

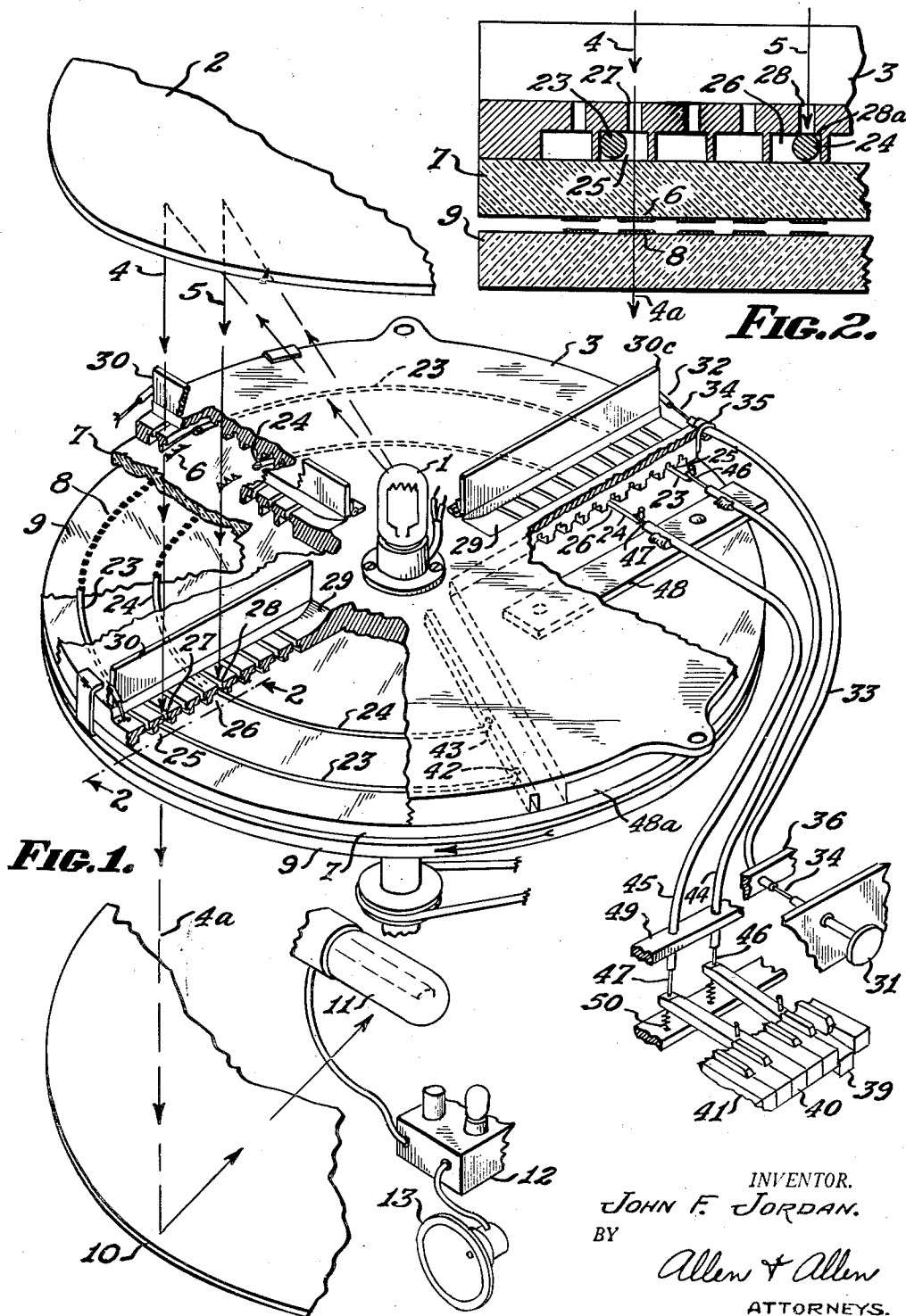
May 9, 1950

J. F. JORDAN
SHUTTER MECHANISM

2,506,599

Filed Aug. 24, 1948

3 Sheets-Sheet 1



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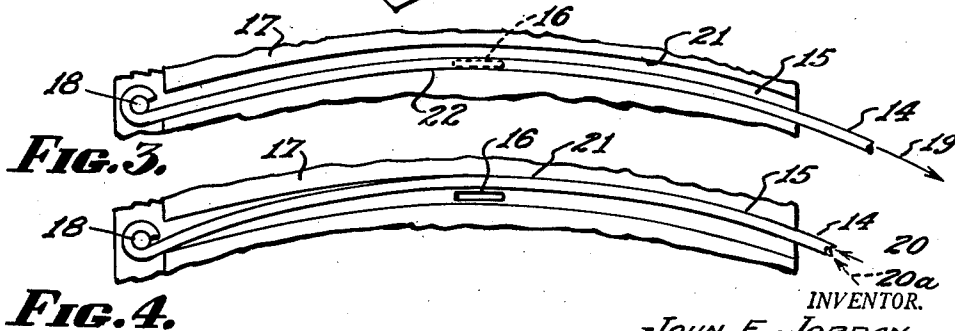
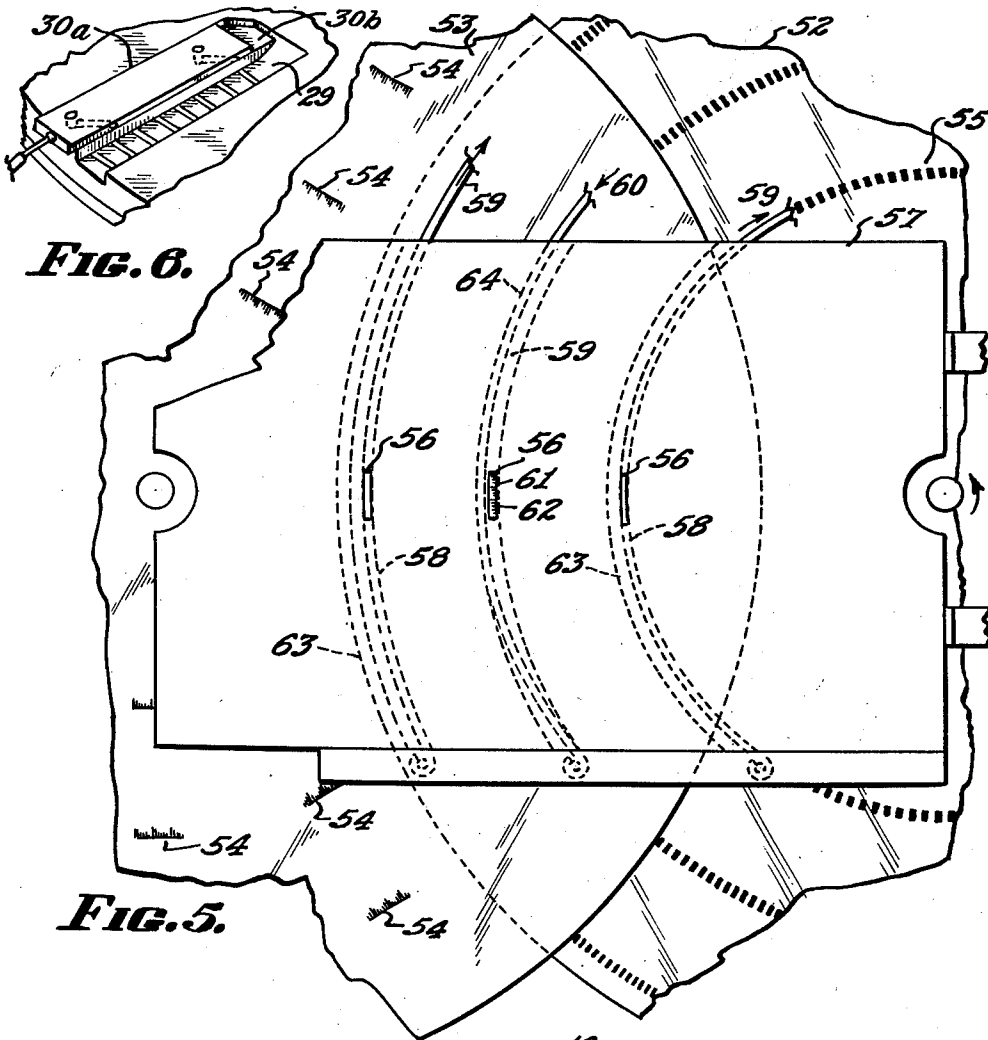
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3 Sheets-Sheet 2



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3 Sheets-Sheet 3

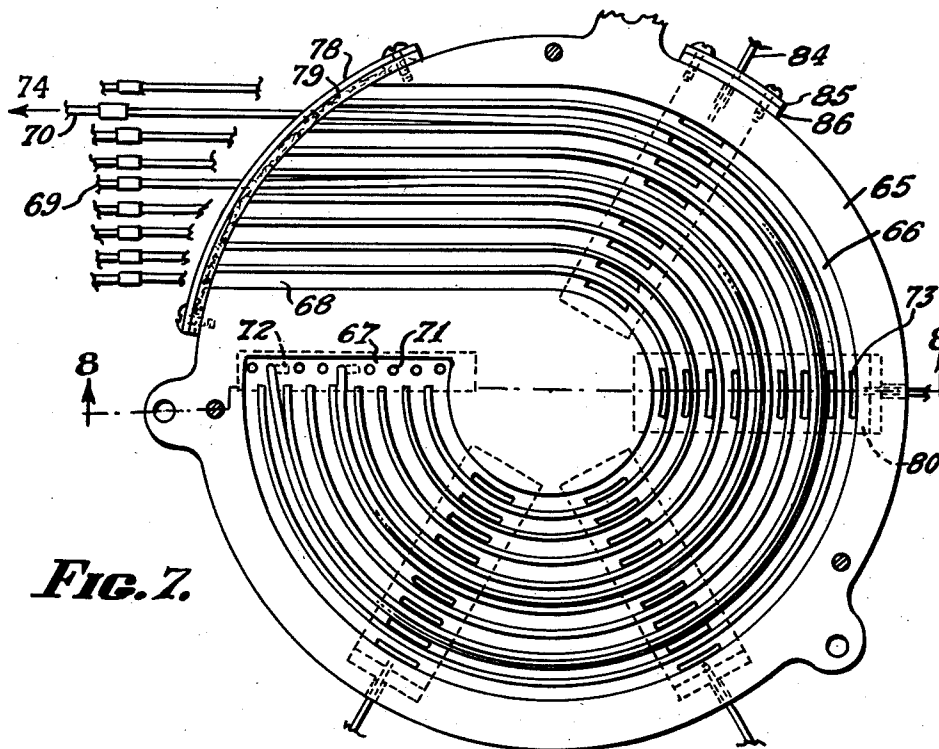


FIG. 7.

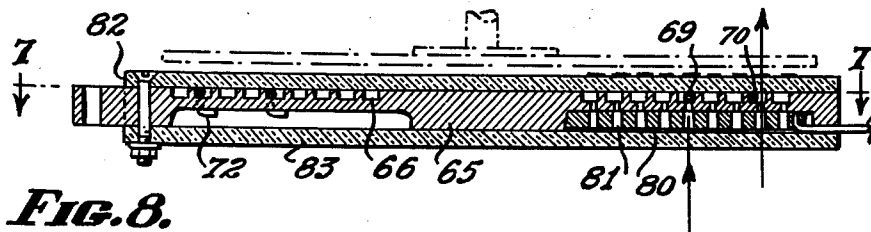


FIG. 8.

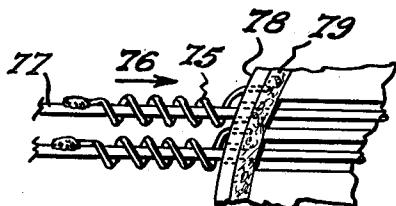


FIG. 10.



FIG. 9.

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UNITED STATES PATENT OFFICE

2,506,599

SHUTTER MECHANISM

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Application August 24, 1948, Serial No. 45,897

25 Claims. (Cl. 84—1.18)

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My invention relates generally to radiant energy shutter mechanisms and particularly to shutter mechanisms such as may be employed in keyboard photoelectric musical instruments of the type wherein at least one beam of light is modified or interrupted to produce in a photocell circuit electric pulsations which are amplified and converted into musical tones by an electro-acoustic translating system.

One of the main problems in producing a practical photoelectric musical instrument is that of reducing its elements to a reasonable size so that a compact structure may be provided. In a copending U. S. patent application Serial No. 39,674, in the name of Armand F. Knoblauch, filed July 20, 1948 and entitled Musical instruments employing continuously moving members, provision is made for the representation on a small rotating disc of a whole gamut of musical tones. On such a disc adjacent concentric rows of transparent radial pitch determining light slots may be as close as $\frac{1}{16}$ " between centers. It is an obvious requirement that shutters for exposing one or more slots in each concentric row be extremely small. In addition to the size limitation, a further problem is presented by the desirability that individual note shutters operate radially rather than circumferentially in order to avoid frequency modulation effects during the opening and closing of individual shutters. Also, if two or more tone colors are to be produced simultaneously in a photoelectric musical instrument from beams of light interrupted by a single pitch disc, a plurality of series of wave form representations must be provided upon a timbre device associated with the pitch disc, thus requiring an individual shutter for each tone color at each frequency or musical pitch. For example, if five different tone colors are to be provided for all the tones in a gamut of six octaves, three-hundred sixty ($5 \times 6 \times 12$) apertures must be exposable by as many shutters.

In view of this, a primary object of my invention is to provide, in a relatively small space, a large number of radiant energy shutters which may be opened and closed radially.

Another object is to provide a single shutter mechanism by means of which a plurality of tone colors may be produced simultaneously in a photoelectric musical instrument having fewer pitch discs than the number of tone colors which are to be combined.

It is also my object to provide a single shutter system which will meet the requirements of a photoelectric musical instrument having more than one keyboard.

It is a further object to provide a substantially dust-proof shutter mechanism of the type provided in the above objects.

It is a further object of the invention to pro-

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vide a shutter mechanism in which the problem of effecting connections between the operating elements and the playing keys or other actuators is simplified.

It is a further object to provide a shutter mechanism which is simple in form and number of moving parts, which is inexpensive to construct, and which is positive in action and not liable to failure in use.

These and other objects which will be apparent to those skilled in the art upon reading these specifications, I accomplish by that construction and arrangement of parts, of which I shall now set forth exemplary embodiments. Reference is made to the drawings forming a part hereof, and wherein:

Figure 1 is a diagrammatic representation in perspective of an exemplary keyboard photoelectric musical instrument employing my invention;

Figure 2 is a partial sectional view taken along the line 2—2 of Figure 1;

Figures 3 and 4 show in plan a modified form of my structure and illustrate the basic principle of operation of a shutter mechanism according to my invention;

Figure 5 shows the modified form of my invention as applied to a photoelectric musical instrument;

Figure 6 is a perspective view of a modified form of tone color shutter such as may be employed with a structure generally like that shown in Figure 1.

Figure 7 is a horizontal sectional view, taken along the line 7—7 of Figure 8 and showing yet another modification of the shutter mechanism in accordance with my invention.

Figure 8 is a sectional view taken along the line 8—8 of Figure 7.

Figure 9 is a plan view of the tone-color shutter employed with the shutter mechanism of Figure 7.

Figure 10 is a detail view of return springs such as may be employed with the mechanism of Figure 7.

In Figure 1, I have shown in purely diagrammatic form the operating elements of a photoelectric device to which my invention may be applied. Proportions are exaggerated in order to clarify the construction and to illustrate its mode of operation, which I shall first describe in a general manner. Light from a source 1, such as an incandescent lamp, impinges upon a concave parabolic mirror 2 which reflects a large beam of parallel light rays having a direction perpendicular to a shutter mechanism which is indicated generally at 3, and which will be described in detail hereinafter. Individual rays, such as 4 and 5, of the parallel light beam may either be allowed to pass through or will be stopped by the shutter mechanism 3, as indicated in Figure 1. If a ray 4 is allowed to pass through the shutter mecha-

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nism, it will pass through a wave form pattern such as that indicated at 6 on a stationary timbre disc 7 which lies immediately below the shutter mechanism 3. The individual beams are also broken up into moving light pencils by transparent slots 8 arranged in continuous rows upon the rotating pitch disc 9, so that these pencils of light effectively scan the wave-form patterns, all as is known in the art. A ray 4a, varying in accordance with a wave form pattern such as 6, is reflected from a second concave parabolic mirror 10 so as to impinge upon the plate of a photosensitive cell 11. Electrical pulsations produced in the photocell circuit are amplified in the usual manner at 12, and converted to sound in a loud speaker 13 or other suitable electroacoustic device. The particular arrangements of elements thus far described are illustrative only and are not limiting with respect to my invention.

I shall now refer to Figures 3 and 4 to explain one principle of operation of my invention. A flexible wire 14, which serves as a movable shutter element, reposes in an arcuate groove 15 and covers, in the position shown in Figure 3, an aperture 16 in a portion of a flat plate 17. The left end of the wire 14 is anchored or held in any suitable way. Diagrammatically, it is shown bent around a pin 18, which is fixed with respect to the plate 17, so as to prevent movement of the wire 14 along the groove 15. In Figure 3, a tangential (tensile) force, the direction of which is indicated by the arrow 19, causes the wire 14 to conform to a smaller radius as determined by the lower side of the groove 25. If the force indicated by the arrow 19 in Figure 3 is sufficient, the shutter wire 14 will be retained against the lower side 22 of the groove 15. In Figure 4, however, a tangential (compressive) force, indicated by the arrow 20, causes the wire 14 to conform to a longer radius as determined by the upper side 21 of the groove 15, thus moving radially to expose the aperture 16. Any suitable means may be employed to exert the tangential forces indicated by the arrows 19 and 20 of Figures 3 and 4 respectively. The specifically illustrated conditions of operation are not limiting. The point is that a pull or push exerted upon a wire or strand-like element in the direction of its axis can, by varying the curvature of the element, cause it to move sidewise in a groove in a supporting member whereby to cover or uncover a slot associated with the groove. It is not necessary that an exactly tangential force be applied to a shutter wire. I may apply a force in a direction such as that indicated by the arrow 20a of Figure 4, the requirement being that the force have a tangential component sufficient to flex a wire as required.

Referring back to Figure 1, I shall describe in detail an exemplary shutter mechanism. The shutter wires 23 and 24 correspond to the wire 14 of Figures 3 and 4, but they extend around longer arcs to serve more than one aperture at a time. The grooves 25 and 26 correspond to the groove 15 of Figures 3 and 4. Apertures corresponding to 16 in Figures 3 and 4 are indicated in Figure 1 at 27 and 28. These apertures are formed by the meeting of substantially radial recesses or grooves 29 in the upper side of the plate 3, with concentric deeper grooves 27 and 28 disposed in the bottom of the concentric main grooves 25 and 26. A plurality of recesses similar to 29 may be disposed substantially radially around the plate 3 and are aligned with groups of wave form patterns, each group comprising all the patterns, such as 6, corresponding to a given

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tone color. For the purposes of clarifying the description of the shutter, the wires 23 and 24, the grooves such as 25 and 26, and the apertures such as 27 and 28 have purposely been enlarged in proportion to certain other elements. Also, only two wires have been shown, although it is obvious that one will be necessary for each note in the range of the instrument on the particular pitch disc and voice disc.

It will now be apparent that the shutter plate 3 can be readily and inexpensively formed by milling or turning circumferential grooves of the required configuration in one side of a plate, and cutting radial grooves in the other side. Or if desired a mold may be made by similar operations and shutter plates formed by die casting, plastic molding and the like.

Figure 2, an enlarged sectional view 2—2 of Figure 1, illustrates the physical relationship between wires 23 and 24 and associated parts in open and closed positions, respectively. Wire 23 is shown permitting the beam 4 to pass through to the timbre plate 7 and pitch disc 9, as described above. Wire 24 is shown stopping the beam 5. A shoulder as at 28a in the groove 26 may be provided to prevent undesired light from passing through, should a wire as at 24 not conform exactly to the contour of the inner wall of a groove 26. In the embodiment shown, the timbre disc 7, mounted against the shutter plate 3 serves to retain the wires within the grooves.

Tone color or timbre shutter doors as at 30 in Figure 1 may be hinged to the shutter plate 3 adjacent the radial grooves 29, or may be slidably engaged thereto as shown in Figure 6 at 30a, an additional recess 30b permitting the door 30a to be flush-mounted and to move to cover or uncover the groove as desired. An advantage of the sliding construction is that it permits the use of a cover plate of glass or other transparent material for making the shutter mechanism essentially dust-proof. I may prefer, however, to use hinged shutters, enclosing the complete structure of Figure 1, with the exception of the keyboard, stops, amplification and output systems, in an appropriate dust-proof housing.

I may select a particular timbre shutter as at 30c by means of a stop tab 31 connected to an arm 32 extending from the shutter 30a, by means of a mechanical transmission cable 33, the moving element of which is indicated at 34, and which may be supported as at 35 and 36. The shutter wires 23 and 24 may be actuated by playing keys 39 and 40 forming a part of a keyboard indicated generally at 41. The fixed ends of shutter wires 23 and 24 are preferably pivotally joined with the plate 3 as indicated at 42 and 43, respectively. Tangential forces may be transmitted from the keys 39 and 40 to respective shutter wires 23 and 24 by transmission cables 44 and 45, respectively, whose respective moving elements are indicated at 46 and 47. The transmission cables 44 and 45 may be clamped as at 48 in a recess 48a in the shutter plate 3 and guided as at 49 to their respective keys. A coil spring as at 50, employed to retain a key 40 in its normal position, may also serve to retain a shutter wire 24 in a closed position as indicated in Figure 1, thus preventing a light beam from passing through the timbre disc 7 and pitch disc 9.

I do not wish to be limited to the structure illustrated in Figure 1, my invention having broader aspects than those indicated therein

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For instance, the timbre shutter 30 and the shutter wires as at 23 and 24 may be moved by suitable electromagnetic means controlled by electric switches actuated by stop tabs and playing keys, respectively. Also for retaining shutter wires such as 23 and 24 in a closed position, I may employ suitable springs connected directly to the free end of the wires or connected to the movable elements 46 and 47 of the transmission cables.

Further, I may employ my invention in a photoelectric instrument of the type disclosed by Edward M. Jones in U. S. Patent application No. 688,577, filed August 5, 1946, entitled "Photoelectric musical instruments" and now Patent No. 2,474,847, issued July 5, 1949. In this instrument only one tone color is produced at a time by one pitch disc and one timbre plate; but the instrument affords a mechanical simplicity, as can be seen by reference to Figure 5. In the Jones instrument a rotary pitch disc 52 cooperates with a rotatable timbre disc 53, mounted on a separate center, so that one overlaps the other. Wave form patterns such as 54 are scanned by moving rays of light, derived from a large beam through transparent slots of the pitch disc as at 55, arranged in endless concentric rows in numbers depending upon the pitch of the corresponding note to be produced. Since only one set of wave form patterns can be scanned at a time by one disc, only one corresponding set of apertures such as 56 will be required in a shutter plate 57. Further, since only one set of apertures is employed, no recess such as that indicated at 29 in Figure 1 with its corresponding voice shutter is necessary. Referring to Figure 5, the shutter wires 58 resposing in grooves 63 in a shutter plate 57, are shown in a closed position in which the apertures 56 are covered, arrows 59 indicating the direction of the tangential force required to retain the wires 58 in said closed position. The wire 59 has been displaced in its groove 64 by a tangential force 60 so as to expose the aperture 61, thus permitting rays of light produced by slots in the pitch disc 52 to scan the wave form pattern 62, aligned with the aperture 61. As in the case of the grooves 25 and 26 of Figure 1, the grooves 63 and 64 of Figure 5 have a small shoulder at the right to prevent stray light from passing through corresponding apertures should its shutter wire not conform exactly to the contour of the inner wall of its respective groove, against which the wires are retained in their closed position. The shutter wires 58 and 59 in the instrument described in part in Figure 5 may be actuated by any suitable means such as those described with reference to Figure 1 described above.

An additional modified form which my invention may assume is illustrated in Figures 7 and 8, certain details being shown in Figures 9 and 10. In this embodiment a shutter plate 65 is provided with a series of concentric grooves such as 66, terminating at one end in a common recess 67 and extending at the other end into non-concentric parallelism as at 68, so that the grooves intersect the edge of the plate and form exit paths for shutter wires such as 69 and 70. These wires have ends fixed with respect to the plate 65 by virtue of their engagement with holes such as 71 located in the recess 67, the ends of the wires being bent as at 72 so as to prevent disengagement therefrom. As illustrated in Figures 7 and 8 a shutter wire 69 may normally lie against the outer wall of its respective corresponding groove

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such as 66, thereby covering the apertures such as 73 in that groove. This can be accomplished by employing resilient wires and initially preforming the shutter wire to a radius substantially greater than that of its respective groove. A force 74 exerted on wire 70 by suitable means in connection with a playing key, acts to bring the wire 70 into contact with the inner wall of its respective groove, thereby exposing its respective aperture. If I do not wish to depend on the initial stress in the shutter wires to return them to their closed positions with reference to their respective apertures, I may employ a coil spring as indicated at 75 in Figure 10, normally exerting a pull indicated by the arrow 76 upon a shutter wire 77. The outer end of the spring 75 may be soldered to a shutter wire 77, the inner end engaging a hole in the curved strap 78, which is perforated for the passage of the several shutter wires and serves to hold in place a strip of suitable fibrous material 79, the purpose of the latter being to contribute to a dust-tight construction hereinafter described.

An advantage of this construction is that the shutters are self-closing, and may be opened by a simple pull on the shutter wires, eliminating the necessity of sheaths on the transmission cables.

I may provide tone color shutters such as illustrated at 80 in Figures 7, 8 and 9 in cooperation with the shutter plate 65. Openings 81 are arranged in a shutter 80 to be aligned with respective apertures in the shutter plate 65 when the shutter 80 is in its open position (inner position with respect to the plate 65). Suitable actuating means in connection with stop tabs may be employed to open and close the tone color shutters 80. The above mentioned dust-tight construction for the shutter plate 65 is accomplished by the enclosure of all exposed moving parts. The tone color plate 82 covers the grooved side of the plate 65 while a transparent plate 83 serves to enclose the tone color shutter side of the plate 65. Openings for the shutter wires such as 69 and 70 are enclosed by the above mentioned members 78 and 79 while the openings provided for the tone color shutter actuating rods 84 are protected by parts 85 and 86, similar in nature respectively to the members 78 and 79.

It is obvious that any of the forms of the shutter mechanism described herein can be made very compact. If the concentric rows of pitch determining slots are $\frac{1}{8}$ " between centers, the following exemplary set of dimensions may apply to the structure illustrated in Figures 1 and 2:

	Inches
Diameter of the shutter wire 23	.025
Width of the groove 25	.052
Depth of groove 25	.026
Width of cut out or aperture 28	.015
Depth of cut out 28	.030
Width of shoulder in a groove	.006
Dimension between centers of adjacent cut outs	$\frac{1}{8}$
Thickness of shutter plate 3	$\frac{1}{4}$

The width of a recess such as 29 is determined by the number of wave form patterns to be scanned, and is preferably sufficiently great to accommodate an integral number of cycles. It need not be accurately dimensioned to a given number of cycles, however, since any excess of wave form pattern may be blacked out on the timbre plate.

Shutter mechanisms in accordance with my in-

vention can be modified to accommodate more than one keyboard by dividing a shutter plate, such as that indicated at 3 in Figure 1, into as many sectors as there are keyboards. In this case, the arcs covered by the shutter wires are restricted to the sectors associated with the respective keyboards and are actuated by suitable means as described above, in connection with keys in the respective keyboards. In a similar manner timbre shutters controlling the tone colors of the several keyboards are limited to the sectors designated for the respective keyboards.

Suitable couplers of the types known in the reed and pipe organ art may be employed with my invention for producing various desired effects, such as octave coupling, and for playing notes in various registers, such as 16 foot, 8 foot and 4 foot.

Modifications may be made in my invention without departing from the spirit of it. Having outlined the principles of the invention in certain exemplary embodiments, what I claim as new and desire to secure by Letters Patent is:

1. A shutter plate having a plurality of arcuate grooves formed in one face thereof, and having deeper grooves narrower than said arcuate grooves extending inwardly from the bottoms of said first mentioned grooves, the opposite face of said plate having a recess transverse said grooves and of a depth to intersect the bottoms of said deeper grooves whereby to form apertures in said plate.

2. A shutter plate having a plurality of arcuate grooves formed in one face thereof, and having deeper grooves narrower than said arcuate grooves extending inwardly from the bottoms of said first mentioned grooves, the opposite face of said plate having a recess transverse said grooves and of a depth to intersect the bottoms of said deeper grooves whereby to form apertures in said plate in combination with flexible strand-like shutter elements lying in said grooves for covering and uncovering said apertures selectively.

3. A shutter plate having a plurality of arcuate grooves formed in one face thereof, and having deeper grooves narrower than said arcuate grooves extending inwardly from the bottoms of said first mentioned grooves, the opposite face of said plate having a recess transverse said grooves and of a depth to intersect the bottoms of said deeper grooves whereby to form apertures in said plate, in combination with flexible strand-like shutter elements lying in said grooves for covering and uncovering said apertures selectively and a supplementary shutter in connection with said recess for opening and closing said apertures simultaneously.

4. A radiant energy shutter mechanism comprising in combination, a base plate having in one face an elongated, arcuate groove and in its other face an aperture extending into one radial half of said groove, said aperture having a dimension transverse said groove of not more than half the width of the groove, and a shutter wire disposed in said groove normally against one side thereof, so as to cover said aperture, said wire having a diameter not greater than half the width of said groove, nor less than said transverse dimension of said aperture, said wire having one end fixed against substantial longitudinal movement with respect to said plate and its other end responsive to longitudinal movement by a force having a longitudinal component to move said wire transversely of said groove into con-

tact with the other side of said groove so as to uncover said aperture.

5. A radiant energy shutter mechanism comprising in combination, a base plate having in one face an elongated, arcuate groove and in its other face an aperture extending into one radial half of said groove, said aperture having a dimension transverse said groove of not more than half the width of said groove, a shutter wire disposed in said groove normally against one side thereof so as to cover said aperture, said wire having a diameter of not greater than half of the width of said groove nor less than said transverse dimension of said aperture, said wire having one end fixed against substantial longitudinal movement with respect to said plate and its other end responsive to longitudinal movement, and actuating means for exerting upon said other end of said wire a force having a longitudinal component to move said wire transversely of said groove into contact with the other side of said groove so as to cover said aperture.

6. The combination claimed in claim 5, including spring means retaining said wire in said covering position with respect to said aperture.

7. A radiant energy shutter mechanism comprising in combination, a base plate having an aperture therein and a narrow arcuate groove in one side of said plate, said aperture opening into one radial half of said groove and extending transversely of said groove almost to one side of said groove so as to form a shoulder, a shutter wire reposing in said groove and normally covering said aperture, said wire having a diameter of not less than the aperture dimension which is transverse said groove, said wire having an end fixed against substantial longitudinal movement with respect to said plate and an end free to move transversely in said groove, and force applying mechanism affixed to the free end of said wire, whereby a tangential component of force in one direction moves said wire so as to cover said aperture and a tangential component of force in the opposite direction moves said wire so as to uncover said aperture.

8. A radiant energy shutter mechanism comprising in combination, a base plate having an aperture therein and having a narrow arcuate groove in one side of said plate, said aperture opening into one radial half of said groove and extending transversely of said groove almost to one side thereof so as to form a shoulder, a flexible shutter wire reposing in said groove, said wire having a diameter of not less than the aperture dimension which is transverse said groove, said wire having an end fixed against substantial longitudinal movement with respect to said plate and an end free to move in said groove, force applying mechanism in connection with the free end of said wire, and spring means in connection with said mechanism, said wire being forced against one side of said groove by said spring means to cover said aperture until said mechanism is caused to flex said wire against the other side of said groove to uncover said aperture.

9. In a musical instrument including a light source, a pitch disc having concentric rows of pitch tracks, a timbre plate having a group of wave form patterns thereon respectively aligned with said pitch tracks, a photocell and playing keys, a shutter mechanism comprising in combination a shutter plate having in one face a recess of substantially rectangular cross-section aligned with said group of wave form patterns, said shutter plate having in its other face a series of nar-

row grooves aligned at least in part with respective rows of said pitch tracks, said shutter plate having also a series of cutouts in respective grooves, said cutouts extending through said shutter plate from one radial half of said grooves at least to the bottom of said recess, said cutouts being respectively aligned with said rows of pitch tracks, shutter wires disposed respectively in said grooves so as normally to cover said cutouts, said wires being of a diameter at least equal to the radial dimension of said cutouts, each said wire having an end fixed against substantial longitudinal movement with respect to said shutter plate and an end free to move in its respective groove, and force transmission means connecting said playing keys to respective free ends of said shutter wires, whereby said wires prevent the passage of light from said source through respective cutouts to said photocell except when a key is depressed.

10. In a musical instrument including a light source, a pitch disc having concentric rows of pitch tracks, a timbre plate having a group of wave form patterns thereon aligned with said tracks, an optical system, a photocell and playing keys, a shutter mechanism comprising in combination a shutter plate having in one face a recess of substantially rectangular cross-section aligned with said group of wave form patterns, said shutter plate having in its other face a series of narrow grooves aligned at least in part with respective rows of said pitch tracks, said shutter plate having also a series of cutouts in respective grooves, said cutouts extending through said shutter plate from one radial half of said grooves at least to the bottom of said recess, said cutouts being respectively aligned with said rows of pitch tracks, shutter wires disposed respectively in said grooves so as normally to cover said cutouts, said wires being of a diameter at least equal to the width of said cutouts, each of said wires having an end fixed against substantial longitudinal movement with respect to said plate and an end free to move in its respective groove, and mechanical force transmission cables connecting said playing keys to respective free ends of said shutter wires, whereby said wires prevent the passage of light from said source through respective cutouts to said photocell except when a key is depressed.

11. In a musical instrument including a light source, a pitch disc having concentric rows of pitch tracks, a timbre plate having a group of wave form patterns thereon aligned with said tracks, a light source, a photocell and playing keys, a shutter mechanism comprising in combination a shutter plate having in one face a recess of substantially rectangular cross-section aligned with said group of wave form patterns, said shutter plate having in its other face a series of narrow grooves of substantially rectangular cross-section aligned at least in part with respective rows of said pitch tracks, said shutter plate having also a series of cutouts in respective grooves, said cutouts extending through said shutter plate from one radial half of said grooves at least to the bottom of said recess and extending transversely of said grooves almost to one side thereof to form shoulders therein, said cutouts being respectively aligned with said rows of pitch tracks, arcuate shutter wires disposed respectively in said grooves, said wires being of a diameter at least equal to the width of said cutouts, each said wire having an end fixed against substantial longitudinal movement with respect to said shutter

plate and a portion free to move in its respective groove, mechanical force transmission cables connecting said playing keys to respective free ends of said shutter wires, and spring members in connection with respective shutter wires, whereby said wires prevent the passage of light from said source through respective cutouts to said photocell except when a key is depressed.

12. The combination claimed in claim 9, including a timbre shutter having covering and uncovering positions with respect to said recess.

13. The combination claimed in claim 12, wherein said timbre shutter is flush mounted with respect to said shutter plate and is slidably engaged therewith, and including a transparent plate covering the recessed face of said plate.

14. The combination claimed in claim 12, including a stop tab and a mechanical force transmission system connecting said stop tab with said timbre shutter.

15. In a musical instrument including a light source, a pitch disc having concentric rows of pitch tracks, a timbre plate having a group of wave form patterns thereon aligned with said tracks, a light source, a photocell and playing keys, a shutter mechanism comprising in combination a shutter plate having in one face arcuate grooves aligned at least in part with respective rows of pitch tracks, said plate having apertures therein opening into one radial half of each of the respective grooves and extending almost to one side of said grooves so as to form shoulders therein, shutter wires reposing in respective grooves so as normally to cover said apertures, each of said wires having a diameter of not less than the aperture dimension which is transverse said grooves, said wires having an end fixed against substantial longitudinal movement with respect to said plate and an end free to move in its respective groove, and mechanical force transmission means connecting said playing keys to respective free ends of said shutter wires, whereby the shutter wires prevent the passage of light from said source through respective apertures except when a playing key is depressed.

16. In a musical instrument including a light source, a pitch disc having concentric rows of pitch tracks, a timbre plate having a group of wave form patterns thereon aligned with said tracks, a light source, a photocell and playing keys, a shutter mechanism comprising in combination a shutter plate having in one face arcuate grooves of substantially rectangular cross-section aligned at least in part with respective rows of said pitch tracks, said plate having apertures therein opening into one radial half of respective grooves and extending transversely of said grooves almost to one side of said grooves so as to form shoulders therein, shutter wires reposing in respective grooves so as normally to cover said apertures, each of said wires having a diameter of not less than the aperture dimension which is transverse said grooves, said wires having an end fixed against substantial longitudinal movement with respect to said plate and a portion free to move in its respective groove, and mechanical force transmission cables connecting said playing keys to respective free ends of said shutter wires, whereby said shutter wires prevent the passage of light from said source through said apertures except when a playing key is depressed.

17. In a musical instrument including a light source, a pitch disc having concentric rows of pitch tracks, a timbre plate having a group of

wave form patterns thereon aligned with said tracks, a light source, a photocell and playing keys, a shutter mechanism comprising in combination a shutter plate having in one face arcuate grooves of substantially rectangular cross-section aligned at least in part with respective rows of said pitch tracks, said plate having apertures therein opening into one radial half of each of the respective grooves and extending transversely of said grooves almost to one side of said grooves so as to form shoulders therein, shutter wires reposing in respective grooves so as normally to cover said apertures, each of said wires having a diameter of not less than the aperture dimension which is transverse said grooves, said wires having an end fixed against substantial longitudinal movement with respect to said shutter plate and a portion free to move in its respective groove, mechanical force transmission cables connecting said playing keys to respective free ends of said shutter wires, and spring members in connection with respective shutter wires, whereby said shutter wires prevent the passage of light from said source through said apertures except when a playing key is depressed.

18. In a shutter mechanism, a member having an elongated aperture therein, a flexible strand-like element extending in the direction of the elongation of said aperture, having a cross-sectional dimension greater than the width of said aperture, having an end beyond one end of the aperture anchored to the member against longitudinal movement, guiding means for longitudinal movement of the strand beyond the other end of said aperture, and means for applying a longitudinal force to said strand whereby to cause said strand to flex laterally to cover and uncover said aperture.

19. In a shutter mechanism, a member having an arcuate groove in it and an aperture extending through said member and opening into the bottom of said groove, an arcuate strand-like element lying in said groove, said aperture being of lesser transverse dimension than the cross-sectional dimension of said strand-like element, and means for moving said strand-like element transversely of said groove to cover and uncover said aperture, opposite sides of said groove determining the covering and uncovering positions of said strand-like element.

20. The structure claimed in claim 19 wherein

said aperture is elongated in the direction of the extent of said groove and is arcuate in shape.

21. The structure claimed in claim 19 wherein said aperture is elongated in the direction of the extent of said groove and is arcuate in shape, and wherein said aperture terminates laterally a slight distance from that side of the groove which determines the covering position of said strand whereby to insure covering of said aperture by said strand.

22. The structure claimed in claim 21 wherein said groove has a plurality of said apertures simultaneously covered and uncovered by said strand.

23. The structure claimed in claim 21 wherein said strand is maintained in said groove by a covering plate of translucent substance juxtaposed to said member.

24. A shutter plate having a plurality of substantially arcuate grooves formed in one face thereof, the opposite face of said plate having a plurality of recesses traversing said grooves, said plate having apertures opening from said grooves into said recesses, flexible, strand-like shutter elements lying in said grooves and movable to cover and uncover said apertures, and other shutter elements associated with said recesses to cover and uncover a plurality of said apertures.

25. A shutter plate having a plurality of arcuate grooves formed in one face thereof, there being a plurality of apertures for each such groove opening through said plate into the bottoms of said grooves, said apertures being arranged in series extending transversely of said grooves, strand-like shutter elements lying in said grooves and movable to cover and uncover said apertures, and other shutter elements on the opposite side of said plate to cover and uncover a plurality of apertures in said several series.

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