H. J. VAN DER BIJL.

PHOTO-ELECTRIC TRANSLATING DEVICE.

APPLICATION FILED NOV. 7, 1916.

1,369,764. Patented Feb. 22, 1921.

2 SHEETS—SHEET 1.

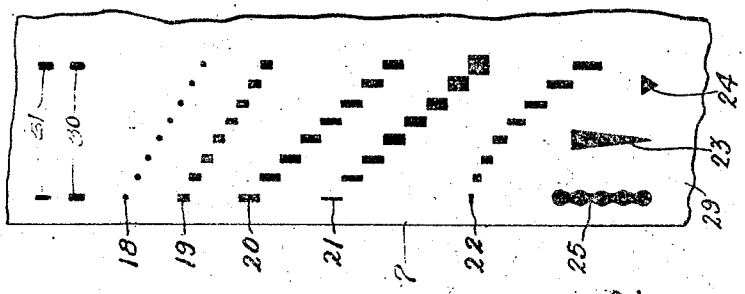

Fig. 2.

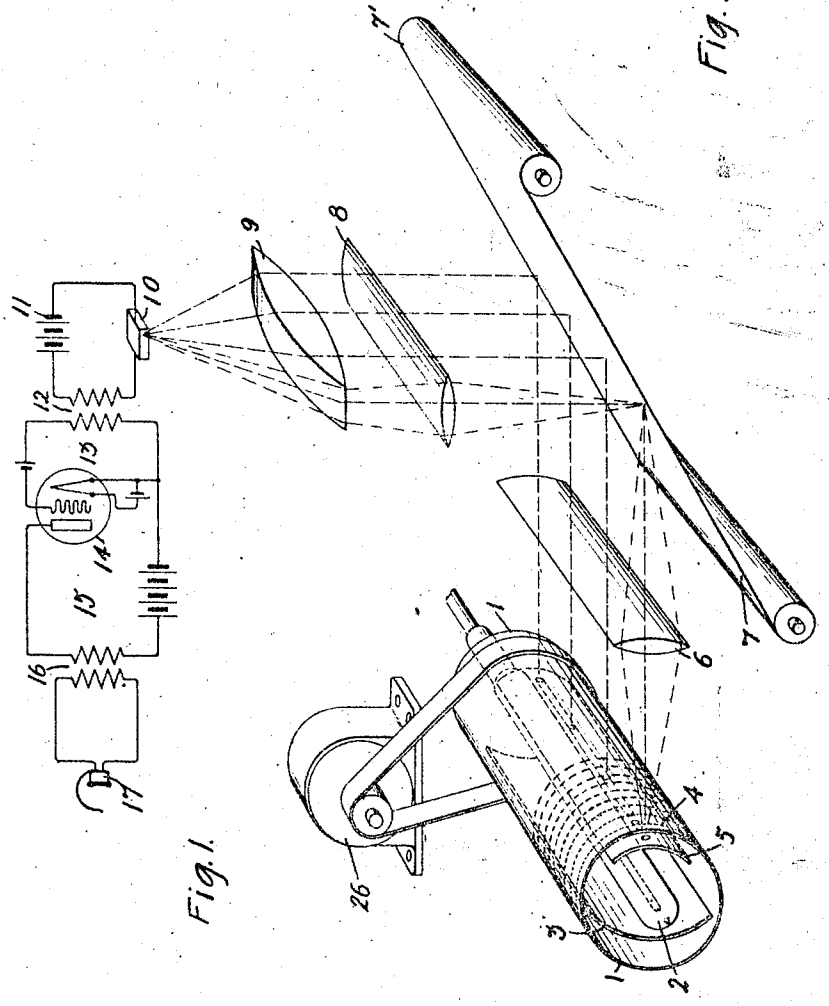

Fig. 1.

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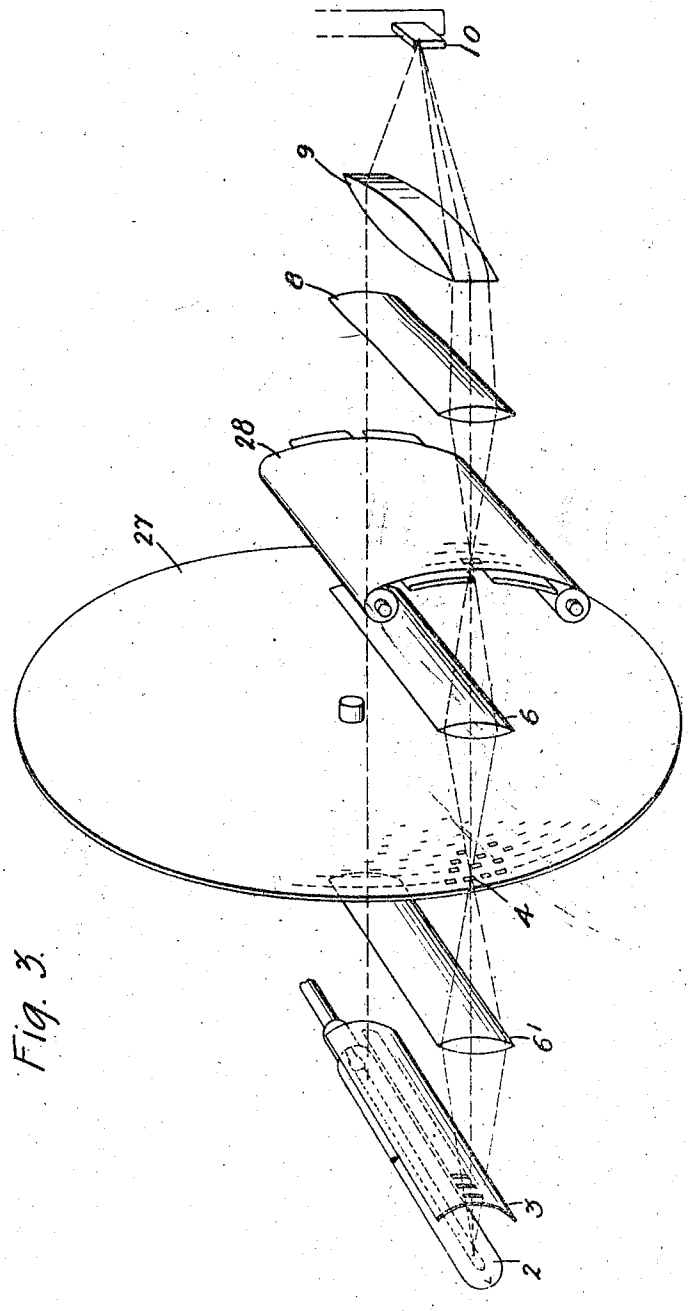

Fig. 3.

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UNITED STATES PATENT OFFICE.

HENDRIK JOHANNES VAN DER BIJL, OF NEW YORK, N. Y., ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

PHOTO-ELECTRIC TRANSLATING DEVICE.

1,369,764. Specification of Letters Patent. Patented Feb. 22, 1921.

Application filed November 7, 1916. Serial No. 130,091.

To all whom it may concern:

Be it known that I, HENDRIK JOHANNES VAN DER BIJL, a subject of the King of Great Britain, residing at New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Photo-Electric Translating Devices, of which the following is a full, clear, concise, and exact description.

This invention relates to combinations of means for and methods of producing sound waves and in the hereinafter described embodiment thereof comprises apparatus adapted for use in rendering musical compositions.

Its object is to provide methods and means whereby all the notes and over-tones of a musical composition synthetically prepared may be rendered as musical sounds of the required quality, intensity and pitch.

Its object is attained by allowing interrupted radiant energy, for example light, to fall upon a light sensitive substance, the frequency of the interruption being such as to give the desired note. The variation of the electrical properties of this substance, due to the interrupted light incident upon it, furnishes a means for supplying a suitable receiver with a fluctuating current, the variations in which correspond to, and are controlled by the frequency of interruption, the intensity and quality of the interrupted light rays.

This invention depends upon the photo-electric properties of certain substances, such as the change of resistance of a substance when acted on by light or other radiant energy waves.

The invention may be better understood by reference to the accompanying drawings in which Figure 1 shows one method by which the aforesaid photo-electric properties of a substance may be used for the production of musical tones; Fig. 2 shows various musical passages upon a note sheet; Fig. 3 shows another form that this invention may take. Like reference characters represent like parts.

The operation of the device illustrated in Fig. 1 may be described as follows:

1, 1 represents a hollow cylinder, capable of being rotated at a constant speed and containing circles of perforations 4. Within the cylinder is a source of light 2. The rays of light passing through these apertures fall upon the note sheet 7 a definite number of times per second, and are reflected to the light sensitive substance 10, giving it alternate periods of light and darkness with a definite frequency. A selenium crystal is the particular light sensitive substance that is herein used for illustrating the invention although other suitable substances whose resistance varies under the influence of radiant light or other energy may be used. Since the resistance of the crystal changes under the influence of light, the current through the crystal, due to the battery 11, will then undergo like variations. That is, the current through the crystal will be pulsatory in character, and a suitable telephone receiver 17, placed directly in the circuit of the crystal or in a circuit inductively associated therewith will then emit a note of a pitch determined by the frequency of the illuminated periods. These fluctuations in current may be amplified before being impressed upon the receiver 17. The vibration frequencies of the notes emitted by the receiver will be proportional to the number of apertures in each circle of perforations in the cylinder from which the light issues, providing the cylinder is rotated at a constant speed; so that by having a different number of apertures in each circle of perforations, any desired note can be produced in the receiver. As shown in the diagram, the cylinder is rotated at constant speed by means of a motor 26.

Now, if the note sheet 7 has a high reflecting power for incident light, the receiver 17 will give forth a complex sound resulting from the combination of the individual notes corresponding to each circle of perforations. But if the rays from part of the circles of perforations are absorbed by the note sheet 7, the notes corresponding to those perforations will not be heard in the receiver. In general, for the rendering of a musical composition, it will be found desirable to hear only a few of the notes at a given instant.

Consequently, in order to prevent the crystal from receiving light simultaneously from every circle of perforations, it is necessary to have the note sheet 7 part reflecting and part absorbing, so that light only from the circle or circles of perforations opposite the reflecting portion will be incident upon the crystal. This will afford a method for

selecting the pitch, duration and intensity of the note or notes that are desired in the receiver. Such a selecting means may be provided by having the note sheet 7 in the form of a strip of black paper with white marks thereon, the strip capable of being rolled in either direction, and each white mark being of the proper size and in the proper position in respect to the circle of perforations from which it is to receive interrupted light beams. In Fig. 1, the note sheet 7 should be of this character.

In order to limit the light from source 2, to small and properly positioned areas, and to increase the intensity on said areas, it is desirable to use the converging lenses 6, 8 and 9 the cylindrical lens 6 concentrating the light to a narrow transverse region extending across the strip, and lenses 8 and 9 bringing it to a focus on the crystal. In order to insure that the beams coming from the source 2 have each a definite direction, it may be desirable to have a stationary row of apertures in the plate 5. The material containing these apertures should have considerable thickness so that a beam or pencil of light emerging from each aperture has a definite direction and cannot interfere with light from other apertures. The reflector 3 is a further means for increasing the intensity of the light from source 2.

If it is necessary to amplify the fluctuations of the current flowing through the crystal before impressing them upon the receiver, it may be done by such an electric system as is shown in connection with the crystal. 12 is a transformer for impressing the fluctuations in the current of battery 11 on the input circuit 13 of the amplifier 14, which may be of the well-known audion type. The oscillations in the output circuit 15 of the amplifier are impressed on the circuit containing the receiver 17 by means of the transformer 16. If further amplification is needed, it may be obtained by connecting a plurality of amplifiers, such as shown, in parallel or in tandem or in any other manner well-known in the art.

Thus, in order to render a certain desired musical sound, we cause a white mark on note sheet 7 to be placed opposite the circle of perforations giving the frequency desired, and the interrupted beam from the perforations striking the selenium causes the receiver to give forth the note, the intensity and duration of which depends upon the width and length of the white mark on note sheet 7. In order to get a succession of musical sounds, the note sheet 7 may be rolled, say from left to right on the drawing or toward the end 7', there being marks on the paper of the right size, shape and position to give any particular note or notes at any particular time or for any length of time.

The sheet 7 does not need necessarily to have light marks on a dark background. In order to function properly, the sheet 7 needs only to have certain portions of itself capable of reflecting light to which the light sensitive substance responds, the other portions either absorbing or transmitting the light incident upon them or reflecting only that part of the incident light to which the light sensitive substance will not respond. The sheet used in connection with the apparatus in Fig. 1 should have portions giving substantially total reflection on a light absorbing or transmitting background.

Fig. 2 shows a portion 29 of a sheet, which illustrates the different markings that may be used to produce various musical effects. However, before such a sheet could be used in connection with the system of Fig. 1, the markings would have to be changed to reflecting portions on a dark background, just the opposite to that illustrated; otherwise the form and relative positions of the markings would be identical in both cases for the production of the desired musical passages. The marks represented by 18 would give a staccato scale; 19, a legato scale; 20, a legato scale played one half as fast as 19; 21 a slow crescendo scale; 22 a ritardando scale of the same intensity throughout; 23 a drawn-out diminuendo note; 24 a diminuendo note of short duration; 25 a note of alternately increasing or diminishing intensity; 30 two notes an octive apart and of substantially the same intensity sounded simultaneously; and 31 a fundamental tone together with the first harmonic thereof, the harmonic having a much smaller intensity than the fundamental.

Fig. 3 represents the invention in a slightly different form from Fig. 1, a rotating disk 27 being used instead of a rotating cylinder, and the interrupted light on the crystal being received by transmission through apertures in the sheet 28 instead of by reflection. The disk has circles of perforations similar to those in the cylinder. The operation of the system is essentially the same as previously described for Fig. 1. An additional cylindrical lens 6' is used for concentrating the rays of light on the disk.

This invention permits complete control of any number of simultaneous tones and their relative intensities and duration, with means for successively producing them in any order and at any desired time intervals necessary to render a musical composition. Furthermore, each and every note may be combined with any desired number of its harmonics in any relative intensity desired and the relative intensities of the various harmonics may be regulated at will.

It is well known that by properly relating the internal impedance of a thermionic am-

plifying tube with respect to its external output impedance, it may be made to amplify practically without generation of harmonics, or on the other hand, if desired, to act as a harmonic generator, that is, to produce harmonics of considerable intensity. Ordinarily the tube will be adjusted to generate no harmonics because the harmonics will be properly controlled through the note sheet. Otherwise, undesirable harmonics or multiple frequencies of the overtones would be heard in the receiver 17. However, it may be desirable as, for example, in imitation of an instrument which naturally possesses a series of overtones, to produce only fundamental tones by means of the note sheet, and so adjust the tube 14 that it will act as a harmonic generator and thereby generate a desired series of overtones.

It is to be understood that the term "light" as used in this specification is not to be interpreted as limited to ether waves of a length to which the human eye is sensitive, as it is well known that selenium and other substances of a similar nature are sensitive to radiant energy over a wide range of wave lengths. Hence, the invention naturally includes within its scope the use of any suitable form of radiant energy upon any suitable element whose conducting properties are affected thereby.

While particular apparatus has been described for carrying out the purposes of the invention, it should be understood that other modified forms of apparatus not specifically mentioned herein will fall within the scope of invention, which is generic to the synthesis of music containing any desired combinations of tones and harmonics thereof in any desired intensity by means and methods hereinafter claimed.

What is claimed is:

1. The combination with a device adapted to emit one group of light beams varying in intensity with a given frequency and selected harmonics thereof and another group of beams of another frequency and selected harmonics thereof, of means for translating said light waves into sound waves of corresponding frequencies, and means for determining which of said groups of beams shall be supplied to said first means.

2. The combination with a device adapted to emit radiant energy varying in intensity according to a plurality of constant frequencies, of a means for translating said radiant energy into sound, and a second means for selecting and automatically supplying to said first mentioned means in predetermined order radiant energy having different intensity variation frequencies.

3. The combination with a device adapted to emit light beams of a plurality of interruption frequencies, of means for the translation of light waves into musical sounds, said means including a light sensitive element, and of a second means for selecting, in a predetermined order, light beams of different interruption frequencies and means for causing said selected light beams to fall upon said sensitive element.

4. A device adapted to render musical compositions comprising, a plurality of sources of interrupted light beams of frequencies corresponding to the notes to be rendered, a light sensitive means and a source of current therefor, a note sheet for variably absorbing light waves for causing the light beams of the desired frequencies to strike said means with the proper intensity and duration, and means for transforming into musical sounds the resulting changes in the current through the light sensitive means.

5. A musical instrument comprising, a source of light, means for deriving therefrom a plurality of interrupted light beams of different frequencies, a selenium cell and a source of current therefor, a note sheet having portions of different light absorbing properties for causing certain selected ones of the interrupted light beams and not others thereof to fall upon said selenium cell at any instant of time, a receiver, and means for causing current changes in said selenium cell to produce corresponding changes in current through the said receiver.

6. A device adapted to produce musical sounds from a synthetically prepared record comprising, means for producing a plurality of interrupted radiant energy beams of frequencies corresponding to the notes to be rendered, a selenium cell and a source of current therefor, a member synthetically prepared in accordance with the music to be rendered, said member constituting a means for selecting the frequency and controlling the duration and intensity of the radiant energy beams incident upon said selenium cell, and means for transforming the resultant changes in current into musical sounds.

7. In combination, means for producing a plurality of radiant energy beams having different interruption frequencies, a note-sheet, means for passing said sheet across the path of said beams, said sheet having a longitudinal region thereon corresponding to each of said beams, an element sensitive to radiant energy, certain portions only of certain of said regions having characteristics which cause transmission of the energy of the particular beam corresponding to said region to said element, said portions having characteristics which enable the intensity of application of said beam to said element to be instantaneously or gradually varied.

8. Means for the rendition of music, said means comprising the combination of a rotating cylinder containing perforations, a source of radiant energy within said cylinder, an electrical system containing an ele-

ment sensitive to radiant energy, a receiver and a source of current, a note sheet, and means for passing it before said cylinder, of which sheet only certain portions are capable of reflecting said radiant energy, the said radiant energy beams from said cylinder being reflected by means of the reflecting portions of said moving sheet to said sensitive element, thereby causing fluctuations in the current through said element, the electric oscillations arising therefrom being impressed on said receiver.

9. Means for producing a musical composition including means for producing a series of pencils of radiant energy, each said pencil having a constant frequency of interruption, there being a frequency corresponding to the vibration-frequency of each tone and overtone in the composition to be produced, means to translate interrupted radiant energy pencils into sound waves of corresponding frequency and intensity, and means for successively producing from said pencils other pencils and combinations of pencils of such relative intensity as are necessary to produce the successive tones and combinations of tones in such relative intensity as are desired in the musical composition, and means for transmitting said second mentioned pencils to said translating means.

10. The method of producing sound waves which comprises producing a beam of ether waves, interrupting said beam at a uniform rate and separately modifying the cross sectional area of said beam at intervals and transforming into sound waves the energy of the beam thus produced.

11. The method of producing sound waves which comprises producing a beam of ether waves, interrupting said beam at a uniform rate and separately modifying the cross sectional area of said beam at intervals, transforming into fluctuating electric current the energy of the beam thus produced and transforming the energy of the electric current into sound waves.

12. The method of producing musical sounds which includes producing a plurality of interrupted light beams of different constant frequencies of interruption, selecting and varying them in intensity and duration, and in translating said interrupted light beams into musical sounds.

13. A method of producing a musical composition which consists in producing a series of beams of radiant energy, each said beam having a constant frequency of interruption, there being a frequency of interruption corresponding to the frequency of every tone and overtone of the composition to be produced, successively selecting said beams and combinations thereof whose frequencies are necessary to the production of successive tones and combinations of tones of the composition to be produced, and translating said beams and combinations thereof into corresponding tones and combinations thereof.

14. A combination of devices for use in producing music including an element whose impedance to electrical current changes with a frequency corresponding to the frequency of interrupted radiant energy impinging thereupon, means for successively causing interrupted radiant energy of different frequencies and combinations of frequencies to impinge upon said element, an electric circuit in which said element is located, and a thermionic amplifier so associated with said circuit as to amplify current changes therein.

15. In combination, a source of radiant energy, a space discharge device having an input circuit, radiant energy sensitive means operatively related to said input circuit, an element between said source and said sensitive means for variably controlling the radiant energy from said source, and sound producing means controlled by said device.

16. In combination, a source of radiant energy, a space discharge device, a radiant energy sensitive means for controlling the discharge current of said device, a moving record upon which said radiant energy impinges for variably controlling the quantity of radiant energy falling upon said sensitive means from said source, and sound producing means controlled by said device.

In witness whereof I hereunto subscribe my name this 6th day of November, A. D. 1916.

HENDRIK JOHANNES van der BIJL.