PUBLISHED
JUNE 15, 1943.
BY A. P. C.

C. HOOK
ELECTRICAL MUSICAL INSTRUMENTS OF THE KEYBOARD TYPE SUCH AS ORGANS
Filed Nov. 4, 1940

Serial No.
364,305
2 Sheets-Sheet 1

FIG.1.

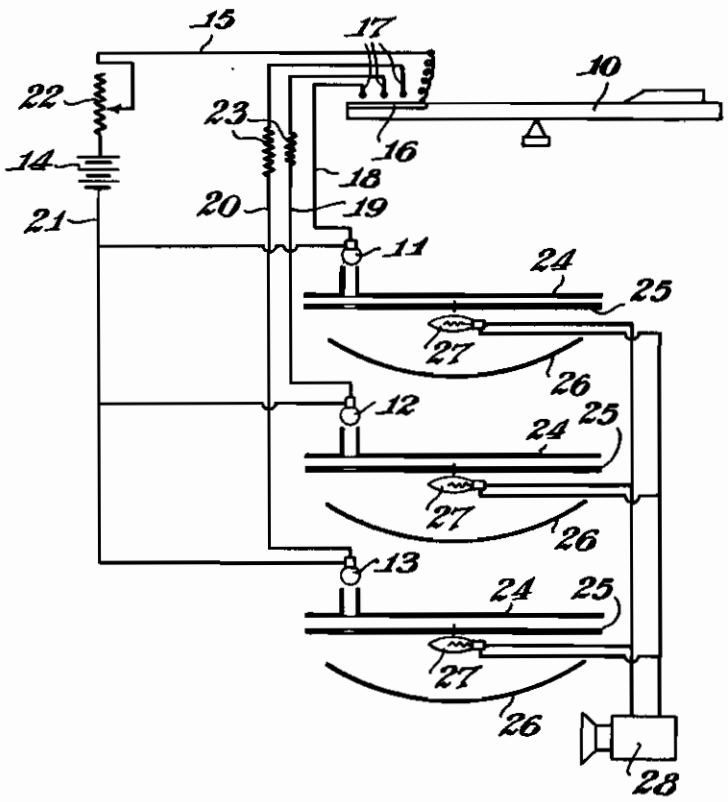
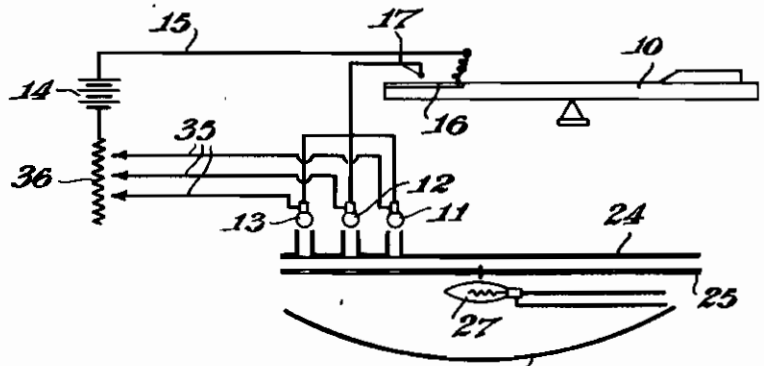


FIG.2.



INVENTOR
CHRISTOPHER HOOK
By Wolcott & Hoff Attys

PUBLISHED
JUNE 15, 1943.
BY A. P. C.

C. HOOK
ELECTRICAL MUSICAL INSTRUMENTS OF THE KEYBOARD TYPE SUCH AS ORGANS
Filed Nov. 4, 1940

Serial No.
364,305

2 Sheets-Sheet 2

FIG. 3.

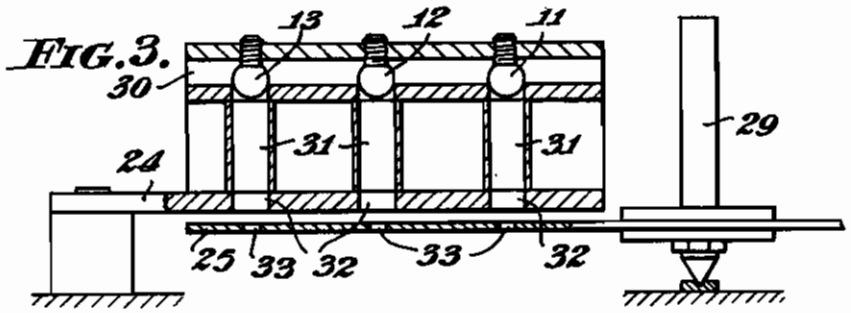


FIG. 4.

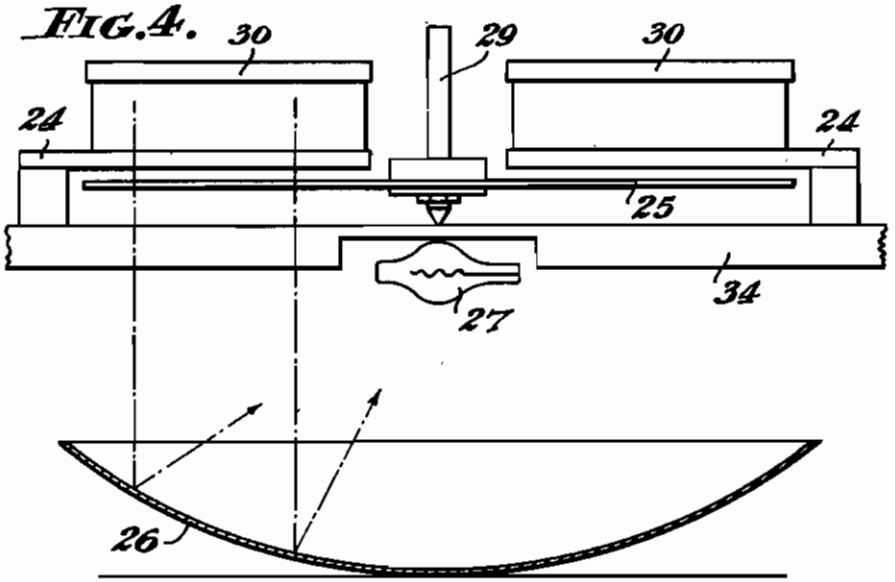


FIG. 5.

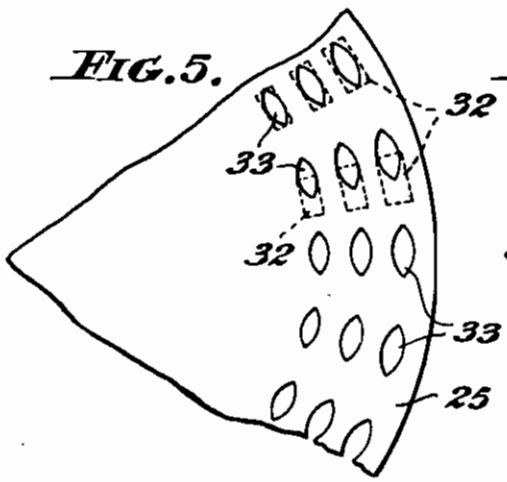
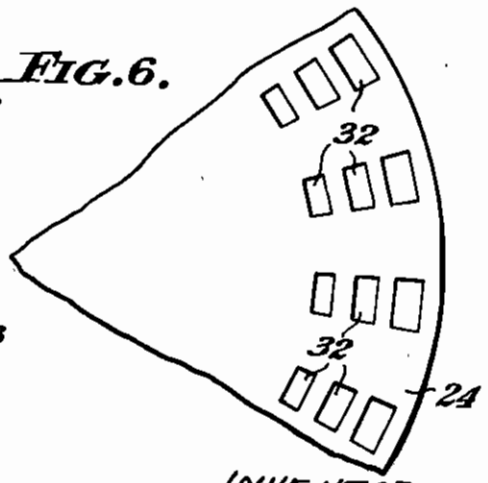


FIG. 6.



INVENTOR
CHRISTOPHER HOOK
By Wallenstein & Wolff Attys

Published June 15, 1943 Serial No. 364,305

ALIEN PROPERTY CUSTODIAN

ELECTRICAL MUSICAL INSTRUMENTS OF THE KEYBOARD TYPE SUCH AS ORGANS

Christopher Hook, Thiers, France; vested in the Alien Property Custodian

Application filed November 4, 1940

This invention relates to electrical musical instruments of the keyboard type in which notes are produced by electrical alternating current frequencies under the control of the keys of the keyboard, the electrical impulses being transmitted to electrical sound-producing apparatus which is responsive thereto. The main object of the invention is to provide an improved instrument of this type which can produce individual tones and a variety of compound tones of greater perfection than has hitherto been possible, thereby in the latter connection achieving greater fidelity in simulating various musical instruments.

According to the invention the method of producing notes under keyboard control consists in generating alternating current frequencies having the required note frequencies, by causing continuously moving elements having graphical impressions of the said frequencies or co-acting with stationary elements having such impressions to vibrate light beams propagated towards a photo-electric cell or cells or equivalent light-sensitive current-generating or controlling device or devices, transmitting the resulting electrical impulses to electrical sound-producing apparatus, and arranging the keys of the instrument to control the light beams.

The invention also consists in the provision of an instrument constructed to operate according to such method and which accordingly comprises a plurality of light sources arranged to propagate light beams towards a photo-electric cell or cells or equivalent light-sensitive current-generating or controlling device or devices, a plurality of elements having graphical representations of the required note frequencies and which are adapted to vibrate the light beams, keyboard-controlled means for controlling the propagation of the light beams, and electrical sound-producing apparatus to which are transmitted the alternating current frequencies emanating from the photo-electric cell or cells or the equivalent thereof.

The keyboard-controlled means for controlling the propagation of the light beams preferably is such that control is exercised on electric lamps constituting the light sources so as to bring same into operation as required, although alternatively the keys could be arranged to actuate interceptor means normally positioned in the paths of continuously projected beams and adapted to be selectively withdrawn therefrom to allow the beams to be projected on to the photo-electric cells.

Each of the elements having a frequency graphically represented thereon preferably has said frequency photographically impressed thereon and in carrying out the invention it is preferred to provide a series of rotary discs to constitute the said elements, each disc being formed with concentric rings of frequency impressions although, as an alternative, each of the said elements may consist of a continuously driven endless film band.

The invention, although applicable to an instrument for producing simple tones, i. e. having single notes assigned to different keys, is more particularly concerned with producing an instrument which will produce, by the depression of a single key, not only a pure fundamental note or tone but also harmonies thereof resulting in a compound tone of great purity, the invention having provision for varying the relative amplitudes of the harmonics so that numerous effects are obtainable. A further feature consists in providing for reading either a single frequency impression or a group of frequency impressions pertaining to a fundamental and harmonics thereof at a plurality of points which are in out-of-phase relation, that is to say one reading is in out-of-phase relation to the other reading, although the invention also contemplates arranging for such readings to take place in phase and provides also for varying the degree of phase.

Further features of the invention consists in the construction of apparatus provided for carrying out the invention and in methods employed for producing the frequency rings and apertures of a fixed plate co-acting therewith, whilst still further features by which the invention is characterised will become apparent from the following description.

Reference is directed to the accompanying diagrammatic drawings, wherein:

Figure 1 is a view of the installation according to one embodiment of the invention, showing one of the keys and associated arrangements for producing a compound tone, i. e. a fundamental and harmonics thereof on manipulation of the key.

Figure 2 is a view showing an alternative manner of arranging for the production of a fundamental note and its harmonics,

Figure 3 is a fragmentary sectional view showing the arrangement of the frequency impressed disc, lamps by which the light beams are propagated and a fixed apertured reading plate which co-acts with the frequency-impressed disc.

Figure 4 is an elevation showing in addition to the elements of Figure 3 the disposition of a

photo-electric cell and a reflector for directing the light beams thereto,

Figure 5 is a fragmentary plan view of the frequency-impressed disc, and

Figure 6 is a fragmentary plan view of the apertured reading plate.

Referring firstly to Figure 1, one of the keys 10 of a keyboard is adapted to serve as a switch so that when depressed it simultaneously closes circuits of lamps 11, 12 and 13. Said lamps are fed from an electric battery 14 or other source of supply through a common lead 15, a contact plate 16 contacts 17 adapted to be engaged by said contact plate 16, branch leads 18, 19, 20 and a common return lead 21. If so desired, a variable resistance 22 may be incorporated in the lead 15 or return lead 21 for simultaneously varying the illuminating intensity of all of the lamps 11, 12 and 13, or in the case where an electric battery forms the course of supply, the lead 15 or return lead 21 may be connected to an intermediate tapping of the battery for the same purpose. Fixed resistances 23 may be incorporated in the branch circuits to the lamps for adjusting the relative intensity thereof. Any equivalent switch means may be substituted for the contact plate 16 and contacts 17.

The apparatus for generating electric alternating currents having the frequency of a required musical note, and for translating into sound the impulses thus generated, comprises in conjunction with a group or groups of lamps, a stationary apertured plate 24, the apertures of which coincide with the light beams to permit passage thereof, a continuously rotating disc 25 having rings of openings therein constituting frequency impressions, a concave reflector 26 which preferably but not essentially is constituted by a mirror, a photo-electric cell 27 positioned at the focal point of said reflector and an amplifier and sound-reproducer indicated in general by reference 28.

Referring now to Figure 3 the disc 25 is secured to a vertical shaft 29, and above said disc is disposed a box-like structure 30 suitably supported in a fixed position. Said structure 30 is fitted with a plurality of tubes 31 in which are fitted lamps 11, 12, 13 respectively. Said tubes constrain the light rays to pass to apertures 32 which are formed in the plate 24, said plate constituting the bottom of the structure 30.

In the disc 25 are formed rings of beam-controlling openings 33 which are concentric with the shaft 29 and arranged in register respectively with the light-beam conveying tubes 31. As shown in Figure 5, the openings 33 are of sine-wave form, and they are spaced apart the distance of a complete wave. All of said openings in a given row are identical to one another so that the modulation of a light beam by said openings results in the production of a musical note of predetermined and constant pitch. Said openings contained in a single row, co-operate in turn with an aperture 32 (or with each aperture of a set of apertures) assigned to said row. Said aperture 32 (or each thereof) is substantially rectangular shape, see Figure 6, and has a length equal to that of one of the sine-wave openings 33 with which it co-operates. If there are two or more apertures assigned to each row of openings 33, then same may have an out-of-phase relationship with respect to the said openings 33 as shown in Figure 5, but an in-phase reading can be alternatively arranged for. If out-of-phase relationship is required then suitable provision may be made for varying the degree to which the readings are out of step.

In the arrangement shown in Figure 1, the fundamental note and harmonics thereof are selected from different discs 25 whereas in the arrangement shown in Figure 2 one and the same disc is used for the fundamental and harmonics thereof. In this case the group of lamps 11, 12 and 13 to any required number conveniently may be arranged in a radial line (Figures 2 and 3) and there may be two or more of such radial lines if the rings of frequency-impression openings 33 are to be read at two or more positions as above set forth. The diameter of the discs may be such as to provide for other concentric rings of frequency-impression openings 33 in addition to those pertaining to a particular fundamental and its harmonics, and further the lamps which are arranged in a radial line need not necessarily pertain to a fundamental and harmonics but may pertain to any arrangement of musical notes for individual operations. A considerable number of rings of frequency-impression openings 33 can be assigned to a single disc.

In Figure 4 is clearly shown the manner of arranging the photo-electric cell 27 and the concave reflector 26. The cell 27 is situated as close as possible to the underside of a fixed base plate 34 by which shaft 29 is supported, said base plate being so formed or arranged as not to obstruct the light beams. A concave reflector 26 which preferably is of elliptical form is suitably supported at such a position that the photo-electric cell 27 lies at the focal point of said reflector. Thus the reflector will serve to reflect and concentrate all of the light beams on to the cell 27. If so desired, an optical condenser may be fitted above or below the base plate 34 for concentration of the light rays during their passage to the reflector.

In the arrangement shown in Figure 2 the return leads 35 from the lamps 11, 12 and 13 are selectively adjustable along a resistance 36 (or may be selectively connected to different tappings of battery 14) in order to adjust the relative intensity of the different lamps, but alternatively fixed resistances 23 could be employed as in Figure 1. Likewise the arrangement of leads 35 in conjunction with resistance 36 may be used in the arrangement shown in Figure 1 in substitution of the fixed resistances 23. The variation of the relative intensities of the light beams and consequential relative strengths of the fundamental and associated harmonic notes will enable an infinite variety of different tones to be obtained.

Instead of providing only a single lamp in each of the tubes 31 there may be arranged therein a plurality of lamps at different positions in the length of the tube. In this case the lamp nearest the disc 25 may serve for an unison reading for the appropriate musical note and a more distance one may serve for the production of the same note when used as a borrowed harmonic to another note. Or, one of said lamps may be wired to a key of one keyboard and another to a key of a different keyboard of the same or a different musical instrument.

As a modification to the employment of a flat frequency-impression disc 25 and the concave reflector 26 for directing the light beams on to the cell 27, there may be employed a frequency-impressed disc of part-spherical shape having the cell at the centre of curvature thereof, the fixed plate 24 having the light apertures 32 being

of corresponding arcuate shape and disposed outside the said frequency-impressed disc with the light tubes 31 radially arranged with respect to the cell. Thus the light rays will converge to the cell.

It is pointed out that the required volume of tone can be obtained without excessive amplification of the generated electric currents. This is due to the fact that large reading apertures 32 are provided in the plate 24. Such large apertures are permissible since each aperture only has to handle a predetermined and constant frequency. Thus, as compared with the scanning of cinematograph sound films where a very small scanning slot has to be employed having a width not exceeding that of the smallest wave of the constantly varying wave form, the same volume can be obtained with much less amplification and consequently with appreciably less distortion, since a considerably greater quantity of light flux is able to pass.

Although in the arrangements above described and shown the openings 33 constituting the frequency impressions are formed in the rotary disc 25 and the apertures 32 which co-operate therewith are formed in the stationary plate 24, the arrangement may be reversed, i. e. the stationary plate 24 may have the frequency-impression openings 33 formed therein, the co-operating openings 32 being formed in the rotary disc 25. In either case there will be the same modulation of the light beam.

It is also to be understood that although in the arrangements above described the harmonics are obtained by utilising a series of rings of frequency-impression openings 33 pertaining to the group of notes comprising the fundamental and harmonics, the invention also contemplates as an alternative thereto, forming the said openings 33 as compound wave forms so as to produce the fundamental note and harmonics by openings of a single row.

In playing the instrument, the player regulates, by means of stop keys, the strength of the electric current which is to flow to the lamps thereby regulating the strength of the fundamental notes and correspondingly adjusting the strengths of harmonics. In order to vary the tone, for instance in simulating different musical instruments, the strength of the currents passing to the lamps utilised for the harmonics are adjusted relatively to the fundamental and to one another through the medium of the resistances provided. The keys are then depressed in playing the instrument and the actuation thereof closes the electric circuits with consequent lighting of the appropriate lamps, and modulation of the light beams produced thereby, such modulation resulting from the co-operation of the frequency-openings 33 and light apertures 32. The modulated light rays are reflected by the reflector 26 and thereby concentrated on the cell 27. Electric impulses are consequently generated by the cell 27 having the frequencies of the required tones and such impulses are converted into sound by the electric reproduction apparatus 28 which can be of any known form. The frequency of the note produced will depend, of course, on the speed of rotation of the disc 33 and this speed is maintained constant, the rate being predetermined. The only motion involved (apart from the constant rotation of the disc 25) when playing the instrument is the movement of the keys and the stops used for varying the strengths of the currents passing to the lamps; thus negligible wear is involved.

A feature of the invention is the method of forming the rotary disc with the frequency openings. The said openings are produced photographically and accordingly said disc is a transparent member coated with light-sensitive material, adjoining sectors thereof along an individual ring of frequency impressions being successively exposed to the same negative. The sector thus progressively reproduced subtends an angle such as to contain several sine-waves. The same negative may embody portions of other frequency impression rings contained within the same sector so that the whole disc is produced by a single sector-by-sector printing operation but preferably each frequency ring is built up in turn from an individual negative. As a modification all of the frequency impressions may be simultaneously produced in a single step by photographing a drawing or other original containing the entire layout of such impressions.

The openings 33 which are formed as above consist of transparent portions in a black disc although as a modification they may take the form of opaque markings on a transparent disc.

Preferably, the apertures 32 in the fixed reading plate 24 also are formed photographically, said plate being a transparent member coated with light-sensitive material which is exposed to a drawing or other original or negative taken therefrom.

As an alternative to the above methods of production of the disc 25 and plate 24, the openings and apertures thereof may be stamped out or otherwise cut away.

By way of example, the discs 25 can be made of a diameter to contain a considerable number of frequency rings, so that only a few rings, say four, are required to embrace 8 octaves.

Although the invention is mainly applicable to organs it can nevertheless be applied to other instruments having a single keyboard or plurality thereof. The instrument may be constructed for operation by two or more players operating on the same sets of lamps and set of discs. Thus an orchestra of players can set up the required additive effects pertaining to different instruments, this being permitted by the out-of-phase reading of the discs. True harmonics as distinct from borrowed harmonics may be obtained by adding fresh sets of discs and regulating their speeds to give the required notes.

CHRISTOPHER HOOK.