rocking action applied to the swell pedal 58 will raise or lower the diffuser 61. The opaque portion 62 obstructs the light falling on the cell 49 whereas the transparent portion 63 freely passes the light to the cell. The gradual shading between opaque and transparent produces a corresponding change in the amount of light falling on the cell. The movement of the diffuser will cause variations in the amount of light on the cell which will produce corresponding changes in the volume of sound produced by the instrument. Expression may be put in the music by the use of this control. In addition there are the usual volume, bass, and treble controls on the amplifier.

The instrument just described is suitable for combination with a radio receiver and phonograph. Such a combination is shown in Figs. 6, 7, and 8 being entirely self-contained in the cabinet (41L and 41T). This cabinet is best described in two parts. The lower part 41L forming a housing and support for the speaker keyboard and associated mechanism. The upper part forming a housing over the record player, record compartment, and the amplifier power supply 45. The center portion thereof is recessed to accommodate a control panel and a music rack consisting of the ledge 76 and the sloping front 77. The phonograph or record player 85 is mounted in the drawer 86 which may be drawn out to the position shown in Fig. 6 for loading or unloading of records. The partitioned drawer 87 forms a convenient storage compartment for the records when not in use. It can be drawn out from the cabinet housing as shown in Fig. 6 for loading and unloading of records.

Referring to Fig. 8, part 45 can be subdivided into a radio-frequency amplifier and detector 80, an audio-frequency amplifier 81, and a power supply 82. The audio-frequency amplifier 81 has three separate imputs radio R, phono P, and organ O, connected through the multiple master selecting switch 69. To complete the circuit the three imputs have a common ground terminal G.

The radio tuner 80, having station selector knob 73 and push buttons 74, is connected to the amplifier 81 when the switch 69 is positioned at R. When positioned at R the phono and organ circuits are inactive. The panel light 75 is operated at a suitable intensity to illuminate the radio dial by the current present in the radio tuner 80. The radio dial forms a part of the panel light and is also identified as 75.

When the switch 69 is positioned at P, a circuit is closed connecting the record player 85 by lead 79 with the P input to the amplifier 81. The

recorded player draws current from the line 83 through the lead 78. When the switch 69 is positioned at P the radio tuner 80 and the organ are inactive.

When the organ or O position is selected two separate circuits are completed; first, the photocell 49 from G to O input, second, the power supply 82 for operating the lights 27 and the motor 35 through lead 84 are connected to the power line 83. The dial and panel light 75 is also operated from the power supply 82 at a high intensity, thereby illuminating the music rack formed by the ledge 76 and the sloping front 77.

The volume control 70, the treble control 71 and the bass control 72, may be used at any time with any one of the divisions radio, phonograph, or organ, to control tone and volume. A switch actuated by the volume control 70 connects or disconnects the instrument with the power line 83.

My invention is not to be limited to the construction covered by the drawings and specification or to the improvements as a combination but may be applied to and embodied in any instrumentality within the scope of the following claims.

I claim:

1. A musical instrument having a plurality of octaves activating a photocell coupled to an amplifier and sound producing means with each octave comprising a frame supporting a shaft upon which a plurality of keys are pivoted, the keys oscillating between vertical guides and horizontal bumpers secured to the frame, a group of counterbalanced shutter-bars rockably mounted on a shaft supported by the frame, one end of each shutter-bar being pivotably attached to a key at a point below the key's operating surface and with the free ends of the shutter-bars grouping together between adjustable guides secured to the frame, a tone wheel mounted on and driven by a motor mounted on the frame, a mirror adjustably mounted on the frame, a light bulb in a socket attached to the frame; the light bulb being positioned to shine through the tone wheel toward the group of shutter-bars, the light being effectively blocked thereby, except when a shutter-bar is moved by the motion of the key to which the shutter-bar is attached, at such times the light being free to pass on to the mirror where it is reflected to the photocell.

2. The invention as defined in claim 1 including means positioned in front of the photocell to vary the light intensity falling on the cell thereby controlling the volume of sound produced comprising a diffuser having a transparent portion and an opaque portion with gradual shading in between connected to a pedal by suitable means so that the diffuser may be raised or lowered by tilting the pedal.

3. A musical instrument having a plurality of octave producing means activating a photocell coupled to an amplifier and sound producing means with each octave producing means comprising a tone wheel mounted on a geared motor, a light bulb behind the tone wheel, a group of shutters positioned between guides in front of the tone wheel, each shutter fulcruming over a shaft with one end pivotally attached to a key and a mirror positioned to reflect to said photocell any light variations generated by the tone wheel, geared motor, and light bulb and controlled by keys and shutters and means interposed between the light source and the photocell for controlling the volume of sound produced compris-

ing a diffuser having a transparent portion and an opaque portion with gradual shading in between, connected to a pedal by suitable means so that the diffuser may be raised or lowered by tilting the pedal.

4. A photoelectric organ and radio-phonograph combination having an amplifier and sound producing means common to the three devices and a cabinet the lower part of which supports a keyboard of the organ and acts as a resonator for the sound producing means and the upper part which projects above the keyboard has the center section recessed and sloping to form a music rack and contains a radio receiver, an amplifier, a record player, and a record storage compartment.

5. A photoelectric organ and radio combination housed in a cabinet having a lighted control panel located above and behind the organ keyboard in a recessed sloping center portion of the cabinet with a ledge behind the control panel cooperating with the sloping center portion of the cabinet to form a music rack receiving illumination from the lighted control panel.

6. A multiple purpose instrument composed of a radio receiver, a phonograph, and an organ housed in a cabinet having, a base supporting the keyboard of the organ and its associated mechanism, a three part structure above and behind the keyboard the center part of which contains a radio frequency amplifier, detector, tuner and an audio frequency amplifier with a panel containing instrument selector, station selector, bass, treble, and volume controls of the tuner and amplifier located in the same plane and in close relation to the keyboard, the remaining two parts containing and housing respectively a drawer containing a record player and a partitioned drawer for record storage either of which can be drawn out for loading, and a music rack located behind the amplifier controls and illuminated by a panel and dial light.

7. An electronic circuit comprising an audio frequency amplifier connected thereto, a radio frequency amplifier and detector, a phonograph, a photocell, a group of light bulbs operated from a power supply, a group of motors, and a three position four-gang multiple selector switch having contact means and circuit connectors between said contact means and said components for effecting the connection of the latter in the following order: first, the radio frequency amplifier and detector with the audio frequency amplifier; second, the phonograph with the audio frequency amplifier, and third, the photocell with the audio frequency amplifier and the motor and power supply with the power source to which the audio frequency amplifier is connected.

8. The invention as defined in claim 7 including the addition of a dial and panel light which operates on the first and third positions.

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