Feb. 5, 1935. I. EREMEEFF 1,990,024

SYNTHETIC ELECTRONIC MUSICAL INSTRUMENT

Filed Aug. 23, 1933 6 Sheets-Sheet 1

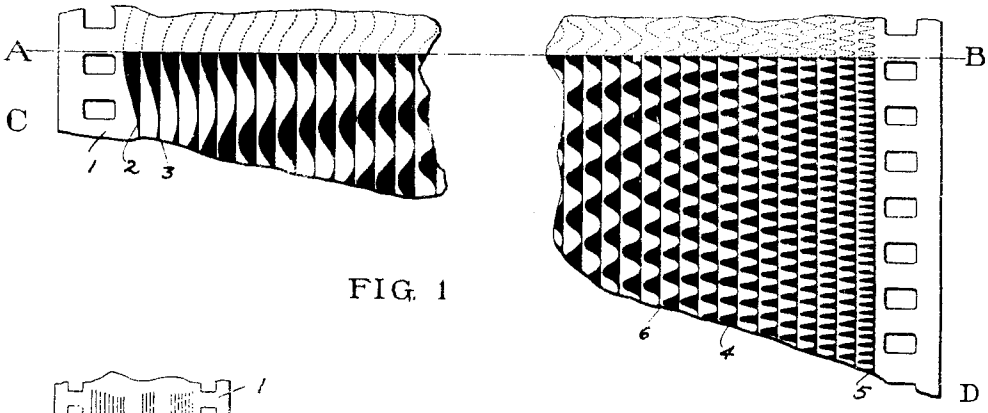
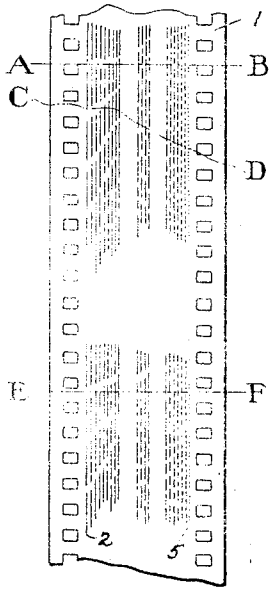


FIG. 1



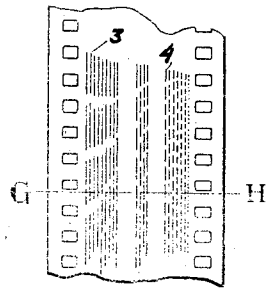


FIG. 2

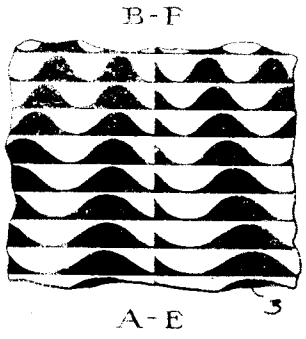


FIG. 3

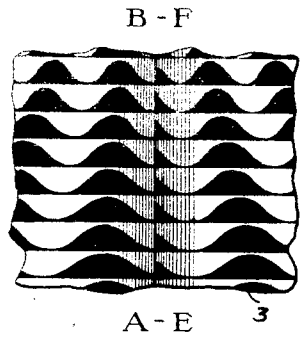


FIG. 4

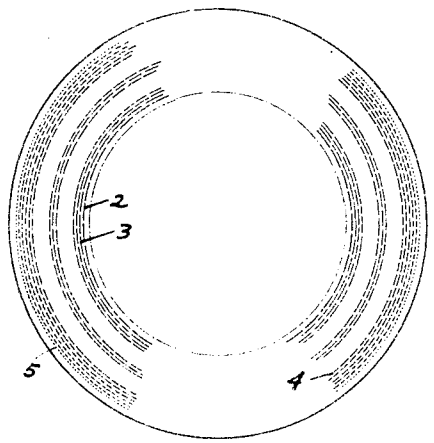


FIG. 5

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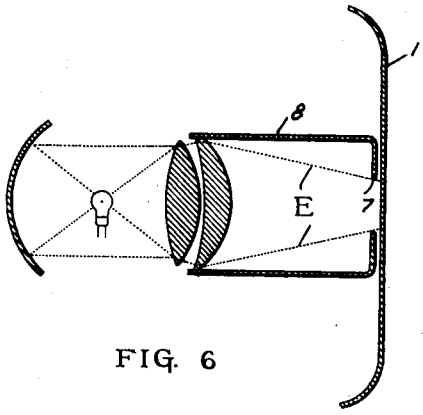


FIG. 6

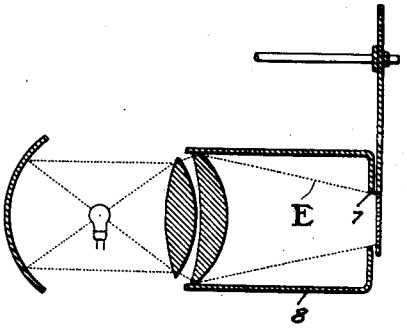


FIG. 7



FIG. 8

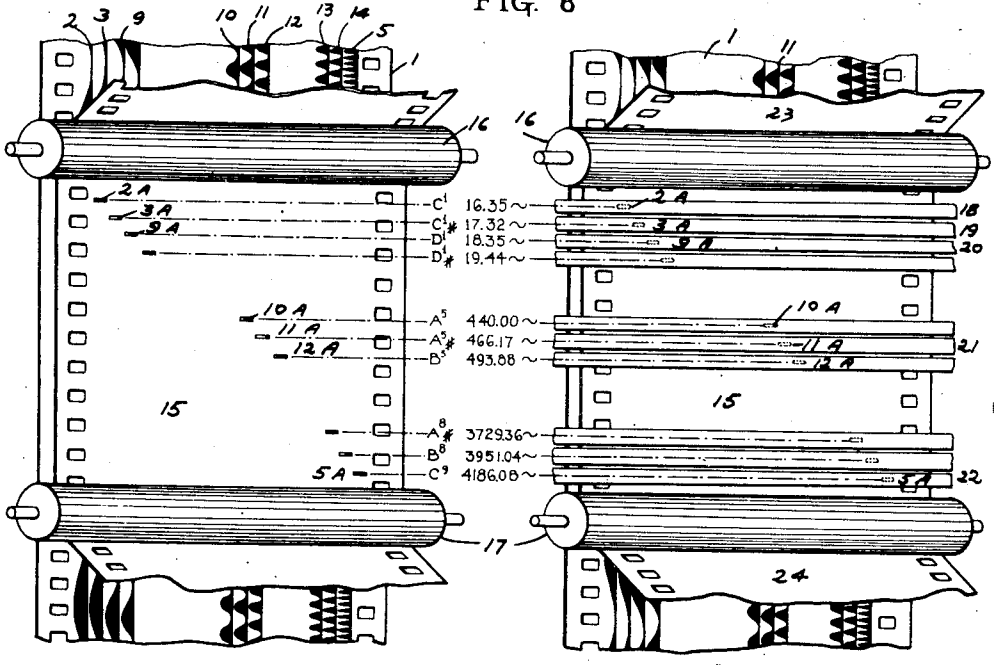


FIG. 9

FIG. 10

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SYNTHETIC ELECTRONIC MUSICAL INSTRUMENT

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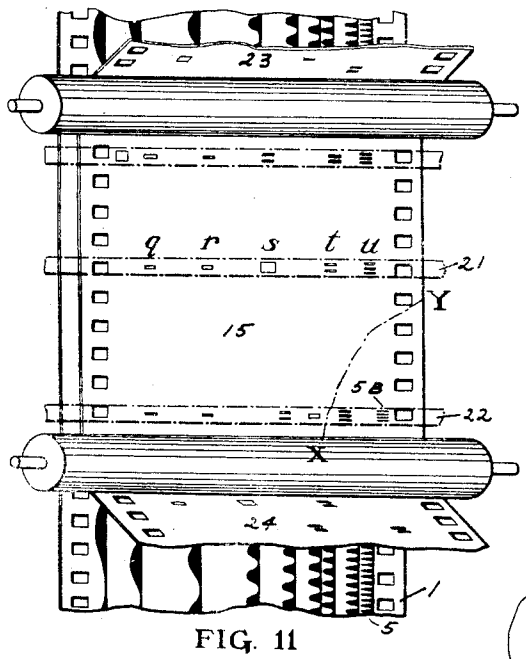


FIG. 11

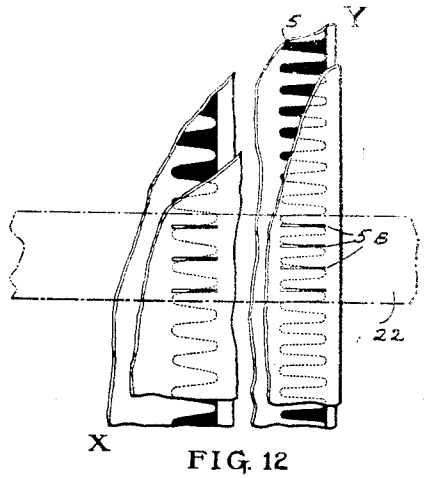


FIG. 12

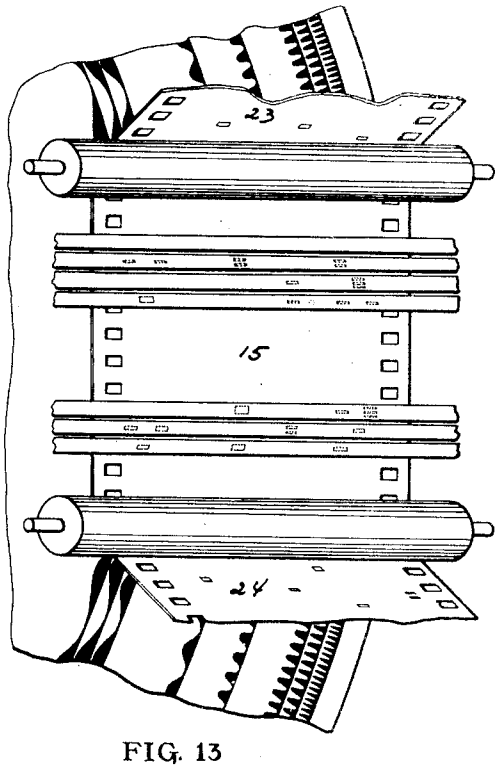


FIG. 13

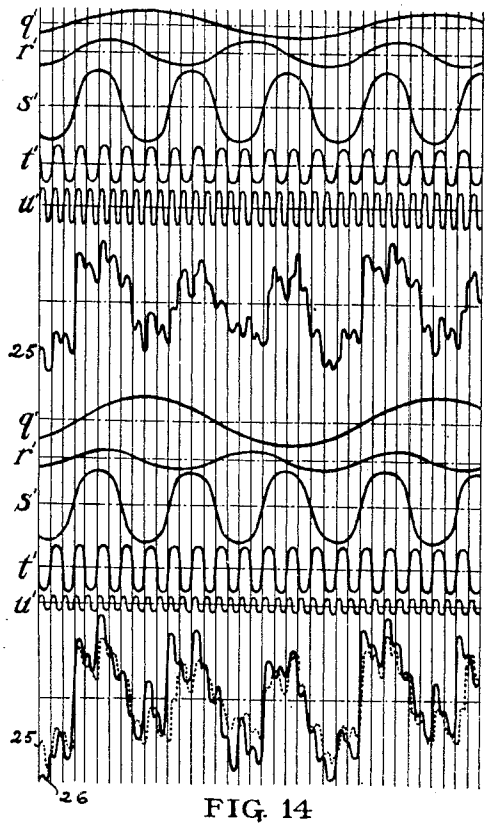


FIG. 14

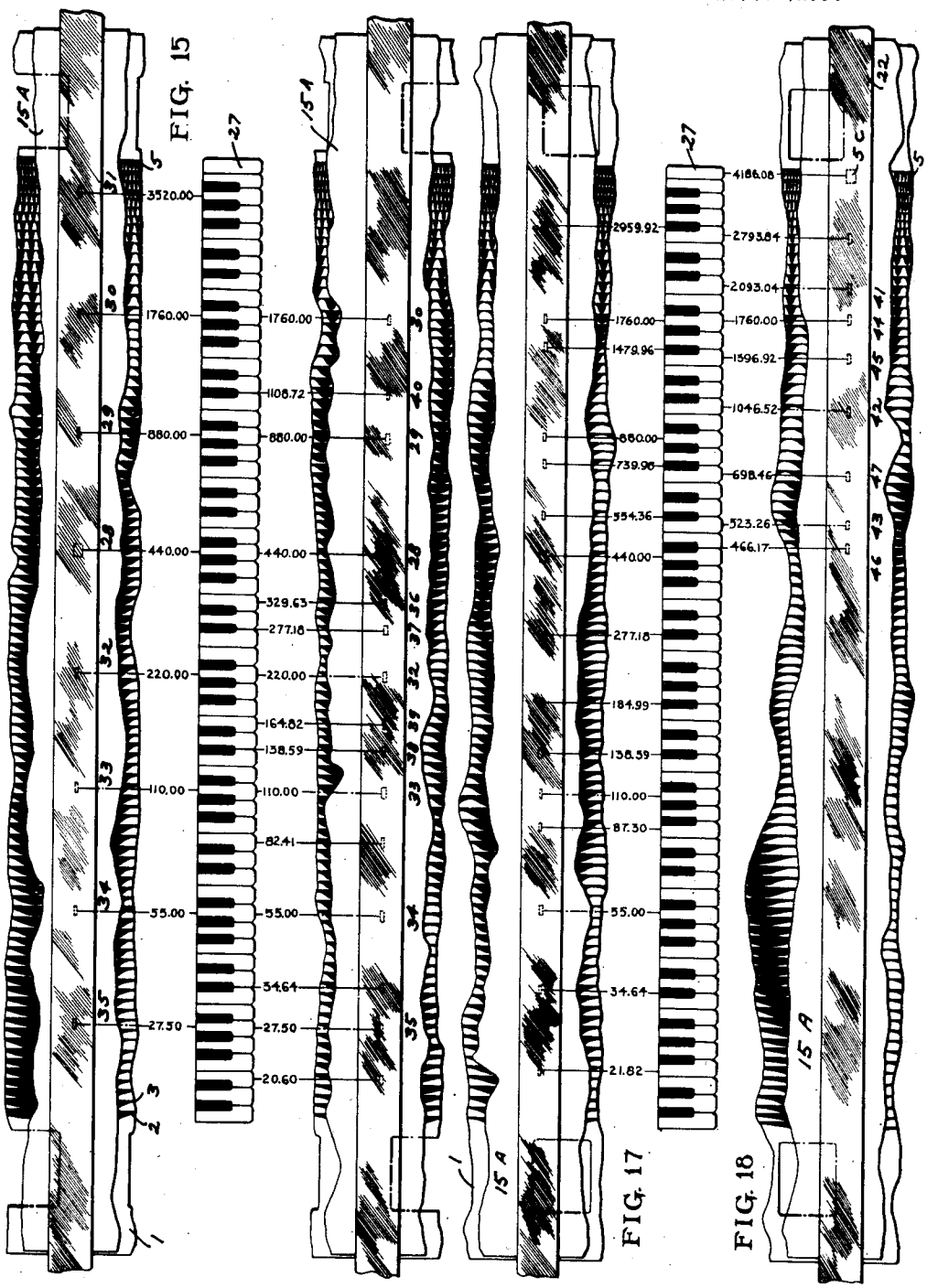
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SYNTHETIC ELECTRONIC MUSICAL INSTRUMENT

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SYNTHETIC ELECTRONIC MUSICAL INSTRUMENT

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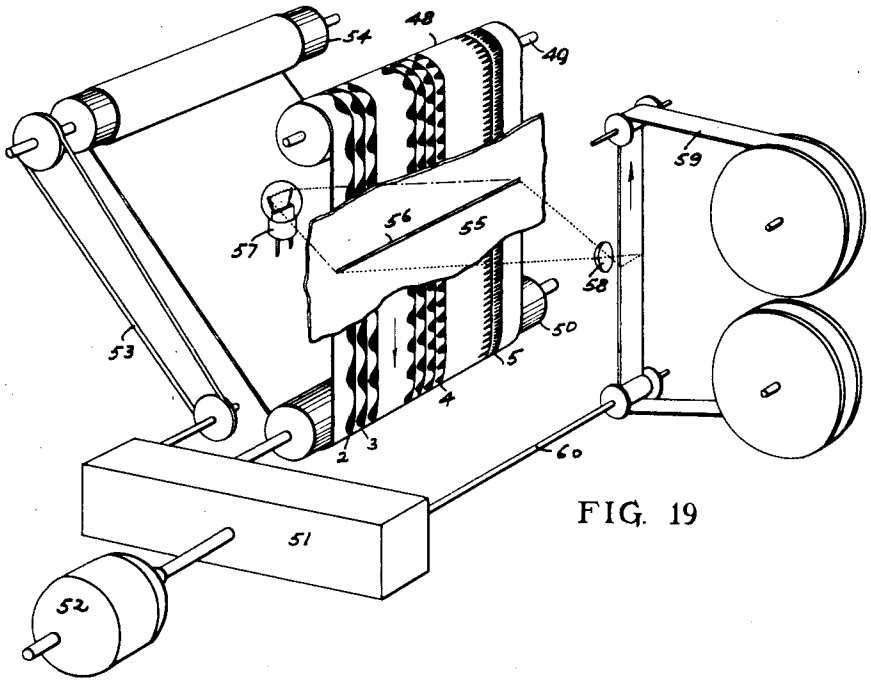


FIG. 19

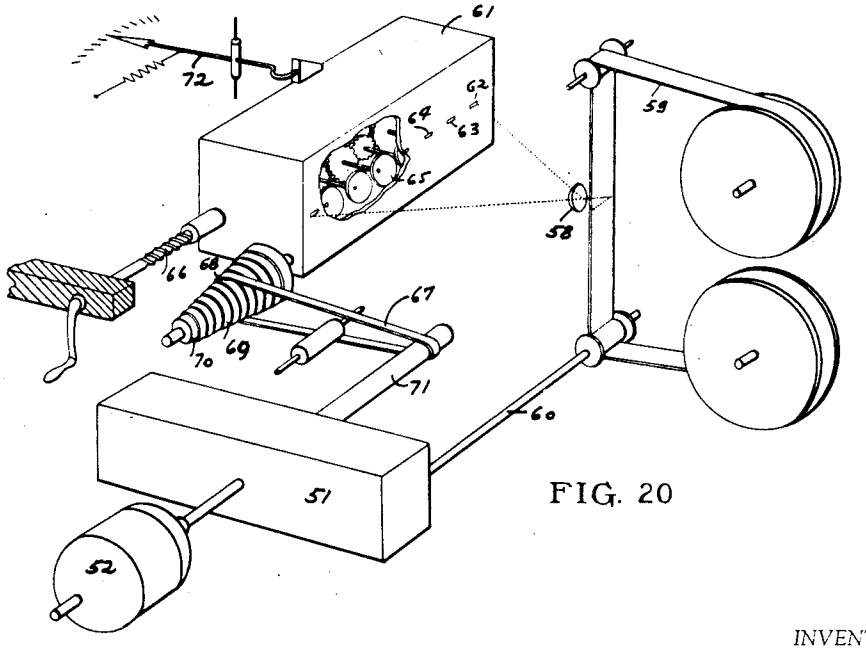


FIG. 20

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SYNTHETIC ELECTRONIC MUSICAL INSTRUMENT

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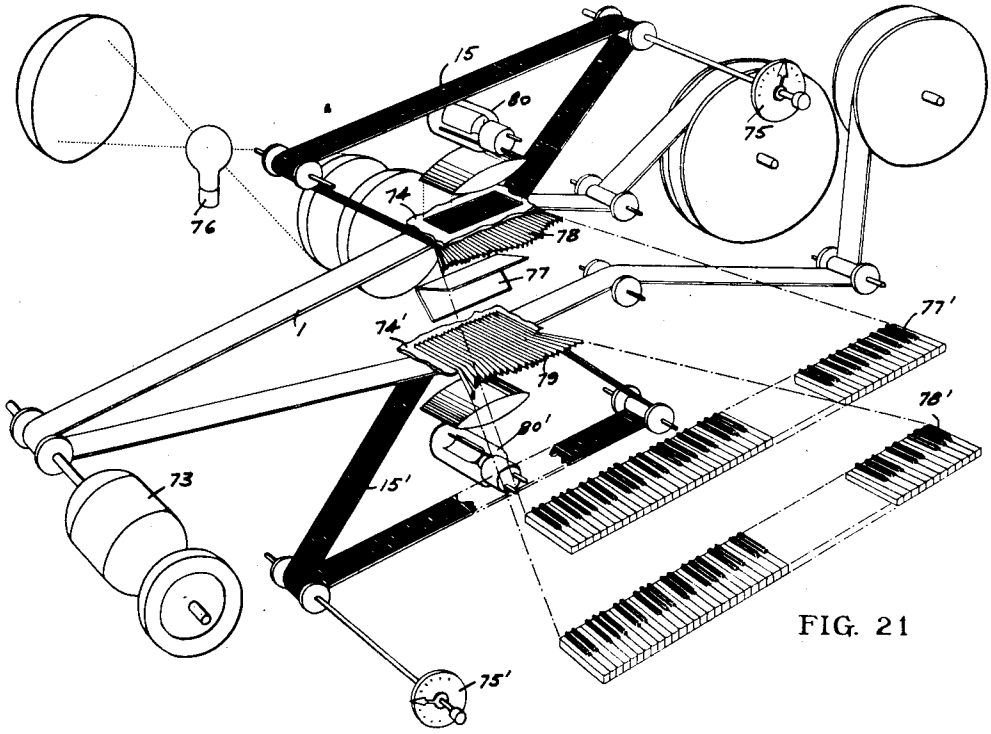


FIG. 21

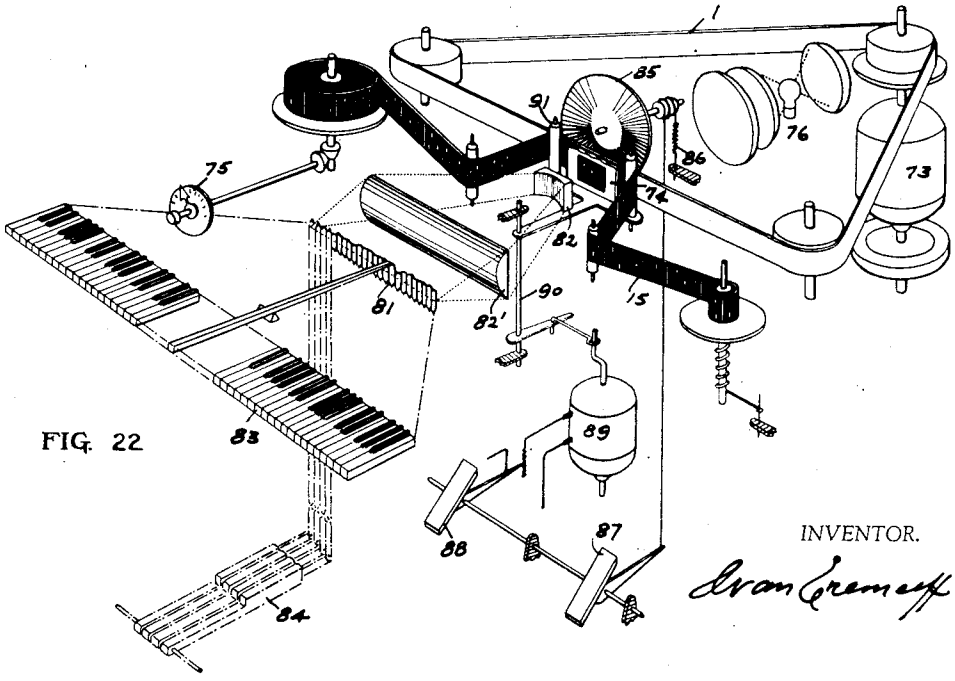


FIG. 22

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Ivan Eremeeff

Patented Feb. 5, 1935

1,990,024

UNITED STATES PATENT OFFICE

1,990,024

SYNTHETIC ELECTRONIC MUSICAL INSTRUMENT

Ivan Eremeeff, Philadelphia, Pa.

Application August 23, 1933, Serial No. 686,361

11 Claims. (Cl. 84—1)

My invention relates to methods and means for producing a synthetic electronic musical instrument for professional use. More particularly, it relates to the production of a musical instrument in which the tuning is mathematically accurate, the tone qualities and intensities made in accordance with predetermined requirements, both tone quality and intensity being easily and quickly changeable, and a number of manuals and pedals being provided for the use of those skilled in piano as well as organ playing. Such an instrument exceeds the requirements of other up-to-the-present classical musical instruments, in various characteristics, such as in tuning and in tone quality, due to the precision of adjustment.

This invention also relates to tone generation and means for producing accurate frequencies, with improved methods of synthesis of such frequencies. The various structural details of this instrument, including lenses, rollers, films, etc., as shown in the accompanying drawings, are of secondary importance, since the actual invention lies in the method for accurately producing correct frequencies, and improved methods of synthesis. The instrument itself can be regarded as a device for projecting a plurality of light energies at different frequencies, at predetermined wave forms, and at predetermined intensities, with a series of screens for masking undesired frequencies, and for passing desired frequencies, for the purpose of synthesis. Keying arrangements are provided for controlling the synthesized light energies, for utilizing them in the production of musical tones, with a light sensitive element for converting the light energies into sound.

While the light sensitive element is a secondary part of the invention, and the above-mentioned projection device is not alone the musical instrument, my claims do not pertain only to a musical instrument, but it is to be understood that I can use the projection device for any suitable purpose, such as, for example, in the production of synthetic electronic waves, signaling, etc.

One of the objects of my invention is to produce a synthetic electronic musical instrument which is so precisely tuned that it will not be subject to criticism from professional musicians and piano tuning experts, by producing frequencies which are mathematically correct in their relative ratios, so that in trying out the instrument for checking beat tones, it will be more accurate in tone than any well-tuned piano or organ. The phase relationships between the frequencies are always predeterminedly fixed and maintained constant, for avoiding unnecessary beat frequencies, and the intensities of the tones, either simple or synthetic, are distributed correctly along the entire keyboard of musical tones in definite ratio to the frequencies, conforming with any predetermined law. The tuning in the intensity distribution throughout the entire keyboard can be adjusted at will, for either simple or synthetic tones.

It is another object of my invention to produce an instrument which is capable of producing simple tones of sine or other simple uniform repeating wave form, which are predetermined and fixed, their shapes not depending on peculiarities of details or parts of the instrument, and producing synthetic tones combined of fundamentals and partials in a great variety of numbers and selections, for example, the synthesis of fundamental and harmonics, sub-harmonics, divisions of the harmonics, divisions of the sub-harmonics, and multiples and divisions of divisions of the harmonics and sub-harmonics.

For a better understanding of the methods of tone synthesis, this invention may be considered with reference to that disclosed in my Patent Number 1,924,713. The present application shows improvements in the methods described in the aforementioned patent, and in my application, Serial Number 258,466, allowed July 26, 1933, now Patent No. 1,948,169, dated February 20, 1934.

It is a further object of my invention to provide for predetermined adjustment of the quality of each key tone, which may be changed at will, for many different combinations, without causing special effort on the part of the operator in making such alterations. Each key of the entire keyboard is capable of the combination of for example, ninety-seven independent frequencies, in predetermined numbers, at different intensities, and without any interference from other keys.

Another object of my invention is to provide an instrument which does not have electrical circuits and wiring, outside of the connections for light sensitive elements and amplification mediums, which are not actual parts of my invention.

A further object is to provide a photographic method of generating simple and synthetic tones correctly, which can be applied to film, disc, cylindrical drum, or other shaped image or wave-bearing parts, depending on the suitability of such parts in practical application. As far as I am aware, the up-to-the-present inventions dealing with the same subject, cannot be utilized in the construction of actual instruments, due to

such unavoidable errors as in the case of films which are made by photographic processes, either by recording sound on strips of such film, and pasting them on their transparent carrying mediums with the usual splice, which produces additional harmonics at each revolution. The inventors fail to notice that, due to close different ratios between one tone and another, the tones cannot be mathematically correct unless hugh size discs or carrying mediums are made. See, for example, the patent of Mercadier, Number 420,884, which provides for the production of music, but such music will be out of tune. In such inventions which have a plurality of shafts for providing for different ratios between frequencies there will be trouble in the displacement of different tones, producing the generation of additional harmonics, due to unavoidably loose mechanical movements, especially at high frequencies, at which the error accumulates, magnifies, and gives undesirable audible tones. My invention provides for long period cyclic repetition, which may extend, for example, over one hour, while, by the use of shafts, there are approximately, for example, fifteen to thirty beats per second.

A still further object of my invention is to provide a generating medium for several manuals each manual having its individual quality adjustment means, foot petals, etc., such generating medium being driven by a constant speed motor, controlled by house current, in order that International pitch is automatically adjusted. The adaptation of constant speed motor for this purpose is disclosed in my Patent Number 1,924,713.

Another object of my invention is to show methods and means for obtaining mathematically correct ratios between frequencies, either by photographing a correct scale drawing or by employing a flickering device which accomplishes the same, automatically. A synchronized flickering device with similar features has been disclosed in my co-pending patent application, Serial Number 559,209.

My invention employs a method of synthesizing frequencies by masking and unmasking them selectively. One key controls a plurality of apertures, the area of the apertures, or the amount of their transparency, remaining predeterminedly constant to conform with the law governing the existent ratios between the pitches and the intensities of the tones of the entire keyboard, regardless of whether the tones are simple, or complicated synthetic ones. In this case, the apertures in the light synthesizing masks are produced photographically, considering their microscopic dimensions, either on film or on sensitized material which is etched into by photo-engraving methods. The photographic method allows for easy and accurate duplication. The masks are either separate or joined, allowing for quick changes of tone quality throughout the entire musical scale as included in the keyboard.

In the case of wave-carrying films which have wave tracks of microscopic size, high-intensity light energy is utilized, special provision being made for allowing greater amounts of light to pass through the apertures which co-operate with the high frequency wave tracks, in order to overcome the handicap of their small size.

The nature and objects of my invention will be more fully understood from the following specification and claims, reference being had to the accompanying drawings, in which:—

Fig. 1 represents portions of film with a plurality of wave tracks;

Fig. 2 is a view of a larger portion of a film such as in Fig. 1;

Figs. 3 and 4 represent film junctions, illustrating errors and splicing;

Fig. 5 represents a disc showing wave tracks;

Figs. 6 and 7 show side elevations of projection arrangements;

Fig. 8 is a view of a keyboard, with frequencies of the musical scale, International pitch, A-440.00;

Fig. 9 represents a masking arrangement;

Fig. 10 represents a masking and a keying arrangement;

Fig. 11 represents a masking arrangement, illustrating different aperture dimensions;

Fig. 12 represents a detail of part of Fig. 11;

Fig. 13 represents a masking arrangement, partially showing a disc with wave tracks;

Fig. 14 is a graph illustrating a type of wave synthesis;

Figs. 15, 16, 17, and 18 show portions of wave track films, with masking and keying arrangements;

Fig. 19 illustrates method and means for producing a record of waves, with mathematical precision, from manual preparation;

Fig. 20 illustrates method and means for producing a record of waves, with mathematical precision, by machine;

Fig. 21 is an assembly view of a projection device with controls for synthesizing, and keyboards for controlling light impulses;

Fig. 22 shows another arrangement of what is shown in Fig. 21.

In Fig. 1, the film 1 carries a plurality of wave tracks as 2, 3, 4, 5, etc., which represent waves of uniform repeating wave form, which are distinguished from each other by spaces such as 6. The frequencies of the waves, their relative ratios, and methods for photographing them onto the film will be described later.

Fig. 2 depicts a strip of the film 1, with the section ABCD, also shown in Fig. 1 in large size. I have already mentioned that in order to produce an electronic musical instrument for professional use, which must be tuned with perfect precision, the wave frequencies must be maintained very accurately, their representative frequency numbers being carried to at least two decimal places, as can be seen by referring to the table of frequencies in Fig. 8. In order to conform to this accuracy, the waves are calculated by the use of, for example, the whole figure 1,635, representing the lowest frequency, and 418,608 as the highest frequency, which are derived from the frequencies 16.35 and 4186.08, with the decimal places removed. Using whole figures for the frequencies, and reproducing them at one-hundredth speed, the ratios between frequencies will be accurate.

It can be supposed that the distance indicated by AG, in Fig. 2, represents a portion of the film, in which all of, for example, ninety-seven waves have their starting and ending points in the same line. In Fig. 1 it can be seen that at the line AB, all of the waves have their starting points. Referring to Fig. 2, the line GH represents the ending point of all the waves. For practical application, the distance of AG is used since it is impossible to make the cycles of the waves start and end at the same points excepting by this means of calculation. AG, for example, is found by multiplying 418,608, taken from the highest frequency, by .002, which represents, for example, in inches, the

size of each cycle of the frequency 4186.08, giving 837.216 inches. Turning to the lowest frequency, 16.35, which must fit into AG with its starting and ending points at the same lines as those of the highest frequency, 837.216 inches is divided by 1,635, giving .512 inch as the size of the wave length of frequency 16.35. The same procedure is followed for obtaining the sizes of the remaining frequencies between the highest and the lowest. For example, the size of the wave length of frequency 17.32 is found by dividing 837.216 by 1,732, which gives .483 inch. It is to be understood that even by choosing .002 inch as the size of the smallest wave length which is, of course, microscopic, the waves of the entire musical scale can be made to start and end at the same points.

In the case of discs, drums, or cylinders, using the same methods of calculation, AG is found to be 69.768 feet, divided by pi, giving 22.207 feet as the diameter. In the case of the entire AG there is no need for splicing, since, at every revolution, the waves run into starting point smoothly and directly from ending point, as explained. However, for more conveniences, a smaller disc or drum can be used by a method of splicing.

Instead of using the entire space of AG, a portion of AG, for example, one-tenth AG, or AE, as shown in Fig. 2, may be used as the circumference of the disc. It must be mentioned here that in the disc, drum, or cylinder with a diameter of 22.207 feet, the circumferential or peripheral movement per second is 8.372 inches, which is obtained by multiplying 4186 by .002. Thus the speed of the disc, drum, or cylinder is found by dividing AG, or 837.216 inches by 8.378 inches, giving one revolution per 99.930 seconds. For the smaller disc, drum, or cylinder, one-tenth AG gives 83.721 inches as the length of AE. The diameter is 2.220 feet, obtained by dividing AE by pi. Such disc, drum, or cylinder will revolve once in 9.993 seconds. In this latter case, splicing is necessary. However, the small silence at each revolution caused by the splice, will not interfere, due to the fact that, as I have said, the disc or drum revolves only once in 9.993 seconds, and at such speed it is impossible to have any additional harmonics resulting from the splice. At a high speed, it would be different, since, if the disc would revolve about twenty times per second, and silence would be detected at each revolution, due to the splice, there would be an additional harmonic, which would have to be eliminated. However, this would not happen in the present invention.

While in my invention there is a possibility of a small silence occurring at each revolution, in the case of smaller disc, drum, or cylinder, it is also to be considered that the tones of the instrument are not played endlessly. That is, the keying of various different tones by the fingers produces sounds which are rarely held over 9.993 seconds at one time. The figures used here are merely for explanation, and are not to be taken as an actual part of the invention. I do not wish to limit myself to any specific dimensions, since these will vary according to convenience and application.

Fig. 3 shows a portion of the film 1 with the line points AB and EF brought together for splicing, and it can be seen that the waves are not continuous at the starting and ending points. In order to avoid the additional sound from the splicing, the film is darkened in a gradual manner, crosswise, for the purpose of partially muffling the sound, as illustrated in Fig. 4. If the splicing is to be avoided altogether, the film must be connected at the points AB and GH, as previously explained.

For desirable results, the portion AG may be repeatedly printed on a continuous strip of film, in order that it may be used, for example, for one hour steadily, and then reversed as desired. Beside provision for avoiding additional sounds which occur from splicing, in the former case, the phases of the frequencies are matched, and the frequencies are mathematically correct according to the tempered scale given in Fig. 8. In expert piano tuning practice, a perfect fifth is obtained, and flattened or sharpened, until a specific number of beats are heard accompanying the tone, and the accuracy can be compared to that of the scale shown in Fig. 8, in which the frequency numbers are carried out to two decimal places. In less accurate tuning, the frequency numbers are carried only to the whole number. This does not happen in the present invention.

Fig. 5 shows a disc on which a plurality of wave tracks are placed, the ratios between the frequencies of the successive waves being the same as those in the film 1 shown in Fig. 1. It can be said that the working space of the disc in Fig. 5 is equal to ABGH of Fig. 2; considering the fact that the working space of the disc is circular, the calculations are made with radial allowances. The beginnings and ends of the waves run smoothly into each other, there is no splicing, and the recording and reproducing is done entirely mechanically. There is no recording from a given source of sound, in which the phases cannot be controlled, and the frequencies cannot be checked. Instead, each wave is measured in its wave length, accurately in ratio, phase, wave form, and amplitude.

Fig. 6 shows a projection arrangement for the film 1. Light energy E passes through the aperture 7, through the tracks on the film 1, which travels outside of the lamp housing 8. Fig. 7 shows the same arrangement as in Fig. 6, but in Fig. 7 the light energy E passes through the wave tracks of a disc. Aperture 7 allows light energy E to pass through all the wave tracks in the full width of the film working space.

Fig. 8 shows the frequencies of the musical scale of International pitch, A-440.00, according to which the frequencies of this instrument correspond.

In Fig. 9 the film 1 has a number of wave tracks as 2, 3, 5, 9, 10, 11, 12, 13, 14, etc., before which a stationary mask 15 is placed, so that when the film is made to move upward or downward, light energy is allowed to pass through the wave tracks and into the apertures as 2A, 3A, 5A, 9A, 10A, 11A, 12A, etc. The wave tracks as 2, 3, 5, 9, 10, 11, 12, etc. may be uniform in width, or different, the widths of their co-operative apertures as 2A, 3A, 5A, 9A, 10A, etc., being made the same size as the wave tracks. The corresponding frequencies and notes of the musical scale are given in Fig. 9. The mask 15 is held at a suitable distance from the passing film 1 by means of 16 and 17.

Fig. 10 shows a similar arrangement to what is in Fig. 9, with the shutters 18, 19, 20, 21, 22, etc. placed over the apertures of mask 15, in order to prevent light energy from passing through the apertures when it is not desired. By lifting or sliding in and out, for example, shutter 21, light energy with frequency 466.17 passes through wave track 11 on film 1, through aperture 11A of mask 15, and is impressed on a light sensitive element and converted into sound energy, heard in the

tone of A#5. The same applies to the next shutter, which, when moved, passes light energy, frequency 493.88 through aperture 12A in mask 15. Mask 15 allows for passage of simple tones, with one tone for each key of the keyboard. The arrangement of the apertures described in regard to mask 15 is a part of one portion or frame, which contains specific groups of apertures for passing simple tones. The portions as 23 and 24 may have other orders of arrangement of apertures, and will be explained later. The widths and lengths of the apertures as 2A, 3A, 5A, 9A, etc., are made in accordance with the law of intensity distribution throughout the keyboard of the instrument and can be altered to conform to such law, by changing the widths of the apertures, while the lengths remain the same.

Fig. 11 represents a similar arrangement to what is in Figs. 9 and 10, but that certain apertures are enlarged or duplicated in order to pass more light. This feature can be seen illustrated more clearly in Fig. 12, which shows the portion XY. Several apertures as 5B are fitted into the space of one shutter for increasing the amount of light passed when, for example, wave 5 is to be used at high tensity. It is to be noted that the several apertures which form 5B have the same position relative to the cycles of wave 5. Any number of apertures may be used for passing more light, provided they are kept within the space of the same shutter.

In Fig. 13 the arrangement is similar to that of Fig. 11. However, the apparatus of Fig. 13 is adapted to discs instead of to straight film. The mask 15 may be in the form of a straight film or, for the sake of uniformity, may be utilized in the shape of a disc similar in size to the wave track disc shown.

Fig. 14 is a graph illustrating wave synthesis. Referring back to Fig. 11, *s* represents the fundamental, which is shown as a large aperture in mask 15. The size of *s* in Fig. 11 corresponds to the amplitude of *s'* in Fig. 14. Similarly, apertures *q*, *r*, *t*, *u*, in mask 15 of Fig. 11 are proportional in size to the amplitudes of the waves *q'*, *r'*, *t'*, *u'*, respectively, shown in Fig. 14. The apertures *q*, *r*, *s*, *t*, and *u*, in the mask 15 are placed over predetermined corresponding tracks in the film 1. Referring to Fig. 14, their representative waves are shown combined into the complex wave 25, which, when converted into sound energy by means of a light sensitive element arrangement, will be heard as a tone with a frequency of the fundamental *s'* which will have a synthetic quality. By altering the intensities of the partials as *q'*, *r'*, *t'*, and *u'*, without altering anything else, and fundamental *s* remaining at the same intensity, their combination will be a different tone, which can be seen by comparing the waves 25 and 26 in Fig. 14.

Figs. 15, 16, 17, and 18 show methods of wave synthesis which are possible by means of this instrument. In Fig. 15, the mask 15A has a plurality of apertures over the waves on the film 1, the frequencies of the several waves being indicated on the keyboard 27 for identification. It can be seen that the widths of the apertures vary, as previously described, and the aperture of the fundamental, which in this case is 28, is always greater than the apertures of the partials or overtones, since the fundamental tone must always have a higher intensity, than the modifying tones. The partials of the fundamental 28 are the harmonics 29, 30, and 31, and the sub-harmonics 32, 33, 34, and 35. Their frequency numbers and musical notes can be identified by referring to the keyboard 27.

In Fig. 16, 28 again represents the fundamental, 29 and 30 representing harmonics and 32, 33, 34, and 35 representing the sub-harmonics of 28. 36 and 37 represent fractions of 28; 38 and 39 represent fractions of the first sub-harmonic 32; 40 represents a fraction of the second harmonic 30, producing major chords of the fundamental 28, A-440.00, at low intensities for modifying its quality. The frequency numbers and musical notes can be identified by referring to the keyboard 27.

In Fig. 17 the fundamental A-440.00 is mixed with low intensity partials, which, in the musical scale, represent minor chords of the fundamental. The frequencies can be identified by referring to the keyboard 27.

Fig. 18 illustrates synthesis of fundamental 5C, of high frequency, with a plurality of partials, including sub-harmonics as 41, 42, and 43; 44 is a fraction of the first sub-harmonic 41; 45 represents an approximate third division of fundamental 5C; 46 represents an approximate ninth division of fundamental 5C; and 47 represents a fraction of the second sub-harmonic 42. By this instrument, countless combinations can be made, such as fundamentals with harmonics, multiples of the fundamentals, multiples of the fractions of the harmonics, multiples of the fractions of the multiples, sub-harmonics, divisions of the fundamentals, fractions of the fundamentals, fractions of the sub-harmonics, fractions of the divisions of the fundamentals, divisions of the fractions of the fundamentals, divisions of the fractions of the sub-harmonics, and divisions of the divisions of the fundamentals. The frequency numbers and musical notes can be identified by referring to the keyboard 27.

Fig. 19 shows a device for producing precision waves and photographing them on film, such waves being correct in frequency, phase relationships, intensities, and wave forms. 48 is transparent or translucent drawing material, many feet in length, on which waves 2, 3, 4, 5, etc., are drawn to scale at correct phases. 48 is unrolled from 49 by friction roller 50 which is driven from gear box 51 by constant speed motor 52. Slipping belt 53 winds drum 54 for keeping tension in the winding portion of 48. Shield 55 with the narrow opening 56 allows light energy from 57 to pass to lens 58 to the recording film 59, which is exposed in the same manner as in photographic practice. Film 59 is driven by 60 at constant speed from a train of gears cooperating with motor 52. Any length of film can be recorded by this method, especially if 48 is spliced at a point where all the waves meet correctly, as previously described.

Fig. 20 illustrates a mechanical method, with the drawing material 48 substituted by the flicker box 61, which has a plurality of apertures as 62, 63, 64, etc., with shutters as 65 which open for the passage of light at intervals of doubling frequency. That is, the light passed by 62 flickers twice as often as does the light passed by 63, and the light passed by 63 flickers twice as fast as does the light passed by 64, and so forth. On the film 59 there will be, for example, eight tracks recorded, with suitable spaces between them. By displacing the flicker box 61, another eight tracks are recorded on the film 59 just next to the first set of recorded tracks. The displacement is brought about with the aid of the screw device 66, when the spring belt 67 is placed on the pulley

68, for increasing the speed of the light flickering at the ratio which exists between the frequencies of the different waves. There are, for example, twelve pulleys such as 68, 69, 70, etc., which have diameters which correspond to the twelve tones of a musical scale, falling in one octave, the driver 71 having one and the same diameter. Eleven displacements must be made in the space between 62 and 63; these displacements are gauged by 72 which indicates the movements of box 61.

Fig. 21 represents a diagrammatic view of a practical application of a precise frequency generator and synthesizer, for producing a synthetic electronic musical instrument. 1 represents a film which is driven by synchronous motor 73; (the latter is a feature which is disclosed in my Patent number 1,924,713). The motor 73 is provided for reversing when the film 1, after approximately one hour's travel, must go back again. On the film 1, the masks 15 and 15' rest on the aperture plates such as 74, and 74' the masks being placed in positions of desired quality, which is controlled by the indicators as 75 and 75'. The light source 76 projects light energy by means of an optical system, upwards and downwards by aid of mirrors as 77. The shutters as 78, 79, etc., are similar to the shutters 18, 19, 20, 21, and 22, shown in Fig. 10, and are controlled by their corresponding keys which are found in the keyboards 77' and 78'. When a key is depressed, its corresponding shutter moves and opens one or more apertures in a row in the masks as 15 and 15', permitting pulsating light energy to be impressed on the light sensitive elements as 80 and 80'.

Fig. 22 shows an arrangement in which the shutters, such as 81, are larger and do not come in close contact with the masks, as in Fig. 21. The objective lens 82 picks up images of all the apertures in the masks, spreads them horizontally, and lens 82' produces a row of light dots which are focused over the shutters 81. The lenses 82, 82' are shown for the sake of explanation, but in reality, these are wide-angle objectives lenses, one plane for spreading, and another plane for pointing. The row of light dots is focused on the shutters 81 in such a manner that each individual light dot is focused on its own co-operative shutter. The shutters selectively pass or stop light energy from passing to a light sensitive element, by depression of the keys in the keyboard 83, or the pedals 84. The light pencils which pass through the shutter spaces, when these are lifted or lowered, are synthetic, and are composed of pulsating light energy of different frequencies, and different intensities. The shutters are so shaped that as they are gradually lifted, by key, or lowered, by pedal, light energy is permitted to pass in gradually increasing amounts, due to the pointed ends, which can be seen in the drawings.

The volume control arrangement consists of the disc 85 which has different degrees of translucency, for increasing or decreasing the light energy which falls on the wave tracks through the aperture of plate 74. The disc 85 is driven by the belt and spring 86, with the aid of the volume control pedal 87.

For the purpose of producing tremolo effects, the pedal 88 permits of controlling the speed of motor 89 which, by the drive 90, rocks the aperture plate 74 and the rollers such as 91 from side to side, horizontally, or lengthwise, thus increasing and decreasing the occurrence of light impulses as the light energy passes through the wave tracks and through the small apertures in the oscillating mask. This produces slight variations in all frequencies simultaneously.

While it has not been shown in the drawings, in order to avoid confusion, a second disc, similar to disc 85 can be introduced in front of disc 85 for varying the volume at different predetermined speeds, due to the fact that the second disc revolves at different speeds. These features thus provide for producing tremolo effects by means of varying volume, or by increasing and decreasing the cyclic occurrences of all frequencies, or, in musical terms, by slightly varying the pitch.

Having thus fully described my invention, what I claim as new and useful is:—

1. A synthetic electronic musical system comprising means for generating a plurality of pulsating light energies, each of said pulsating light energies having fixed frequency, fixed intensity, and fixed phase occurrence, the ratios between the frequencies of said pulsating light energies having predetermined mathematical relationships, masking means for selectively synthesizing said pulsating light energies in groups of predetermined number, common means for predeterminedly varying the intensities of all of said groups of pulsating light energies, common means for simultaneously advancing and retarding the occurrences of the impulses of said groups of pulsating light energies, common means for combining and translating a predetermined number of said groups of pulsating light energies, and individual means for passing a predetermined number of groups of translated pulsating light energies for their conversion into sound energy.

2. A synthetic electronic musical system comprising means for producing a photographic record of image waves of predetermined frequencies, predetermined intensities, and predetermined wave forms, with predetermined fractional frequency ratios between each of said image waves, a plurality of predeterminedly changeable shields with groups of apertures, each group of said apertures permitting the passage of a predetermined number of pulsating light energies at predetermined intensities, each of said pulsating light energies having a predetermined frequency, camera means for selectively and individually projecting the images of predetermined shields, with magnification in one plane, on a plurality of controlling shutters, for individually passing a predetermined number of said pulsating light energies, for their conversion into electrical energy.

3. A system for the production and synthesis of pulsating light energies, comprising a manually prepared record of wave tracks of fixed amplitudes, fixed wave forms, fixed phase relationships, fixed wave lengths, and fixed mathematically correct ratios between the wave lengths of said wave tracks, means for impressing at reduced size, the manually prepared record on a translucent wave track bearing surface, means for producing a plurality of pulsating light energies from said translucent wave track bearing surface at a predetermined constant fraction of time, means for synthesizing a predetermined number of pulsating light energies so that a predetermined number of said light energies which are fundamentals of predetermined frequencies, are combined with other pulsating light energies which are partials of definite predetermined intensities, certain of the frequencies of said partials being harmonics of said fundamentals, multiples of said fundamentals, multiples of the fractions of the harmonics, and multiples of the fractions of the mul-

tiples, and other frequencies of said partials being sub-harmonics, divisions of said fundamentals, fractions of said fundamentals, fractions of the sub-harmonics, fractions of the divisions of said fundamentals, divisions of the fractions of said fundamentals, divisions of the fractions of the sub-harmonics, and divisions of the divisions of said fundamentals, common projecting means for directing said fundamentals and their partials to their co-operative controlling valves, said controlling valves selectively passing said fundamentals and their partials into a common output, common means for varying the intensity of said common output, and means for periodically increasing and decreasing the intensity of said common output at predetermined intervals.

4. A system for producing synthetic light energy consisting of a plurality of light impulses of different frequencies and different intensities, means for preparing a record of a plurality of wave tracks of predetermined amplitudes, said wave tracks having predetermined ratios between their individual wave lengths, and said wave tracks having predetermined phase relationships between each other, means for simultaneously producing a plurality of light impulses, means for selectively and simultaneously synthesizing a predetermined number of groups of said light impulses, common means for simultaneously and periodically advancing and retarding the occurrences of said light impulses during synthesis, common means for simultaneously changing the intensities of all of the synthesized light impulses in all of said predetermined groups, common objective means for focusing and enlarging said groups of light impulses at a predetermined scale, with enlargement in one plane, upon a key means, for selectively and individually passing said groups of light impulses focused upon them, into a common output.

5. In a sound reproducing system, a moving surface bearing a plurality of wave tracks of microscopic dimensions, means for masking a predetermined number of said wave tracks, means for passing pulsating light energy through predetermined wave tracks through said masking means, said masking means having a plurality of slits which co-operate with said wave tracks, the distance between each of said slits being equal to the wave lengths of the corresponding wave tracks through which said slits permit light energy to pass.

6. In a synthetic electronic musical instrument, means for generating a predetermined number of light energies at a constant predetermined fraction of time, means for synthesizing said predetermined number of light energies so that a predetermined number of said light energies which are fundamentals of predetermined frequencies, are combined with other light energies which are partials of definite predetermined intensities, certain of the frequencies of said partials being harmonics of said fundamentals, multiples of said fundamentals, multiples of the fractions of the harmonics, and multiples of the fractions of the multiples, and other frequencies of said partials being sub-harmonics, divisions of said fundamentals, fractions of said fundamentals, fractions of the sub-harmonics, fractions of the divisions of said fundamentals, divisions of the fractions of said fundamentals, divisions of the fractions of the sub-harmonics, and divisions of the divisions of said fundamentals, keying means for passing said synthesized light energies to a light sensitive element for conversion into electrical and sound energy, means for controlling the volume of said sound energy, means for producing tremolo effects by simultaneously and periodically changing the pitches of said sound energy at predetermined beats, and means for simultaneously and periodically changing the volume of said sound energy at predetermined beats.

7. In a system for the projection of pulsating light energies, endless means for producing a plurality of pulsating light energies with correct frequency ratios between each of said pulsating light energies, said energies being produced at very low error-repeating cycles, the wave tracks which produce said pulsating light energies having uniform wave form of any predetermined shape, masking means for predeterminedly passing pulsating light energy from said wave tracks with the aid of their corresponding mask slits, the intensities and slit areas of said pulsating light energies, at heigh and low frequencies, conforming with any predetermined requirements, means for spreading the pulsating light energies from the vertical rows of slits in said masking means in one plane, condensing said light energies in another plane, and focusing said light energies upon a keying means, and hand and foot operated means for predeterminedly and selectively passing the resultant individual synthetic pulsating light energies in different amounts, and at predetermined fractions of time.

8. In a synthetic light producing system, a moving mask with a plurality of black and white wave tracks, said mask moving at a predetermined uniform fraction of time, a stationary mask with a plurality of rows of slits, each of said rows having a predetermined number of slits, said slits permitting the passage of light energy only through their own co-operative wave tracks on said moving mask, means for combining and projecting the light energies from each row of said slits of said stationary mask, onto the surfaces of their co-operative controlling valves.

9. In a synthetic electronic organ, a plurality of manuals, a plurality of pedals, common means for passing a predetermined number of pulsating light energies through a uniformly moving screen, said screen having a plurality of wave tracks, each of said manuals and pedals having individual means for masking and synthesizing a predetermined number of pulsating light energies, common means for controlling the intensity of all the pulsating light energies of said manuals and pedals, individual means for each of said manuals for periodically controlling the cyclic occurrences of the light impulses of said pulsating light energies.

10. A synthetic electronic organ with precise tuning, having a plurality of manuals, pedals, tremolo pedals, volume pedals, and different stops for controlling synthetic tone qualities, comprising means for producing a photographic record of a plurality of wave tracks of fixed wave forms and fixed phases, the wave lengths and wave length ratios between each of said wave tracks corresponding, respectively, to the frequencies and frequency ratios of a musical scale, two-way reciprocating means for projecting said wave tracks on predetermined selective masks, each of said masks being under the control of its own co-operative manual, enlarging, spreading, and focusing means for synthesizing a plurality of pulsating light energies at different predetermined frequencies, and at different predetermined

intensities on their own co-operative keying means.

11. A system for recording light and for producing pulsating light energies of synthetic frequencies, comprising means for recording on a moving photographic film, a predetermined number of wave tracks of predetermined wave lengths, predetermined amplitudes, and with predetermined wave length ratios and predetermined phase relationships existing between each of said wave tracks, photographic film masking means for selecting a plurality of said wave tracks at different predetermined intervals, said photographic film masking means moving in the same and reciprocating directions as the movements of said photographic film, means for passing predetermined amounts of plusating light energy through said photographic film masking means at high intensities and at small wave lengths, and means for producing a predetermined number of synthetic pulsating light energies, each of said pulsating light energies being the combination of a pulsating light energy of fundamental frequency and predetermined intensity with a predetermined number of pulsating light energies of partial frequencies and predetermined intensities, with predetermined divisional and multiplying ratios existing between said fundamental and said partials.

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