Sept. 22, 1942. C. F. ELTON 2,296,777

TONOSCOPE

Filed Dec. 4, 1939 2 Sheets-Sheet 1

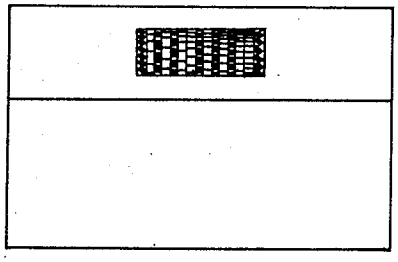

Fig. 1

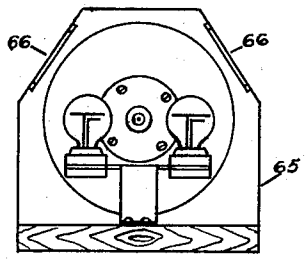

Fig. 2

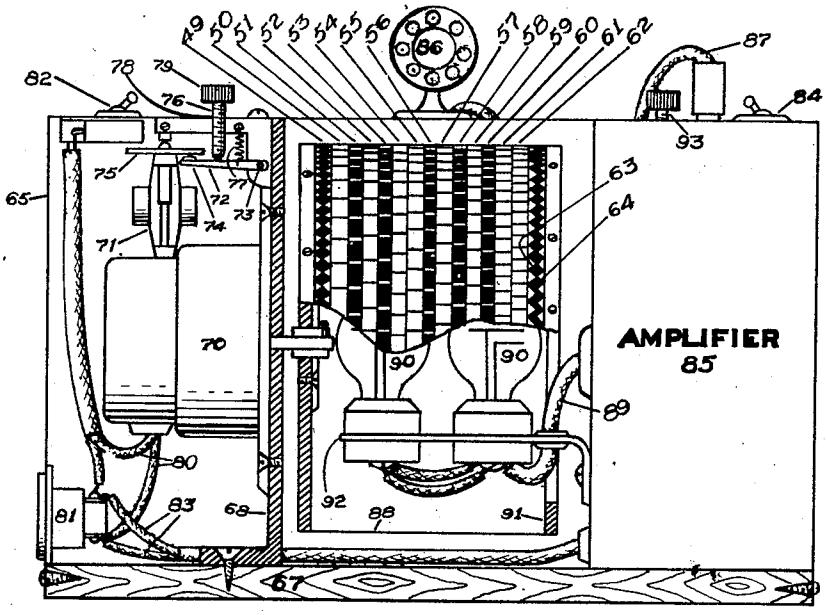

Fig. 3

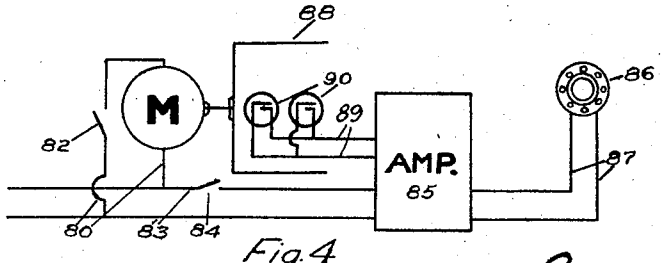

Fig. 4

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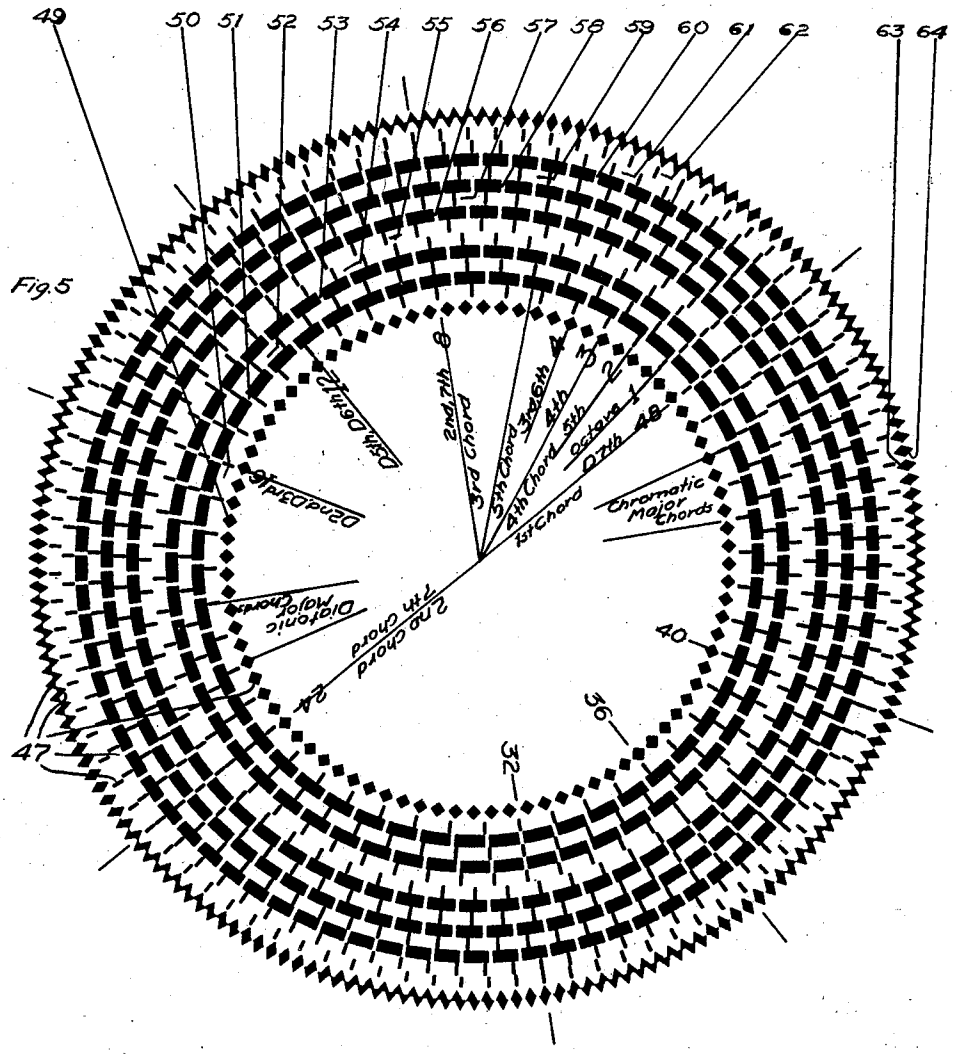
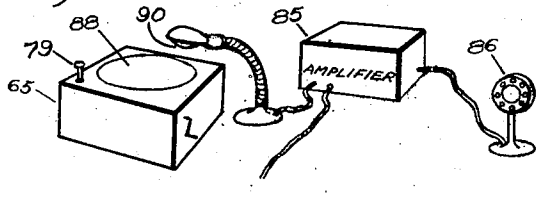


Fig. 6



Carey F. Elton

Patented Sept. 22, 1942 2,296,777

UNITED STATES PATENT OFFICE

2,296,777

TONOSCOPE

Carey F. Elton, Gadsden, Ala.

Application December 4, 1939, Serial No. 307,484

8 Claims. (Cl. 88—14)

My invention relates to tonoscopes or stroboscopic tuning devices and has as one of the principal objects thereof the provision of true standards of musical pitch relations in a device of the above described character, with means for indicating the similarity, relative to the true diatonic musical scale and correlative semitones thereof, of musical tones when sung, played on an instrument, through radio or from any sound source.

Another object of this invention is the provision of a graphic plan of the order of harmony, the chords of the scale, the frequency relations of the various tones of the musical scale and combinations thereof in the stroboscope design for simple demonstration of the basic principles of harmony.

Another object is the provision of a simple and practical standard of the Equal Temperament musical scale to facilitate setting the temperament of pianos, organs or other tempered instruments, and for tuning any number or kind of musical instruments to any desired pitch within their range; extremely low frequencies of pipes or strings, however indefinite to the sense of hearing, being easily indicated with precision with this device.

A further object of this invention is the provision of means for utilizing the sixty cycle frequency of ordinary lighting circuits as a standard for establishing a stroboscope frequency indicative of international pitch (A–440), by means of proportional frequencies; the several fixed ratios of frequencies on one stroboscope eliminating any possibility of variation between them.

A special object of my invention is the provision of a device of the above described character which is simple in construction, efficient in operation and economical in manufacture.

Other objects and advantages will appear in the following description, the appended claims and the annexed drawings.

In the drawings:

Figure 1 is a front elevation of my invention, less controls.

Figure 2 is a side elevation thereof, less controls and with amplifier removed.

Figure 3 is a front elevation in partial section on an enlarged scale showing the position of illuminators within the cylindrical stroboscope.

Figure 4 is a diagram of the electrical circuits employed in operating my device.

Figure 5 is a top plan view of my novel arrangement of frequency patterns for a music stroboscope in disk form, this form being graphically illustrative of harmony and pitch relations.

Figure 6 is a perspective view illustrating a modified form of my invention in which the stroboscope in disk form reflects the sound modified illumination.

In practicing my invention as illustrated in Figures 1 to 4 inclusive of the drawings, I employ a cabinet **65** equipped with observation windows **66**. Securely attached to the base **67** of the cabinet is a motor support **68** which extends vertically to the top of the cabinet where it is further secured and on which is mounted a motor **70**, the latter having connected thereto a speed governor **71** for governing the speed thereof.

The governor control is a brake lever **72** which is mounted in a bearing **73** which is formed in a part of the motor housing. The opposite end of brake lever **72** is provided with a brake **74**, the latter being adjustable in its engagement with the governor brake plate **75** by means of speed adjusting screw **76** disposed in engagement with brake lever **72** and acting against spring **77**. The adjusting screw **76** is threaded in a bearing **78** formed in a part of the motor housing, the outer end of said screw being provided with a finger-piece **79** whereby upon manual adjustment of the speed adjusting screw **76** the brake lever **72** is actuated to effect adjustment of the governor **71** and thus vary the speed of the motor as desired.

The motor **70** is connected by means of wiring **80** to the plug receptacle **81** which has terminals for connection to a source of electrical energy (not shown), the latter being of the 60 cycle 110 volt type of alternating current.

One of the wires **80** between the motor **70** and the receptacle **81** to which it is connected, has interposed therein a manually operated switch **82**, the latter being mounted in the top of the cabinet. The wires **83** from the receptacle **81** connect the amplifier **85** into the 110 volt A. C. circuit, the amplifier switch **84** being in said circuit.

The amplifier **85** is of ordinary construction, such as is used in radios or small public address systems, the output terminals **89** of which are connected to neon lamps **90** in this device instead of the usual loudspeaker. Said amplifier is connected to microphone **86** by means of wires **87** whereby sound vibrations picked up by said microphone are transmitted to the amplifier **85** for amplification and translation, through the medium of the neon lamps **90** into corresponding

light fluctuations, the purpose of all of which is hereinafter set forth.

Mounted on the shaft of the motor 70 is a rotary member 88 in the form of a hollow cylinder having one open end, the closed end being secured to the motor shaft. The curved wall of said cylinder is formed of transparent material, the open end of the cylinder being maintained in true form by an annular rib 91. Mounted upon a bracket 92 which extends within the open end of the transparent cylinder 88 are the neon lamps 90 referred to above. Said lamps are connected to amplifier output terminals as described and as illustrated in the drawings Figures 3 and 4.

In Figure 3, the stroboscope frequency patterns in zones 49 to 64 are printed in opaque ink on translucent paper, said paper being placed on the transparent cylindrical wall of the rotary member 88 in the manner of a closely fitting band about said wall, said frequency patterns being in the form of parallel, vertical, circular zones.

Zone 49 has divisions of distinctive design and is used only for establishing pitch at A–440. Zones 50 to 62 are the musical scale indicators arranged to resemble a piano keyboard; the zones of the natural tones being distinguished by translucence, the sharps by opacity. The frequency patterns of zones 63 and 64 have divisions of another distinctive design and are used only for setting the temperament of tempered musical instruments.

The sixty cycle content of the amplifier output (called A. C. hum and prevalent in all amplifiers of this type), is regulated by the volume control 93 on top of the cabinet. The said sixty cycle frequency will illuminate the stroboscope one hundred and twenty times per second. Zone 50 is divided into forty-eight equal parts. With the speed of the stroboscope adjusted to two and one half revolutions per second, the said adjustment being indicated by synchronism of zone 50 with the said sixty cycle illuminations at the rate of 120 per second, each of the said divisions of zone 50 will be successively illuminated in the exact position of its antecedent division, the entire zone thus appearing motionless.

With zone 50 synchronized with the sixty cycle illumination, the eighty-eight square-shaped divisions of zone 49 will also be moving at the rate of two and one half R. P. S., or 220 divisions per second relative to a given point, and the sound of "A" at 220 vibrations per second, picked up by microphone 86 and amplified to sufficient voltage to flash the lamps 90, will cause the zone 49 to appear stationary thus indicating syncronism of the sound with the standard. A sound of 221 V. P. S. would cause apparent recession of the zone at the rate of one division per second, or 219 V. P. S. would cause apparent procession at the same rate.

Only similarity (perfect or partial resemblance), of the sound to the standard is indicated. Extent and manner of variation are indicated by rate and direction of apparent motion; the standard tone being not otherwise indicated except when sounded, in which case it is indicated by apparent stability of the zone.

With the stroboscope speed maintained by the governor 71 at two and one half R. P. S. as indicated by synchronism of zone 50 with the 60 cycle frequency, the sound of "A" at 110 V. P. S. would cause illumination of zone 49 only 44 times during its cycle, or the "A" at 55 V. P. S. would successively illuminate each of the 88 divisions of the zone in the exact position of its fourth antecedent, or only 22 times during its cycle, thus all of the lower "A's" at this speed would exhibit the actual number of divisions, differing only in brilliancy. A–440 (the international standard of pitch) would illuminate the 88 divisions of zone 49 at 176 equally spaced points in the cycle thus causing the zone to appear as having 176 divisions instead of the actual 88. By doubling the speed of the stroboscope to 5 R. P. S. the sound of A–440 would cause zone 49 to appear motionless in its actual design.

To set the temperament of a piano, the "A" unisons and octaves would be tuned to zone 49 in the manner described. From this point the procedure would be the synchronization of zone 64 with the frequency of the last note tuned and then tuning the next lower semitone and its octaves to synchronism with zone 63 and so on down the scale, or reversely up the scale.

If the piano were tuned to the true musical scale it would be in perfect tune in one key and unequally out of tune in all other keys; whereas in the tempered scale no two of its tones are in tune in any key but all are more or less equally out of tune in all keys; the total variations of the true scale in the twelve keys being approximately one third greater than those of the tempered scale.

With the pitch of some instrument tuned to A–440 and zone 59 (the "la" or "A" zone) tuned to "A" of said instrument, the zones 50 to 62, Figure 3, would be indicative of the tones of the true scale in the key of "C," the keynote being indicated by zone 50. To practice singing or playing in different keys zone 50 is synchronized with the sound of the desired keynote, thus moving the entire ratio up or down as the case might be; the true scale being always indicated as in the key of "C" regardless of its actual pitch. When used as a tempered scale (changing keys without speed adjustment), the maximum deviation from true pitch is approximately one third greater than the maximum deviation of the tempered scale.

The ratio of the semitonic intervals of the true musical scale herein referred to was derived from the fact that three successive groups of intervals comprising the known and established diatonic scale are the 3rd, 4th and 5th harmonics of common successive fundamentals. With fundamentals regarded as 1st harmonics and the ratio of do, re, mi, being established at 8, 9, 10, the relation of the three parts of the true diatonic scale is as follows:

Fundamental or 1st harmonic	2nd harmonic	3rd harmonic	4th harmonic	5th harmonic	6th harmonic
8	16	24 do	32 fa	40 la	48 do.
9	18	27 re	36 so	45 ti	
10	20	30 mi	40 la		

The numbers 16, 17, 18, 19, 20, being the only sequent semitonic ratio compatible with 8, 9, 10, their arrangement in the order of their harmonics resolves the ratio of a chromatic musical scale of correlative diatonic and semitonic intervals.

Following is the arrangement of the said numbers as the fundamental sequence in harmonic

order with the harmonic regarded as the multiple:

Fundamental or 1st harmonic	2nd harmonic	3rd harmonic	4th harmonic	5th harmonic	6th harmonic
16	32	48 do	64 fa	80 la	96 do.
17	34	51 di	68 fi	85 li	
18	36	54 re	72 so	90 ti	
19	38	57 ri	76 si		
20	40	60 mi			

In the following numerical ratios the correlation of the diatonic and semitonic musical scales is evident:

Frequency	48	51	54	57	60	64	68	72	76	80	85	90
Established scale ratio					15—16					8——		9
Diatonic	8——		9——		—10	8——		9——		—10		15
New	16—17—18—19—20					16—17—18—19—20						30
Semitonic scale ratio					15—16					16—17—18		

In Figure 5 the complete cycle of the above musical scale frequencies is arranged in a form graphically illustrative of all of the frequency relations. It may be noted that all of the scale zones are in phase at **48**. Beginning at this point, the order of the relation (harmony), of the several zones is indicated by the order of the synchronism of their respective divisions with those of their keynote zone **50**, the said keynote divisions coinciding as follows: 1, 2, 3, 4, with the octave, 5th, 4th and 3rd intervals. **8**, with the 2nd and 7th, **12**, with the D5th and D6th, **16**, with D2nd and D3rd, and **48**, with D7th.

Although the note of the diminished 7th is least related to its keynote and only half as harmonious in this relation as the established 2nd and 7th chords of the scale, the frequence of its synchronism with other notes is comparable with other notes in such relation. It may be also noted that the semitonic relations of the herein described chromatic musical scale are exactly one half as harmonious as the established diatonic relations, the latter being in total synchronism on the 24th and the former on the 48th vibration of their keynote.

A modified form of my invention is illustrated in Figure 6, wherein the stroboscope illustrated in Figure 5 in the form of a disk is placed on the rotating member **68** and rotated by a governor-controlled motor within the cabinet **65**, its speed being adjustable by means of the governor adjusting screw **79** for synchronizing any desired zone of the stroboscope with the frequency of fluctuations of the lamp **90**, the said fluctuations being effected by means of the amplifier **85** and microphone **86**, said means being actuated by vibrations of a sound source, the indicative means of the zones coacting with said lamp during fluctuations thereof for indicating similarity of sounded tones to the standards established by the several zones on the stroboscope.

It is obvious that the herein described chromatic musical scale and this invention in which it is used are not confined to the uses herein described, as either may be utilized for any purpose for which it is adaptable. It is also to be understood that the invention is not limited to the specific construction as illustrated and described, as the same is only illustrative of the principles of its operation which are capable of extended application in advance forms, and that the invention comprehends all construction within the scope of the appended claims.

What I claim is:

1. In a tonoscope, a light, means to fluctuate the light responsive to the known constant frequency of an alternating electric current, other means to fluctuate said light responsive to sound waves, a rotary member illuminated by the fluctuations of said light, means to vary the speed of said rotary member, a series of stroboscopic indicia on the rotary member adapted when said member is rotating at a predetermined speed and is illuminated by said light fluctuating at said known constant frequency to appear motionless, and other series of stroboscopic indicia on the rotating member related to each other as are the tones of the musical scale whereby when said member is rotating at said predetermined speed and is illuminated by said light fluctuating responsive to selected sound waves said other series of indicia appear motionless when said sound waves fluctuate at frequencies corresponding thereto and indicate visually the relationship of the musical tones embodied in said sound waves.

2. In a tonoscope, a light, means to fluctuate the light at the known constant frequency of an alternating electric current, other means to fluctuate said light responsive to the frequency of sound waves, a rotating member illuminated by the fluctuations of said light, means to adjust the speed of said member, a series of stroboscopic indicia on the rotary member adapted when said member is rotating at a predetermined speed and is illuminated at said known frequency to appear stationary, another series of stroboscopic indicia on the rotating member adapted when said member is rotating at said predetermined speed and is illuminated responsive to a selected keynote of the musical scale to appear stationary, and a plurality of other series of stroboscopic indicia on the rotary member interrelated in accordance with the notes of the musical scale, whereby when said member is rotating at said predetermined speed and is illuminated by said light fluctuating responsive to other selected sound waves, said other series of indicia indicate visually the relationship of the notes of the musical scale embodied in said sound waves.

3. A tonoscope comprising a light, means to fluctuate the said light responsive to sound waves, a member mounted for rotation in position to be illuminated by the fluctuations of said light, means for rotating said member at a constant speed, zones of stroboscopic indicia on the rotating member differing in number in accordance with the frequency ratio of the notes of the chromatic musical scale and adapted when illuminated responsive to selected sounds and when the light is fluctuating in synchronism with said zones to appear stationary and thus indicate graphically the conformity of said selected sounds with the frequency ratio of the notes of the chromatic musical scale, and means to adjust the speed of said member to cause any of said zones selectively to synchronize with the fluctuations of said light responsive to a selected musical note.

4. A tonoscope comprising a light, means to fluctuate the light responsive to the vibrations of sound waves, a rotary stroboscopic member adapted to be illuminated by the light, means to rotate said stroboscopic member, a plurality of series of indicia on the stroboscopic member, the indicia of the individual series differing in number as do the vibrations of the notes of the musical scale, and means to adjust the speed of said stroboscopic member to cause the separate series

thereof to appear stationary responsive to the sounding of musical notes so related to each other in vibrations.

5. A tonoscope comprising a light, means to fluctuate the light at the known constant frequency of an alternating electric current, other means to fluctuate the light responsive to the vibrations of sound waves, a rotary stroboscopic member adapted to be illuminated by the light, means to adjust the speed of the stroboscopic member, a series of stroboscopic indicia on the member adapted to appear stationary when illuminated responsive to the fluctuations of the alternating current and when the speed of the rotary member has been adjusted to a predetermined value, said series also being adapted to appear stationary when rotating at said speed and when illuminated by the light fluctuating responsive to a selected keynote of the musical scale having a frequency which is a multiple of the fluctuations at said known frequency of said light, and other series of stroboscopic indicia on the member related in number to the first mentioned series as are the corresponding notes of the musical scale to the keynote, and each adapted to appear stationary when said member is rotating at said constant speed and is illuminated responsive to one of said musical notes.

6. A tonoscope comprising a light, means to fluctuate the light at the known constant frequency of an alternating electric current, other means to fluctuate the light responsive to the vibrations of sound waves, a rotary stroboscopic member adapted to be illuminated by the light, means to adjust the speed of the stroboscopic member, a series of stroboscopic indicia on the rotary member adapted to appear stationary when illuminated responsive to the fluctuations of the alternating current and when the speed of the rotary member has been adjusted to a predetermined value, said series of indicia also being adapted to appear stationary when rotating at said speed and when illuminated by said light fluctuating responsive to a selected keynote of the musical scale having a frequency which is a multiple of the fluctuations at said known frequency of said light, and other series of stroboscopic indicia on the rotary member related in number to the first mentioned series as are the corresponding notes of the diatonic musical scale and the correlated semitones thereof to the keynote, and each adapted to appear stationary when said rotary member is rotating at said constant speed and is illuminated responsive to one of said musical notes, and a pair of series of indicia side by side on said stroboscopic member related to each other in number as are the semitones of the tempered musical scale, each of said series being adapted to appear stationary when illuminated by a light fluctuating at the frequency of a selected musical note and when the speed of said stroboscopic member is adjusted for said series to synchronize with the fluctuations of the light.

7. A tonoscope comprising a light, means to fluctuate the light at a predetermined frequency which is a multiple of the frequency of a musical tone at standard pitch, other means to fluctuate the light responsive to sound waves, a rotating member in position to be illuminated by the fluctuations of said light and having thereon a plurality of series of stroboscopic indicia which are related to each other in number as are the frequencies of the notes of the true musical scale and its correlated semitones, other series of stroboscopic indicia on the rotating member which bear the same relation to each other in number as do the proximate semitones of the tempered musical scale, said other series being adapted when illuminated responsive to selected sound waves to indicate visually the conformity of said selected sound waves with standard tempered proximate semitones, and means to adjust the speed of the rotating member to synchronize the stroboscopic indicia thereon with the fluctuations of the light.

8. A device for tuning musical instruments in accordance with the true musical scale and the tempered scale selectively, comprising a light, means to fluctuate the light at a frequency of 120 fluctuations per second, other means to fluctuate the light responsive to sound waves, a rotating member in position to be illuminated by the fluctuations of said light, a series of stroboscopic indicia on said member adapted to appear stationary when illuminated at a frequency of 120 fluctuations per second and when said member is rotating at a predetermined speed, a second series of indicia on said rotating member which in number are equal to a multiple of 440 and adapted to appear motionless when illuminated responsive to a sound wave of "A" at international pitch and when said member is rotating at said predetermined speed, other series of stroboscopic indicia on the rotating member the individual patterns of which are so related to each other as to be graphically representative of the pure musical scale including the correlated semitones thereof and adapted when illuminated by the light fluctuating responsive to corresponding musical notes to appear motionless and visually indicate the relationship of said notes, and still other series of indicia on said rotating member the individual patterns of which are related to each other as are the proximate semitones of the tempered musical scale and adapted to appear motionless when illuminated by the light fluctuating responsive to sounds corresponding to proximate semitones of the tempered musical scale, and means to adjust the speed of the rotating member to synchronize the stroboscopic indicia thereon with the fluctuations of the light.

CAREY F. ELTON.