May 3, 1966 E. M. JONES 3,249,678

PHOTOELECTRIC ORGAN AND APPURTENANCES

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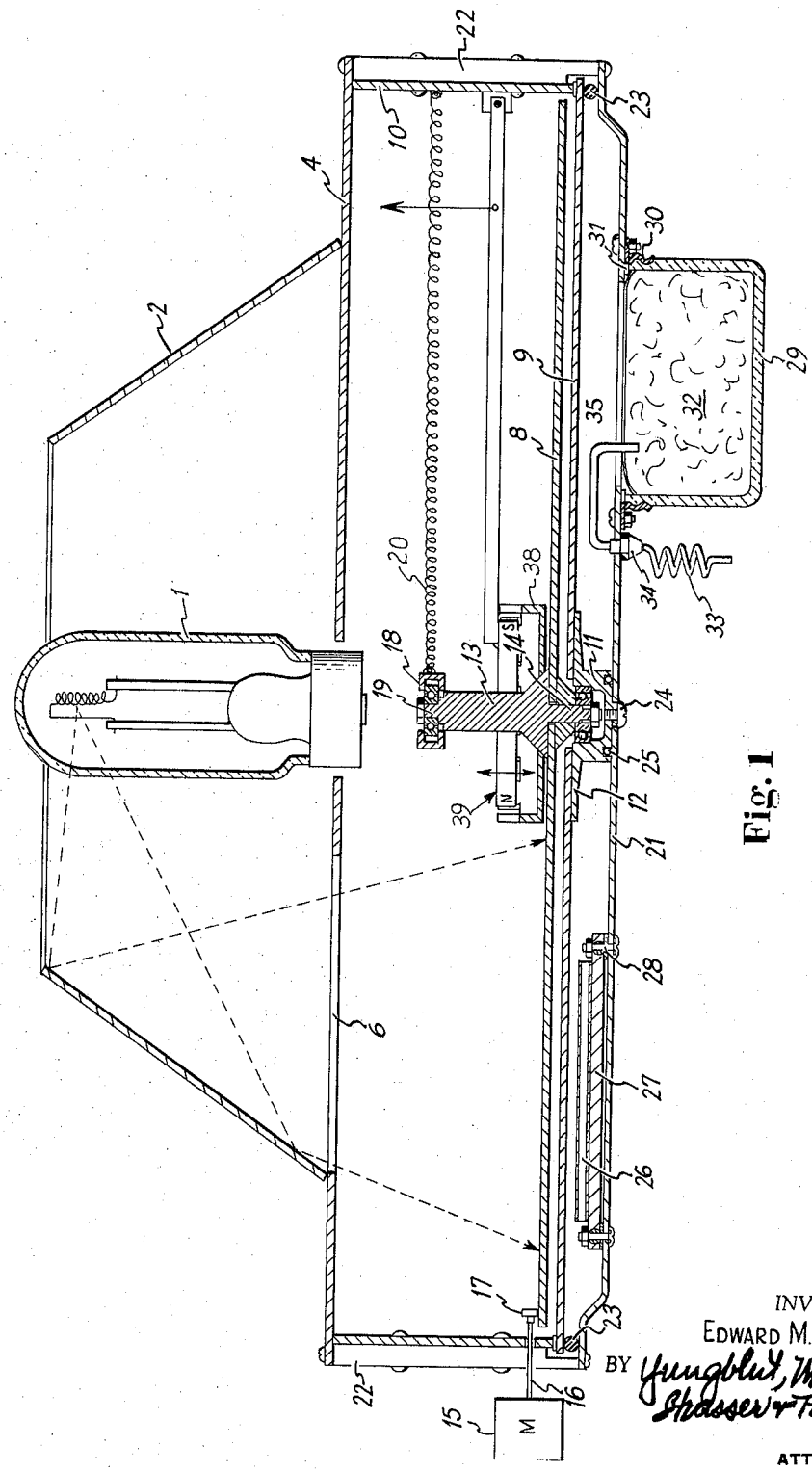


Fig. 1

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PHOTOELECTRIC ORGAN AND APPURTENANCES

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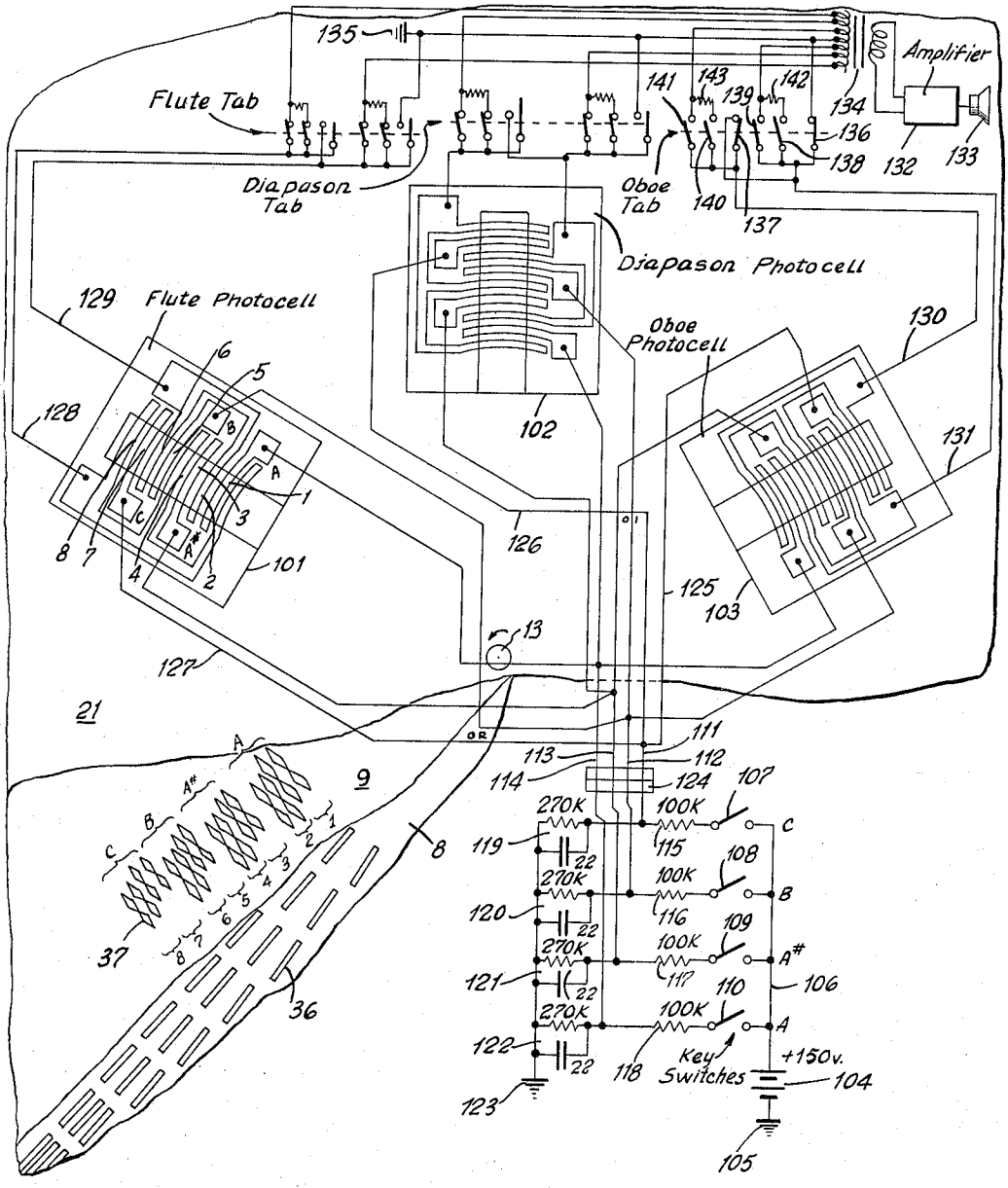


Fig. 2

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PHOTOELECTRIC ORGAN AND APPURTENANCES

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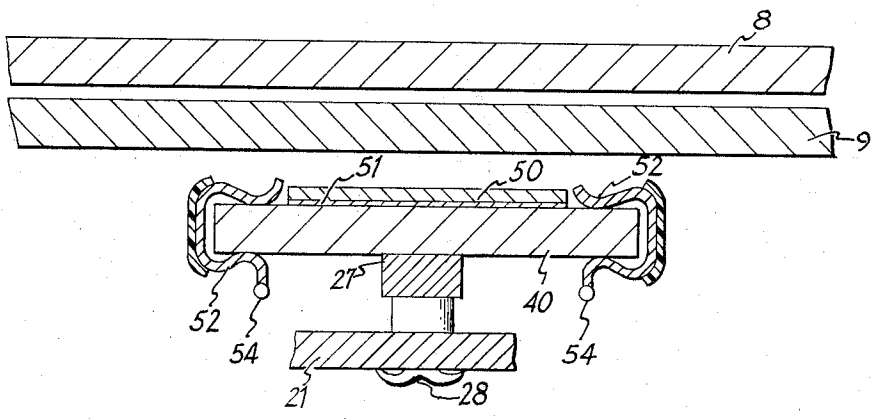


Fig. 3

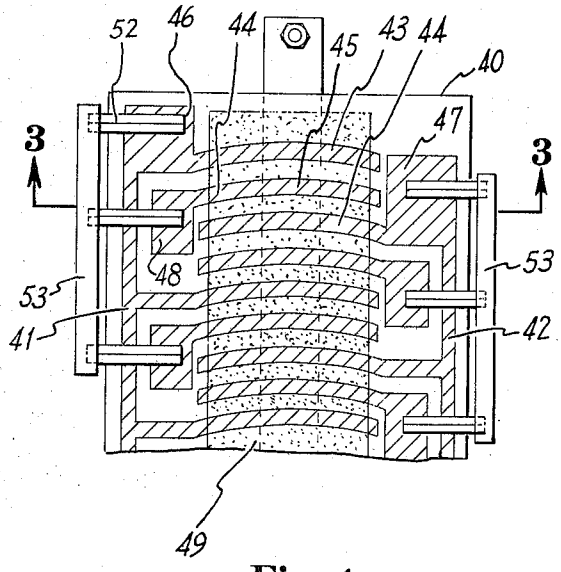


Fig. 4

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PHOTOELECTRIC ORGAN AND APPURTENANCES

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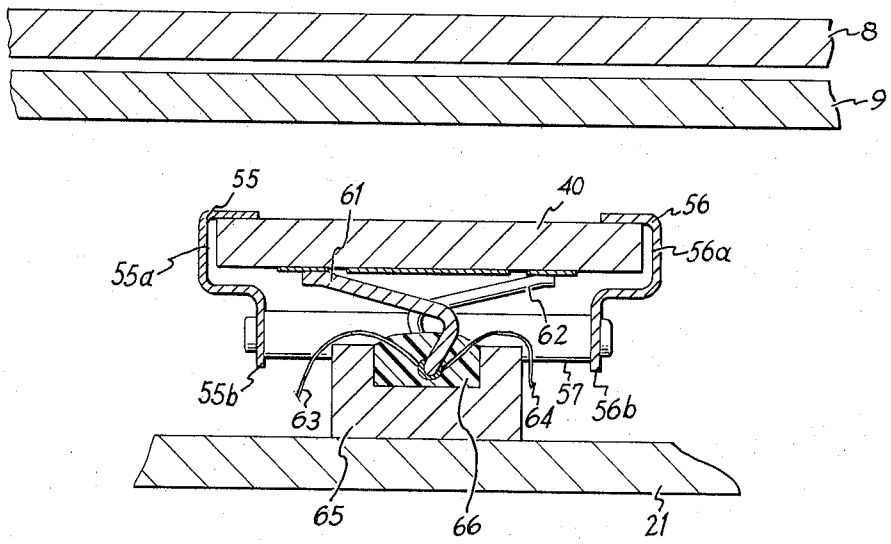


Fig. 5

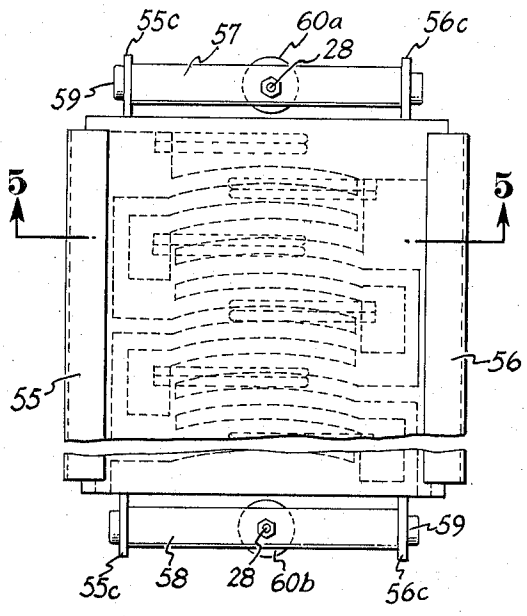


Fig. 6

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PHOTOELECTRIC ORGAN AND APPURTENANCES

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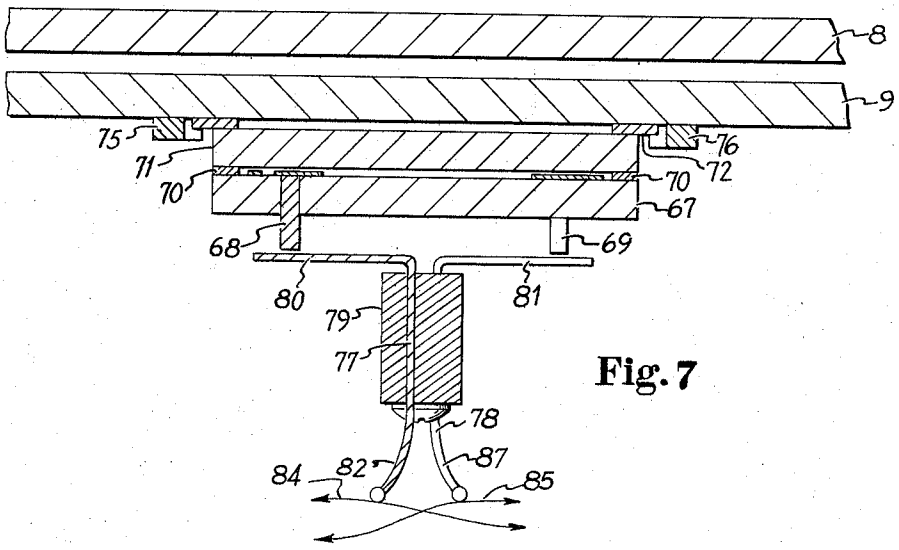


Fig. 7

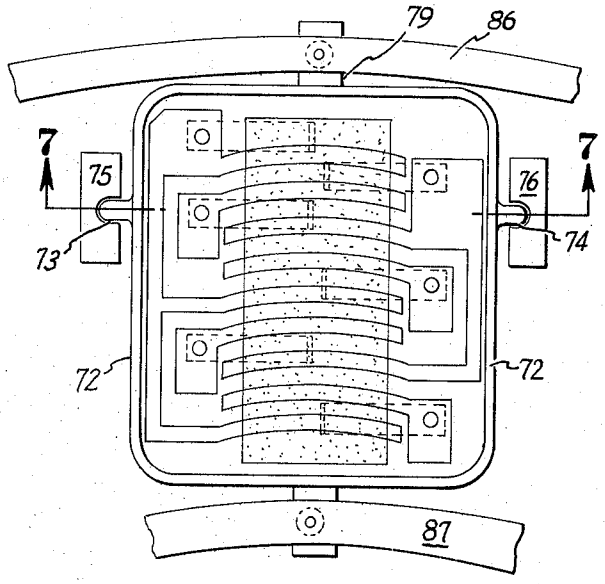


Fig. 8

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PHOTOELECTRIC ORGAN AND APPURTENANCES

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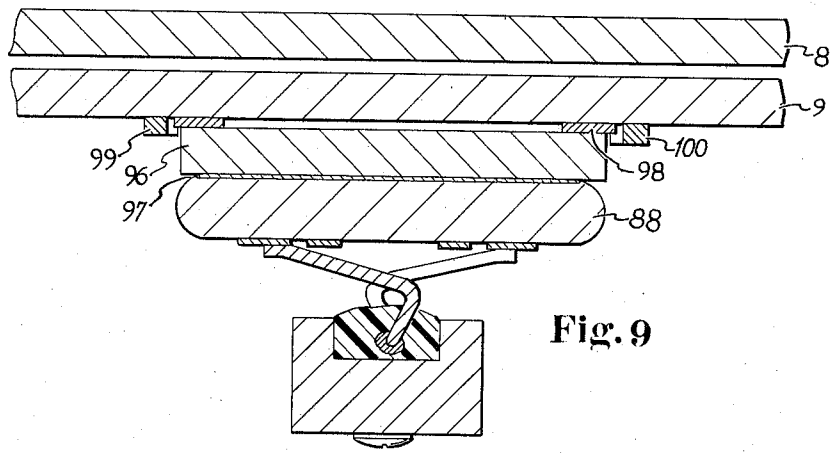


Fig. 9

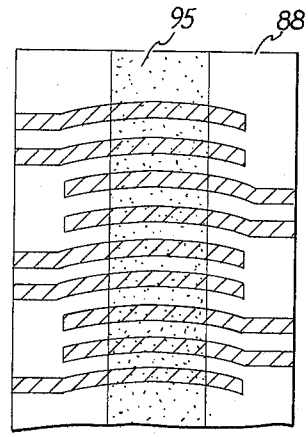


Fig. 10

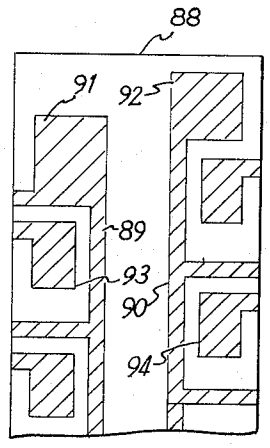


Fig. 11

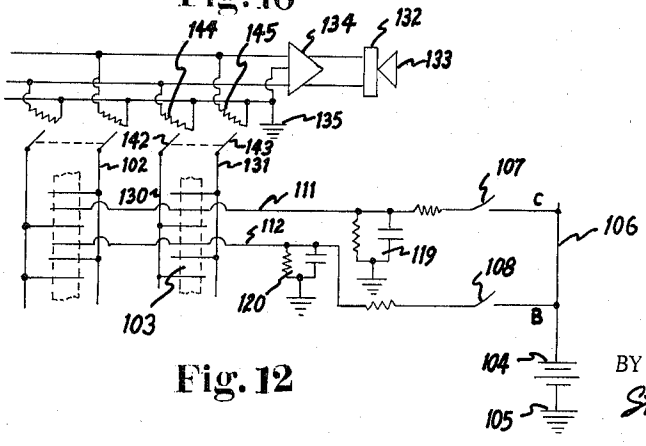


Fig. 12

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United States Patent Office 3,249,678 Patented May 3, 1966

3,249,678

PHOTOELECTRIC ORGAN AND APPURTENANCES

Edward M. Jones, Cincinnati, Ohio, assignor to D. H. Baldwin Company, Cincinnati, Ohio, a corporation of Ohio

Filed Mar. 5, 1962, Ser. No. 195,349
23 Claims. (Cl. 84—1.18)

This case is related to the copending application of Edward M. Jones and Wesley Love, entitled, Photoelectric Musical Instruments and the Like, Serial No. 530,570, filed August 25, 1955, which issued as United States Letters Patent 3,023,657, dated March 6, 1962. That application relates to photoelectric organs and photocell arrays.

It is an object of this invention to provide certain improvements in photocell arrays suitable for use in structures of this class.

It is an object of this invention to provide incombination with photocell arrays improvements in means for making contact therewith.

It is an object of this invention to provide improvements in the assembly of photoelectric musical instruments.

It is an object of this invention to provide means for the protection of photocell arrays in a photoelectric musical instrument.

These and other objects of the invention, which will be set forth hereinafter or will be apparent to one skilled in the art upon reading these specifications, are accomplished by those structures and arrangements of parts of which certain exemplary embodiments will now be described. Reference is made to the accompanying drawings wherein:

FIG. 1 is a sectional view of the main components of a photoelectric organ in combination.

FIG. 2 is a partial plan view of diagrammatic character showing the relationship of certain of these components to each other and to circuitry for such an instrument.

FIG. 3 is a partial sectional view of one way of mounting a photocell array in an electrical musical instrument, there being shown also some additional elements of the instrument to illustrate a relationship of parts. The section is taken along the line 3—3 of FIG. 4.

FIG. 4 is a plan view of the photocell mounting structure illustrated in section in FIG. 3.

FIG. 5, which is a sectional view taken along the line 5—5 of FIG. 6, shows another way of mounting a photocell array and of making contact therewith.

FIG. 6 is a plan view thereof.

FIG. 7, which is a sectional view taken along the line 7—7 of FIG. 8, shows yet another way of mounting and making contact with a photocell array.

FIG. 8 is a plan view of the structure shown in FIG. 7.

FIG. 9 is a sectional view illustrative of yet another way of mounting and making contact with a photocell array.

FIG. 10 is a partial plan view of the upper side of the photocell array.

FIG. 11 is a partial plan view of the lower side thereof.

FIG. 12 is a diagrammatic showing of another form of circuitry.

Photoelectric organs, as hitherto conceived, generally comprise a suitable source of illumination, together with reflecting means, a rotating pitch disc having circular bands or tracks upon it formed in alternate opaque and transparent areas which serve to break up the light into pulsations of frequencies appropriate to the notes of a musical scale. A stationary voice disc is used in combination with the rotating pitch disc; and the voice disc has areas on it responding to portions of the bands on

the pitch disc but serving to impart to the pulsations of light produced by the pitch disc particular wave form characteristic which, when the pulsations are converted to electrical impulses and then (after selection in accordance with the requirements of a musical composition), produce characteristic and desirable voices. The pitch disc will be divided into a large number of radially arranged areas, at least one for each of the desired voices of the instrument.

Shutters have hitherto been suggested for use in connection with an assembly such as that outlined above; but such shutters have had to have an opening for each pitch element of the pitch disc and for each voice which was to be derived from that pitch element. In addition, there has had to be shutters, operated by stop tabs, of such character as to uncover the first mentioned shutter openings in each of the voicing areas on the voice disc. When it is considered that the various shutter elements must be connected by mechanical or other means with individual keys and individual stop tabs, it will be understood that prior suggestions have involved a very great mechanical complexity, making the instrument difficult to construct and difficult to repair.

In the copending application referred to above, it was suggested that the shutter mechanisms be eliminated. Instead of a single photocell as a means for converting the pulsations of light into pulsations of electrical energy, photocell arrays were employed; these arrays each containing a photocell for each of the pitch disc tracks for frequencies desired in the particular voice. The photocell arrays are relatively long and narrow, and they can be arranged radially of the voicing disc so that there would be a photocell array for each of the voices of the instrument. The individual photocells are of the type requiring polarization in order to function; and as a consequence, it becomes possible to substitute electrical circuit means for the mechanical interconnections between the former shutters and the keys and stop tabs. It was also suggested in the said copending application that photocells of the 3-electrode type could be used in the photocell arrays, making it possible to cancel out direct current impulses and to provide alternating electrical impulses only for amplification and reproduction.

Referring now to FIG. 1, a general assembly for such a photoelectric musical instrument is shown diagrammatically as comprising a lamp **1** and a reflector **2** constituting a source of illumination. These are mounted in or on a housing which may take various forms. In the particular embodiment, the housing has an upper plate **4** which may be cut away in radially disposed areas **6** to permit the light to enter. The light, as controlled by the reflector, passes first through a pitch disc **8** and then through a voice disc **9**. The voice disc is stationary in the apparatus; and the side walls of the housing are provided by a circular or other member **10** having engagement with the upper plate **4** and with the voice disc **9**.

A structure **11**, having an upper flange **12**, is cemented to the voice disc **9** and provides a bearing for the pitch disc spindle. The pitch disc is provided with a spindle **13** having a lower extension **14** which, in the embodiment shown, is mounted in a ball bearing in the structure **11**.

The voice disc and pitch disc are preferably made of glass; and the transparent and opaque areas thereon may be formed photographically.

There are many ways in which the pitch disc may be rotated at a suitable speed. One of the simplest of these is illustrated in FIG. 1 as comprising a motor **15** driving by means of a shaft **16** a friction wheel **17** which bears on a marginal portion of the pitch disc **8**. There should, of course, be a bearing means for the upper part of the spindle **13**. This bearing means may comprise a bearing holder **18** which supports a ball bearing on an upward

extension 19 on the spindle. The bearing holder 18 can be mounted on a flexible or pivoted arm (not shown) attached to the side walls 10 of the housing; and the structure shown makes it possible to maintain the friction of the drive by bracing the pitch disc against the friction wheel 17, as by means of a spring diagrammatically indicated at 20, while preventing wobble of the pitch disc in other directions.

The photocell arrays which are employed, and which will be described at some length hereinafter, may include photocells of various types; but lead sulfide photocells have been found particularly adapted for use in this invention. Such photocells, and others as well, should be protected from external influences, and in particular, from the deleterious effects of atmospheric moisture and condensation. In some instances this may be accomplished by providing covers for the individual photocell arrays; but as set forth in FIG. 1, it is also possible to accomplish adequate protection by locating all of the photocell arrays in a sealed chamber of which the voice disc 9 constitutes one wall. In FIG. 1 a base plate is shown at 21. It is held to the structure described above by means of a series of posts 22 fastened to the side wall member 10. The upper plate 4 and the base plate 21 are fastened to these posts by screws as shown. An O-ring 23 lies between the edge portions of the voice disc 9 and the base plate 21 so as to provide a peripheral seal. The O-ring will be made of any suitable rubbery, resilient and distortable substance, as will readily be understood. Since the housing for the lower bearing of the pitch disc spindle is normally held to the base plate by a screw 24, it is advisable to apply an O-ring seal 25 between the structure 11 and the base plate.

The above construction provides a sealed space in which the photocell arrays may be housed and protected from moisture. For the sake of completeness of the showing, a photocell array is indicated at 26 in FIG. 1, supported upon a frame or bracket 27 which, in turn, will be mounted to the plate 21 by any suitable means as at 28. Details of these constructions will be given later; but it may be noted in FIG. 1 that the arrangement illustrated comprises a bolt-like member riveted to the plate 21, of course in a gas-tight fashion.

It is advisable, because of changes of atmospheric pressure and the likelihood that the sealing means may not be perfect to provide a desiccant in connection with the sealed space. To this end a screw-top vessel 29 may be attached to the base plate 21 beneath an opening therein. This can be done by threaded means 30 attached to the base plate; and the skilled worker in the art will appreciate the advisability of a sealing ring 31 or its equivalent. The desiccant 32 may be any suitable moisture absorbent material, e.g. silica gel, anhydrous calcium sulfate, and the like. There are many materials which may be used, and these form no limitation on the invention. Where the vessel 29 is of glass or other transparent material a desiccator having an indicator substance mixed therein may be used.

It is also advisable to provide pressure equalizing means for the sealed space aforesaid. This may be done in various ways, as by the provision of a bellows structure; but a convenient and permanent provision for "breathing" can be provided by using an elongated capillary tube 33 passing in gas-tight relationship through a fitting 34 in a perforation in the plate 21. The inside end of the capillary tube may be brought over as at 35 and caused to enter the container 29.

Where it is possible to use photocell arrays which are individually sealed, the above noted provision of a sealed space between a base plate and the voice disc, together with means for desiccation and breathing become unnecessary. In that event the member 21 instead of being a solid plate may become a spider having radially or substantially radially arranged parts to support the photocell arrays.

The alternating clear and opaque areas on the pitch disc 8 are illustrated in a purely diagrammatic fashion at 36 in FIG. 2. Actually the bands of clear and opaque areas may be made quite narrow and quite closely spaced so that it becomes possible to include bands for the desired frequencies throughout the entire range of the musical instrument upon a single pitch disc having a relatively small diameter, say of slightly more than 1 ft. This dimension of course is illustrative merely and the pitch disc and voice disc may be made of any commercially feasible dimensions; and it is readily possible to employ in a single instrument more than one of the assemblies illustrated in FIG. 1.

The voice disc 9 will bear corresponding markings for the purpose of imparting timbre to the pulsations of light as produced by the bands on the pitch disc. This is well understood in the art. Various voice disc bands are illustrated diagrammatically at 37 in FIG. 2; and it has been found preferable to provide a plurality of voicing bands on the voicing disc for each pitch band on the pitch disc. For a reason later set forth the outer marking in each voicing disc track should be 180° out of phase with the inner markings. It has already been indicated that the light and dark areas on the voicing disc are arranged in radially or substantially radially extending groups each appurtenant to a particular voice, there being a photocell array on the base plate to convert the light pulsations for each such group into electrical impulses. Both the pitch disc and the voice disc may be made photographically by processes and apparatus such as that illustrated in the patent to the present inventor No. 2,839,960, issued June 24, 1958. It has been found that an effect of ensemble between voices of the instrument may be achieved by slight variations from a mean of the width of the clear and opaque areas in the bands 36 on the pitch disc. This is because areas of different width will be passing simultaneously over different voicing areas on the voicing disc. When master copies of the pitch disc and voicing disc have been made, other copies may be reproduced by photographic printing processes.

The effect of vibrato may be obtained in an instrument of this class by varying at a sub-audio rate, the exact rotational speed of the pitch disc 8. This may be done in various ways. There is diagrammatically illustrated in FIG. 1 an armature member 38 attached to the pitch disc. A permanent magnet 39 may be approached to the armature when vibrato is desired, and the armature is formed with teeth so that the magnet can periodically effect a minor change in the speed of rotation of the disc. The vibrato produced is, of course, a pitch vibrato.

The photocell arrays employed each contain a large number of individual photocells. Preferably a photocell array will contain that number of photocells which will equal the number of semi-tones within the range of the instrument which is desired to be reproduced in connection with any given voice. Some voices extend through the entire range of the instrument, in which case sixty-one photocells may be provided in a given photocell array. There may be additional photocells in such an array, i.e., for the provision of 16 ft. and 32 ft. tones in the pedal register, and perhaps additional photocells to take care of a 4 ft., 2 ft. or other footages in the top end of the register. It is not a basic requirement that any given photocell array contain individual photocells for all of the semi-tones desired for a given voice. It is quite possible to divide up into different radial groups the light and dark voicing areas on the pitch disc and employ correspondingly shorter photocell arrays. Dimensional limitations on the photocell arrays do not constitute limitations on the invention. The point is that in actual practice photocell arrays are employed which may be of elongated form and not over, say, ¾ in. to 1 in. in width.

Since the pitch bands on the pitch disc may be spaced on, say, 1/16 in. centers, it will be realized that the photocell arrays may contain and usually do contain a very considerable number (sixty-one to eight or more) of individual photocells which are themselves very tiny. The illustrations herein of photocell arrays are semi-diagrammatic in character, exaggerated in size and greatly foreshortened.

Nevertheless the general nature of the photocells may be appreciated from FIG. 4. On a suitable substrate **40**, which is usually glass, although ceramics and other insulative substances will serve, an array of photocells is formed consisting of electrodes and a coating of photosensitive substance. There are common electrodes **41** and **42** having interdigitating branches **43** and **44**. Between each pair of these interdigitating branches there is located a third electrode **45**. The common electrodes have areas **46** or **47** with which contact can be made, and there are enlarged portions **48** for contacting purposes on the ends of the third electrodes. There is room for these enlarged areas between the main bodies of the common electrodes as will be evident from the figure.

It will be seen that each photocell comprises a first electrode which is part of one of the common electrode structures, a second or intermediate electrode and a third electrode which is a branch of the other common electrode structure. The branches of the common electrode structures thus can serve as electrodes for adjacent photocells. When the electrodes are covered by a common coating **49** of photosensitive substance, the confining of that coating to a band lying inside the ends of the electrodes themselves prevents cross talk and interference as set forth in the copending application first referred to above. The individual photocells in the array are rendered operative by electrical polarization. While this does not constitute a limitation on the invention, best results can be obtained using a lead sulfide type of photocell.

In making up photocells, the usual practice is to deposit a suitable metallic substance upon the substrate **40**. This substance may be any desired, but should be a substance relatively free from oxidation or other corrosion. The noble metals may be employed; and excellent results are obtained through the use of chromium as set forth in the copending application of Clifford B. Luebbe, Serial No. 127,236, filed July 27, 1961, and entitled, Photoelectric Structures. The metal which is to form the electrodes may be deposited in any suitable way as by electroplating; but is preferably deposited by vaporization under such conditions as to provide very high adhesion. While it is possible in some instances to form the electrodes direct by depositing the metal through masks, it is preferred in the formation of the rather elaborate photocell arrays of this invention to deposit an all-over coating of the metal. This can then be covered with a photo-resist as known in the art. Upon exposure to light through a suitable pattern member, the resist is hardened over those areas which are to form the actual electrodes. The softer portions of the resist are then removed in known ways, and the structure is subjected to treatment in a suitable etchant which will remove the uncovered areas of the metal coating. When this is accomplished, the hardened portions of the resist are dissolved away, and the structure is ready for the deposition of the photosensitive layer. In the case of lead sulfide photocells, the photosensitive layer **49** may be deposited by precipitation from a solution.

It is possible under certain circumstances to provide the activatable portions of the photocell array with a cover which will protect the photosensitive area from moisture, harmful gases or the like. In FIG. 3 the photocell array on the substrate **40** is shown as covered with a relatively thin cover glass **50** held on by a suitable transparent and insulative cement **51**. It may be noted, however, that the cover glass must be narrow enough to expose the contact areas **46**, **47** and **48**, and that the effectiveness of the cover glass **50** will depend largely on the cement **51**. This is why in many instances it is preferred to use uncovered photocell arrays and to locate them in the sealed chamber heretofore described in connection with FIG. 1.

In any event there is a problem of making contact with the various contact areas of the photocell array. This may be done by soldering wires directly to the contact areas of the metal electrodes, with or without the imposition of some metal which will render a soldered connection more positive. For example, soldering to chromium electrodes is facilitated by first vaporizing some iron onto the contact areas, at least, of the electrodes. The hand soldering of wires to the individual contact areas is both tedious and laborious. The soldering may be done, using jigs in a gang fashion; but it will be appreciated that in any soldered construction the replacement of a photocell array would be tedious and laborious. As a consequence it is preferred to provide means whereby contact may be made through resilient metal elements positioned to engage the contact areas. In FIGS. 3 and 4 there is illustrated a structure employing a plurality of clip-like elements **52**. These elements are preferably double wire elements as shown in FIG. 4 for the sake of positiveness of contact. The several clips are fastened in properly spaced relationship to insulative supports indicated at **53**; and the clips are so shaped that one end of them will engage a contact element of an electrode, while soldered flexible wire connections may be made to the other end of each clip, i.e., the point **54**. There will be a clip assembly for each lateral edge of the photocell array. Each clip assembly will contain one or more clips for making contact with a common electrode structure and a plurality of clips for making individual contact with the contacting areas **48** of the intermediate electrodes. With this construction it is readily possible to remove and replace a photocell array by slipping the lateral clips on each side off the edges of an old photocell array and onto the edges of a fresh photocell array. The photocell arrays may be mounted in various fashions. One such fashion involves the use of the mounting bar **27** previously referred to, which may be adhesively secured to the substrate **40** and held to the plate **21** by the rivet-bolts **28**.

In FIGURES 5 and 6 there is shown another method and structure including means for making contact with the contact areas of the electrodes on a photocell array. It may be noted that in this instance the array is upside down in the sense that the light passes first through the substrate **40** before reaching the individual cells. This permits the making of contact by means of contact fingers acting from beneath and urging the photocell array upwardly.

Two bracket members **55** and **56** are provided. These may be of insulative material such as a synthetic resinous laminate, but are more conveniently formed of metal. In cross-section they are so configured as to provide channel shaped parts **55***a* and **56***a*, and depending flanges **55***b* and **56***b*. The flange portions are extended at their ends to provide legs, as at **55***c* and **56***c*.

The respective pairs of legs **55***c* and **56***a* are attached to the ends of bar members **57** and **58** as by bolts or screws **59**. The bar members are supported a sufficient distance away from the base plate **21** by column members or spacers **60***a* and **60***b*, which can be part of the bolt-rivet means **28**, for fastening the whole structure to the base plate **21**.

As will be seen from FIGURE 5, edge portions of the photocell array are cemented in the channel shaped parts **55***a* and **56***a* of the bracket members. Spring fingers **61**, **62**, which serve as the means for making contact with the contacting areas of the electrodes on the photocell array engage it from beneath. There are a number of ways in which the spring fingers **61**, **62** may be mounted. A very convenient way is illustrated in FIGURE 5. Here, after the conductor wires **63**, **64** have been soldered to them, the spring fingers are engaged in a jig which will insure

their proper location and spacing. The jig is then positioned properly with respect to an insulative channel **65** and a body of hardenable insulative substance **66** is cast into the channel so as to embed the lower ends of the spring fingers. This provides an integral contact assembly which can be mounted on the base plate **21** in any desired way such as by bolting or by the use of a permanent adhesive. A very satisfactory material for the body **66** in which the ends of the spring fingers are embedded is epoxy resin. This can be applied in a very soft condition but will harden so as to hold the contact fingers securely. It also provides a very good bond to the insulative channel **65**. As will be clear from the dotted line showings in FIGURE 6, the spring fingers are preferably made of double wire construction.

FIGURES 5 and 6 show an excellent mounting for photocell arrays in a sealed chamber such as has been described in connection with FIGURE 1. The photocell arrays may be removed and installed very readily and located accurately without in any way disturbing the wiring. A photocell assembly including the brackets **55** and **56** may be removed by removing the screws **59**. Needless to say the ends of the spring fingers will be prelocated so that they will bear upon the contact areas of the photocell array.

Another form of structure is shown in FIGURES 7 and 8. In this structure the photocell array may be permanently covered and sealed; and the use of this structure makes unnecessary the provision of a sealed chamber. The structure of the photocell array as comprising electrodes and the layer of photo-sensitive substance may be the same as that described above in connection with FIGURE 4; but in the embodiment under discussion contact is made to the contact elements of the electrodes through the substrate **67**. To this end, the substrate is pressed in heat-softened condition around pins **68**, **69**, held in a suitable jig with a flat upper surface so as to form a structure in which the pins extend through the substrate and project from its lower side. The pins are formed from kovar or some other conductive metal having a coefficient of expansion close to that of the glass of the substrate; and, of course, the pins will be so placed in the jig that their upper ends will lie at the positions of the connector areas on the electrodes. After the insertion of the pins as described, the upper surface of the substrate **67** will be ground smooth and flat so as to insure that the upper ends of the pins are exposed at the substrate surface.

It will be usual to deposit a rim of metal **70** about the edges of the substrate of the photocell array but not in contact with any of the electrodes. A similar rim of metal may be deposited upon a glass cover member **71**; and the purpose of these rims of metal is to permit the superposition of the cover member on the substrate and the formation of a dependable seal between the two by soldering. For example, if in following the teachings of the Luebbe application herein referred to, the electrodes are formed of chromium applied by the vacuum-vapor deposition method (which will usually be done through a mask) the rim elements **7** may be similarly formed and then given a thin coating of iron. After the photo-sensitive coating has been applied to the electrodes as above described, the cover member **71** may be placed over the substrate and a very excellent and dependable seal made by applying solder at the outer edge of the superposed rims. By proper selection of glass for the substrate and cover member a structure may be obtained which will withstand the heat of the soldering operation.

It will be appreciated from FIGURE 7 that a sealed photocell array has been provided and that it is only necessary to make contact with the projecting portions of the pins **68** and **69**. These pins respectively are in electrical contact with the contacting areas of the electrodes of the photocell array. The photocell array may be urged upwardly against the voice disk **9** in any suitable way, and especially by contact fingers later described. It is necessary to position the photocell array accurately with respect to the light and dark areas on the voicing disk **9**. One way of doing this is shown in FIGURES 7 and 8. A rim **72**, which may be of metal or other suitably strong substance, is affixed to the edge of the cover member **71** by cementing. The frame will have laterally projecting ears **73** and **74** (at least one on each side of the frame); and these ears will engage in recesses in blocks **75** and **76**, of metal or insulative substance. The blocks are cemented to the under side of the voice disk **9**; but once the blocks are accurately located with respect to the voicing areas on the voice disk, photocell arrays may be installed and replaced without danger of misalignment.

Contacting members **77** and **78**, there being one such contact member for each pin in the photocell assembly, are mounted in an insulative holder **79**. This holder is in the shape of a bar and a convenient construction is to cast or mold the bar of synthetic resinous material while the contacting members are held in a positioning jig. The contacting members have spring finger elements **80**, **81** for contacting the ends of the pins respectively. Other portions of the contacting members projecting downwardly from the bar as at **82**, **83**, serve as means to which electrical leads **84** and **85** may be soldered.

If the bar **79** is rigidly mounted with respect to the base plate, the action of the spring fingers **80** and **81** will be to urge the photocell array up against the under side of the voice disk so as to maintain the ears **73**, **74** in engagement with blocks **75**, **76**. There are various ways in which the bar may be mounted. The ends of the bar may be affixed to ring members **86** and **87**. The ring members may be supported upon the voice disk **9** by being attached thereto or they may be affixed to the base plate **21**, in either event with suitable spacers between the rings and the bar so as to bring the bar to the proper level; since the structure of FIGURES 7 and 8 is a sealed structure, it is not necessary to provide the sealed chamber described in connection with FIGURE 1. The desiccating apparatus and the breathing apparatus may be omitted, and if desired, the base plate **21** may be made in the form of a spider by providing openings in it for easy replacement of the photocells.

In FIGURES 9, 10 and 11 there is illustrated a structure of modified characteristics, wherein the substrate **88** has rounded edges as shown. The electrodes have the same general arrangement as heretofore described in connection with FIGURE 4, but the active portions of the electrodes lie upon one side of the substrate as illustrated in FIGURE 10, while the connector portions of the electrodes lie on the opposite side of the substrate as illustrated in FIGURE 11. It will be clear from the drawings that the bodies **89** and **90** of the common electrodes together with the contactor members **91** and **92** of the common electrodes, together with the contactor members **93** and **94** of the intermediate electrodes, lie upon one side of the glass, while the interdigitating extensions of these elements pass around the curved edges of the glass and lie on the opposite side thereof where they are interconnected by the layer **95** of photo-sensitive substance. This makes it possible to cover the entire top side of the glass substrate with a glass cover member **96** which may be cemented in place as at **97**, or otherwise joined to the substrate. The same locating system can be used as has been described in connection with FIGURES 7 and 8. This is inclusive of the rim **98** affixed to the cover glass **96** and having the previously described ears, and the locating blocks **99**, **100**, attached to the voice disk **9**.

A spring finger contact arrangement identical with that shown in FIGURE 3 may be employed here and does not require re-description.

Various electrical leads have been indicated as attached to the several contact fingers described above. It will be understood that an electrical lead attached to each of the fingers for the intermediate electrodes will serve as

a means for polarizing selectively the individual photocells to which the intermediate electrodes pertain. Such electrical leads may be connected directly or indirectly to a playing key operated system for polarizing the photocells. Such a system will contain a source of polarizing potential and may advantageously contain tone envelope control means as hereinafter set forth. The electrical leads from the common electrodes will be connected to an output system preferably including a balanced amplifier, through stop switches. Since it is often desired to obtain simultaneously a plurality of voices, there may be additional leads from the intermediate electrodes of one photocell array to the intermediate electrodes of other photocell arrays. Thus it is possible to polarize and therefore energize a photocell simultaneously in a plurality or in all of the photocell arrays upon the operation of a single playing key having a single playing key switch. Selection and combination of the voices is accomplished through actuation of the stop switches.

Referring to FIGURE 2, a diagrammatic showing has been made inclusive of the base plate, the pitch disc and the voicing disc. As previously indicated, the pitch disc **8** contains tracks **36** made up of clear and opaque areas. The voice disc **9** contains radially arranged sets of voicing indicia **37**. Three photocell arrays have been indicated in diagrammatic form at **101**, **102** and **103** on the base plate **21**. These have been marked with the legends "flute," "diapason," and "oboe" to indicate that they pertain to different voices in the instrument. The specific nature of the voices, however, is not a limitation upon the invention. For the purpose of polarizing the individual photocells and rendering them active, a circuit is shown comprising a source of D.C. potential **104**, connected between ground or the common return **105** and a bus **106**. The key switches, of which four are shown at **107** to **110** inclusive, have connections to the bus **106**, and to leads **111** to **114** through transient reducing resistors **115** to **118**. Each of these circuits may also be provided with a transient reducing or tone envelope controlling means (illustrated as a network comprising a capacitor and a resistance, and marked **119** to **122**). These networks are connected to ground or the common return as at **123**. It will be understood that the playing key switches are operated individually by the playing keys of the instrument. More elaborate tone envelope controlling networks may be employed if desired, such as those which will give percussive effects.

The various leads **111** to **114** may pass through a separable plug-in connector **124**, if of convenience in assembling the instrument. This connector may be of a sealed type to gain entrance to a sealed photocell enclosure.

The circuit leads **111** to **114** have branches, going to a plurality of the several photocell arrays. Thus the lead **111** has a branch **125** going to one of the intermediate electrodes in the array **103**, a branch **126** going to one of the intermediate electrodes in the array **102**, and a branch **127** going to one of the intermediate electrodes in the array **101**.

The common electrodes of each photocell array are connected to stop tab switching arrangements whereby the several voices may be selected. Thus the array **101** has leads **128** and **129** going to a stop tab switching arrangement marked "flute tab." Similarly, the photocell array **102** is shown connected to a "diapason tab," so marked. The common electrodes of the photocell array **103** have leads **130** and **131** going to an "oboe tab." The switching arrangements of the several stop tabs are in turn connected with an output system comprising an amplifier **132** and a loud speaker **133** through a transformer **134**. This transformer has a center-tapped primary winding, the center tap of which is grounded at **135**; and it will be seen that the leads from the common electrodes of each photocell array are connected by the stop tab switching arrangements to points near the opposite ends of the primary winding of the transformer **134**. This arrangement, having in mind the out of phase relationship in the markings of the various voice disc tracks, makes it possible to balance out D.-C. components of the signal and to pass to the amplifier only the alternating components thereof.

In a system such as has been described, when, during the playing of the organ, a second voice or additional voices are to be added by actuation of their respective stop tabs, a thump or transient is likely to occur. This makes it advisable to provide means in connection with the stop tab switching arrangements for eliminating this transient. In FIGURE 2, the switching arrangement of the "oboe tab" is shown in the tab-off position; and it may be noted that the lead **131** from the photocell array **103** is grounded through a switch component **136**. Likewise the lead **130** from the photocell array **103** is grounded through a switch component **137**. The switches **136** and **137** are, of course, closed when the stop tab is in the off position, and are opened by moving the tab to the on position. Feed-through of D.-C. bias to motor not being played is thus eliminated. There are a pair of switch elements **138** and **139** in the oboe tab switching arrangement whereby the lead **131** may be connected to a point to one side of the center tap of the primary winding of the transformer **134**. Similarly, there are a pair of switch elements **140** and **141** by which the lead **130** may be connected to a point on the other side of the center tap of the transformer primary. Closing the switch **138** will complete this circuit through a resistor **142**, while closing the switch **140** will complete the other circuit through a resistor **143**. No resistors are shown in the leads from the switch elements **139** and **141**.

The several switch elements are so connected with the operating means of the stop tab that when the stop tab is moved to the on position, the switches **138** and **140** will first close, establish connections between the leads **130** and **131** and the primary winding of the transformer through the resistors aforesaid, for the purpose of preventing shorting the transformer winding since the photocell is still grounded. Next the switch **136** will open, allowing the photocell current to flow equally in the two parts of the transformer winding, eliminating or minimizing the transients which might otherwise produce an objectionable thump. Then switch **137** is opened allowing the A.C. current to flow in the transformer. Finally the switches **139** and **141** close, establishing a direct connection between the leads **130** and **131** and the transformer primary. The switch elements in the flute tab and the diapason tab are shown in the positions they occupy when these tabs are in the on position.

A somewhat modified circuitry is shown in FIG. 12. Like parts have been given like index numerals in this figure. The photocell arrays **103** and **102** are shown diagrammatically. The leads **111** and **112** from the key switches **107** and **108** are shown connected first to intermediate electrode members in the array **103** and then to intermediate electrode members in array **102**, in sequence. This is a modification of the branched circuits shown and described in connection with FIG. 2. The center tap of the primary winding of the transformer **134** is again grounded at **135**; but the arrangement for the elimination of the thump or transient when stop tabs are actuated to the on position is different. The leads **130** and **131** from the photocell array **103** are brought out to the moving elements of a pair of potentiometers. These moving elements are indicated at **142** and **143**, and it will be noted that they are mechanically interconnected so that they will move in unison. The resistive parts of the potentiometers are indicated at **144** and **145**; and it will be noted that the first of these is connected between an outer terminal of the primary winding of the transformer **134** and to the ground lead. The other resistive element **145** is connected similarly between the ground lead and the other outer or terminal portion of the primary winding of the transformer. Because of this construction, the leads **130** and

131 from the photocell array 103 will first be connected to the transformer through a high resistance, which will gradually diminish during the actuation of the stop tab.

Modifications may be made in the invention without departing from the spirit of it. The invention having been described in certain exemplary embodiments, what is claimed as new and is desired to be protected by Letters Patent is set forth in the claims which follow:

1. In a photoelectric music instrument having a stationary disc with light-impulse modifying means thereon, and utilizing photocell arrays of the open type, a sealed chamber comprising a base plate in proximity to said disc, peripheral sealing means between marginal portions of said plate and disc, there being a space between said plate and disc within the confines of said marginal portions, and at least one photocell array mounted on said plate within said space.

2. The structure claimed in claim 1 including means for desiccating said space, said means comprising a container of desiccant having a connection with said space and being closed to the outer air.

3. The structure claimed in claim 2 including means for equalizing air pressure within said space with the ambient air pressure.

4. The structure claimed in claim 2 including means for equalizing air pressure within said space with the ambient air pressure, said last mentioned means comprising a capillary tube passing through said plate in gas-tight relationship and having end openings within said space and outside said space.

5. The structure claimed in claim 4 wherein the end of said capillary tube within said space is configured to enter said container of desiccant substance.

6. In a photoelectric musical instrument having a stationary disc with light-impulse modifying means thereon, and utilizing photocell arrays of the open type, a sealed chamber comprising a base plate in proximity to said disc, peripheral sealing means between marginal portions of said plate and disc, there being a space between said plate and disc within the confines of said marginal portions, and at least one photocell array mounted on said plate within said space, said photocell array consisting of a plurality of three-element photocells on a substrate, said array comprising opposed common electrodes having bodies with branches extending toward each other in interdigitating relationship, and additional electrodes intermediate said branches.

7. The structure claimed in claim 6 including a plurality of photocell arrays within said space, and electrical interconnections between said photocell arrays also contained within said space.

8. In a photoelectric musical instrument a stationary voicing disc and a rotating pitch disc on one side thereof, a base structure on the other side of said voicing disc, said voicing disc having a central perforation, said pitch disc having a spindle, a bearing for said spindle located in a space between said voicing disc and said base structure and attached to at least one of said two last mentioned elements, a housing surmounting said voicing disc and enclosing said pitch disc, a light source and reflector in connection with said housing, means for driving said pitch disc, and a plurality of photocell arrays supported by said base structure in proximity to said voicing disc.

9. The structure claimed in claim 8 including an upper bearing for said spindle within said housing.

10. The structure claimed in claim 8 wherein the means for driving said pitch disc is a driven friction wheel engaging a marginal portion thereof, wherein there is an upper bearing for said spindle within said housing and means acting on said upper bearing for biasing said pitch disc against said friction wheel.

11. The structure claimed in claim 10 including an armature member attached to said pitch disc and characterized by teeth, and movable magnetic means within said housing which can be approached to said armature to cause a periodic variation in the speed of said pitch disc at a sub-audio rate.

12. The structure claimed in claim 11 wherein said base structure is a plate having its marginal portion sealed to the said voicing disc and providing a space within which photocell arrays may be mounted intermediate said plate and voicing disc, and including means for desiccating the said space.

13. In a photocell array structure, an elongated substrate, a pair of common electrodes thereon having bodies extending in general parallelism and branches extending toward each other in spaced parallel interdigitating relationship, intermediate electrode members lying in spaced parallel relationship between adjacent ones of said branches, said intermediate electrodes having enlarged contacting portions lying respectively between the bodies of said common electrodes and end portions of said branches, and a coating of photosensitive substance covering portions of said branches and intermediate electrodes but spaced inwardly from the ends thereof.

14. The structure claimed in claim 13 including clip means for making contact with the said common electrodes and the contacting portions of said intermediate electrodes, said clip means being attached to insulative supports, and means for mounting the said photocell array, the said clip means and insulative supports being themselves supported by the photocell array.

15. The structure claimed in claim 13 wherein said interdigitating branches and parallel portions of intermediate electrodes lie upon one side of said substrate, and extend about the edges thereof, the bodies of said common electrodes and the connector portions of said intermediate electrodes lying upon the opposite side of said substrate.

16. The structure claimed in claim 13 including a cover glass cemented to the said photocell array so as to cover portions at least of said branches and intermediate electrodes together with a coating of photosensitive substance interconnecting said elements, while exposing the bodies of said common electrodes and the connecting portions of said intermediate electrodes for electrical connection.

17. The structure claimed in claim 15 including means for mounting and locating the said photocell array, and means including spring fingers for making contact with said bodies of said common electrodes and the said contacting areas of the said intermediate electrodes, said spring fingers serving to urge said photocell array in one direction.

18. The structure claimed in claim 17 including a cover glass cemented to the active side of said photocell array, and having means for locating the said photocell array accurately with respect to another element, said means comprising a rim formed on said cover glass, said rim having projecting ears, whereby the location of said photocell array may be accomplished by locating said ears in notches in blocks on said other element.

19. In a photoelectric musical instrument a voice disc, a base structure interspaced from said voice disc, at least one photocell array mounted upon said base structure, said photocell array comprising an elongated transparent substrate, electrode elements on one side of said substrate, said elements being interconnected by a layer of photoelectric substance, flange elements on the edges of said substrate, locating means on said base structure to which said flange elements can be attached, said flange elements supporting said photocell array with the side thereof bearing the said electrode structures located towards said base structure, and contacting means for said electrodes located between said base structure and said photocell array and comprising an insulative support attached to said base structure, and spring fingers mounted in said insulative structure and bearing against said electrodes.

20. In a photocell array an elongated substate, electrode structures mounted upon said substrate inwardly of the margins thereof, electrically conductive elements ex-

tending through said substrate, a metal rim formed on the marginal edges of said substrate, a cover member of transparent substance having a marginal rim formed thereon, the said rims being of solderable substance, and a soldered joint between the two said rims whereby to form a sealed construction, in combination with spring elements for making electrical contact with the elements passing through said substrate.

21. The structure claimed in claim **20** including means for locating said structure accurately with respect to another element comprising a rim formed on the outer side of said cover, said rim having ears, said ears being capable of entering notches in blocks accurately located with respect to said other element.

22. In a photoelectric instrument a pitch disc having a plurality of pitch tracks thereon, a voice disc having a plurality of voicing tracks thereon arranged in substantially radial groups, each voicing track having at least two wave form bands thereon out of phase with each other, a photocell array in operative relationship with said voicing tracks, said photocell array including a three element photocell for each of the said voicing tracks, the said photocell being so related to its particular voicing track that when an intermediate one of the three elements is polarized, signals of opposite phase will be picked up by the other two elements, means for polarizing the first mentioned element, connections between the said other electrodes and a balanced amplifier, and means in the last mentioned connections for avoiding transients.

23. In a photoelectric musical instrument having a stationary disc with a light-impulse modifying means thereon, and utilizing photocell arrays of the open type, a sealed chamber comprising a base plate in proximity to said disc, peripheral sealing means between marginal portions of said plate and disc, there being a space between said plate and disc within the confines of said marginal portions, and at least one photocell array mounted on said plate within said space, said photocell array comprising an elongated substrate, a pair of common electrodes thereon having bodies extending in general parallelism and branches extending toward each other in spaced parallel interdigitating relationship, intermediate electrode members lying in spaced parallel relationship between adjacent ones of said branches, said intermediate electrodes having enlarged contacting portions lying respectively between the bodies of said common electrode and end portions of said branches, and a coating of photosensitive substance covering portions of said branches and intermediate electrodes but spaced inwardly from the ends thereof.

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