Dec. 21, 1948. V. K. ZWORYKIN ET AL 2,457,099

ELECTRONIC READING AID FOR THE BLIND

Filed June 8, 1946

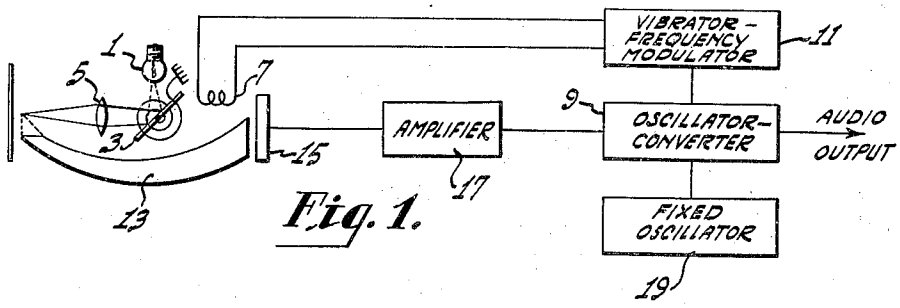


Fig. 1.

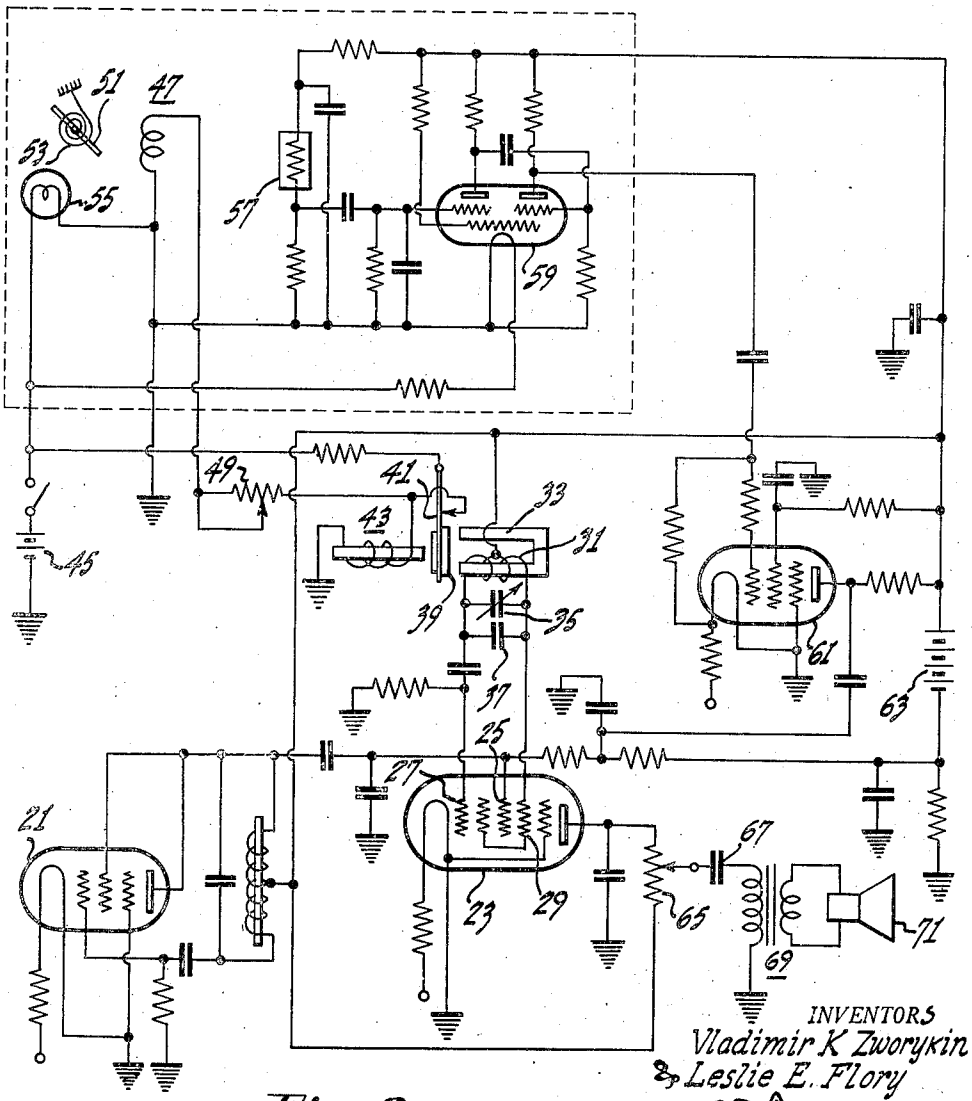


Fig. 2.

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Patented Dec. 21, 1948

2,457,099

UNITED STATES PATENT OFFICE

2,457,099

ELECTRONIC READING AID FOR THE BLIND

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Application June 8, 1946, Serial No. 675,506

7 Claims. (Cl. 250—41.5)

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This invention relates to electronic reading aids for the blind and particularly to an improved apparatus for concurrently and synchronously modulating the frequency of the audio tone, which is used to identify the position of the black areas constituting the letters, while sweeping the scanning light across the printed line. A further object of this invention is to provide an improved electronic reading aid which is completely portable and which requires no alternating current supply.

In a copending application, Serial No. 560,472, filed October 26, 1944, now Patent Number 2,451,014, Zworykin and Hillier describe and claim an electronic reading aid, known sometimes as an Optophone, in which a vibratory member having a spot-producing slit is driven by an alternating current magnetic field to (*a*) cause a spot of light to scan the printed line, and (*b*) vary the frequency of the oscillator used to produce the variable beat note which identifies the position of the spot of light. This system has the disadvantage that a source of 60 cycle alternating current is required. Also the use of a fixed and an angularly disposed movable slit for producing a scanning spot has the disadvantage that the mechanical movement must be nearly as great as the scanning distance, so that the end of the reed vibrates through a considerable angle and the reed must be quite long. It is, therefore, a still further object of this invention to produce a simple, compact and portable Optophone which is free from these disadvantages.

In brief, the improved device utilizes an intermittent contact vibrator which is driven by a small battery. The armature carries a powdered iron element which is located in the magnetic field of a coil whose inductance controls the frequency of one of two beat oscillators. Light is focused on the page by a small mirror adapted to be vibrated about an axis in such a way that the light spot scans the page in the required vertical direction. The mirror is driven by a coil coupled to the vibrator coil and actuated by the pulsating voltage developed across the vibrator. This voltage is, of course, determined by the movement of the vibrator armature, and therefore the frequency modulation is synchronized with the movement of the light.

The novel features that are considered characteristic of this invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and method of operation, as well as additional objects and advantages thereof, will best be

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understood from the following description when read in connection with the accompanying drawings, in which;

Figure 1 is a block diagram of the essential components shown schematically in Figure 2, and

Figure 2 is a schematic diagram of a device made in accordance with this invention.

Referring to Fig. 1, a small spot of light is caused to move up and down along a vertical line which crosses the line of print by means of a lamp 1, mirror 3 and lens 5. The mirror is of a polished magnetic material, or of glass. In the latter case the mirror should be mounted on a magnetized plate. The mirror is so positioned that it can be acted on by the magnetic field produced by coil 7.

In synchronism with the motion of the light spot the oscillator portion of an oscillator-converter tube 9 is frequency modulated by a vibrator-frequency modulator 11, which also provides the energizing current for coil 7. The movement of the mirror is arranged so that the frequency is high when the spot is at the top of the line and low when the spot is at the bottom of the line. The light reflected from the page is picked up by a "Lucite" member 13 and applied to a photoelectric device 15 and then to an amplifier 17. A fixed frequency oscillator 19 and the amplifier 17 are connected to the converter, the former to produce an audio beat note proportioned to the difference in frequency between the two oscillators, and the latter so as to control the amplitude of the output in such a manner that a signal is produced only when the spot is on a black area. Thus the frequency of the tone will depend upon the position and extent of the black area being scanned. If the black area has a large vertical dimension, the audio frequency will vary appreciably during the period it is applied to the ear, giving a warbled character to the tone, the range of the frequency variation being a measure of the vertical extent of the black area. As the lines of letters are manually scanned horizontally along the line, audible information is thus obtained as to the number, the size, and position of black areas under the light at any position of the instrument. The variation of the sound represent these characteristics as the letters and words are scanned successively.

The frequency of vertical scanning is determined by the reading speed. If, for example, a reading speed of sixty words per minute is assumed, the letter frequency would be three hundred per minute or five per second, on the

basis of the standard five letter word. If it is assumed further that a minimum of five complete scans would be necessary to make sure of complete coverage of the letter, then the minimum scanning speed would be twenty-five cycles per second. In the instrument described, the actual scanning frequency is thirty per second. The lower limit of the audio frequency is set by the minimum duration of tone which may be expected. The upper frequency is limited fundamentally by the limit of audibility; practically by the usual limits of frequency response of components in the small sizes necessarily used. In the instrument described, the upper frequency is approximately 4000 cycles.

If the vertical extent of the smallest portion of a letter to be identified such as the top bar of an *n* or *m* is taken as 15 percent of the maximum height of a letter, then the duration of this sound will be, at the 30 cycle (60 scans) rate:

$$\frac{1}{60}\times\frac{15}{100}=\frac{1}{400}\text{ sec.}$$

Then the lowest frequency that can be used to obtain even one full cycle per scan will be 400 cycles.

With such a short duration, the sounds lose their tonal character, at least 4 to 12 cycles being necessary to recognize a sound as a tone in this frequency range. There is, however, a distinct difference between a sound of 1/400 second duration at 400 cycles and one of the same duration at, say, 2000 cycles; the first being popularly described as a "thump" and the latter taking on the character of a "click." Longer durations as represented by the vertical parts of an "*n*" of course take on a more tonal character.

The instrument is preferably composed of two parts; the stylus which is held in the hand and moved along the lines, and a small case containing the batteries and auxiliary apparatus. The elements shown within the dotted line in Fig. 2 are preferably contained within the stylus. A miniature dual pre-amplifier tube is used to conserve space.

The circuit connections are shown in Fig. 2. The audible frequency is produced by conventional beat-frequency methods. Tube 21 is a fixed frequency oscillator which is coupled to the third grid 25 of the convertor-oscillator tube 23. The oscillator frequency is of the order of 50 kc. The variable frequency oscillator utilizes the first grid 27 and second and fourth grids 29 of tube 23. The frequency controlling circuit includes a coil 31 mounted on a U-shaped laminated iron core 33 and tuned to the desired frequency by shunt capacitors 35, 37. Adjacent the open ends of core 33 there is an element of powdered iron 39 mounted on the armature 41 of a vibrator 43 so that the iron element swings very close to the core 33 at the extremity of its outward movement. This alters the reluctance of the magnetic path passing through coil 31 and thus varies the frequency of the oscillator. A ten percent variation in inductance of coil 31 at 50 kc. can easily be obtained by this method with sufficient safety factor to make sure that the armature does not strike the core. The variation of inductance with position of the armature is very nearly logarithmic over the useful range, but the actual curve is influenced to some extent by the shape of the armature and the pole pieces.

An intermittent contact type vibrator 43 is energized by a small storage cell 45. The mirror driving coil 47 is connected in parallel with the vibrator through a variable resistor 49 which is used to control the amplitude of vibration of the mirror. This permits easy adjustment of the length of the scanning line. Since the voltage across the vibrator is determined by the movement of the armature 41, the frequency of the variable frequency oscillator is modulated synchronously with the movement of the mirror, and hence of the spot of light. The mirror 51 is preferably held in normal position by a hairspring 53, and may be weighted so that its natural period of oscillation will coincide with the scanning frequency, that is, with the frequency of the vibrator 43. Lamp 55 is preferably a small aircraft indicator type lamp.

The light reflected from the paper is collected by the "Lucite" conductor 13 and applied to a photosensitive element 57, which may be a photoresistive or photoemissive cell. The output of this cell is amplified by a two-stage hearing aid type tube 59, and then by a further pentode amplifier 61 in the carrying case. The overall voltage gain is approximately 3000. The gain of the two-stage amplifier 59 is about 300 so that the signal level in the connecting cable is quite high, preventing any trouble from microphonics, pick-up, etc.

Battery 45 supplies power to all tube filaments, the lamp 55 and vibrator 43. For most economical operation this battery is preferably a 10 a. h. storage cell. Plate voltage is supplied by a 67½ v. dry cell 63.

The output circuit consists of a volume control potentiometer 65 followed by a high pass filter 67 and step-down transformer 69 feeding a hearing aid type headphone 71. The purpose of the high pass filter is to remove any of the 30 cycle modulating frequency remaining in the signal. Grid 25 of the converter oscillator tube 23 is maintained at a normally negative potential which is sufficiently large to prevent current flow in the absence of a signal from amplifier 61. A positive pulse from photocell 57 applied to grid 25, through the amplifier, permits signal to reach the output circuit only when the scanning spot is on a black part of the print.

What we claim is:

1. In a reading aid having a variable frequency oscillator and a light source for scanning a line of printed matter, the combination of an intermittent contact vibrator having a vibratable armature, a reactance element which controls the frequency of operation of said oscillator, means including said armature for varying the reactance of said element in accordance with the movement of said armature to thereby modulate the frequency of said oscillator, and means controlled by said vibrator for moving a beam of light from said source so as to scan said line of printed matter in synchronism with the modulation of the frequency of said oscillator.

2. In a reading aid, the combination including a fixed frequency oscillator and a variable frequency oscillator, said variable frequency oscillator including a reactance element; an intermittent contact vibrator having a movable armature; means including said armature for varying the reactance of said element; means for producing a spot of light; means synchronized by said vibrator for moving said spot of light across an area; means for combining oscillations produced by said fixed and said variable frequency oscillators to produce a beat note, and means for varying the

intensity of said beat note in accordance with the amount of light reflected from the said area, whereby the frequency and amplitude of said beat note defines the reflectance of points along said area.

3. A device of the character described in claim 2 in which said means synchronized by said vibrator for moving said spot of light includes a mirror and a coil connected to said vibrator for producing a magnetic field which vibrates said mirror.

4. A device of the character described in claim 2 in which said reactance element comprises a coil the inductance of which is varied by said armature.

5. In a reading aid, the combination including a fixed frequency oscillator and a variable frequency oscillator, said variable frequency oscillator including a reactance element; an intermittent contact vibrator having a movable armature; means including said armature for varying the reactance of said element; means including a vibratable mirror for focusing a spot of light on a surface to be scanned; means for vibrating said mirror in synchronism with said vibrator; means for combining oscillations produced by said fixed and said variable frequency oscillators to produce a beat note; and means for varying the intensity of said beat note in accordance with the amount of light reflected from said surface, whereby the frequency and amplitude of said beat note defines the reflectance of points along said surface.

6. In a reading aid, the combination including a fixed frequency oscillator and a variable frequency oscillator, said variable frequency oscillator including an inductor for determining the frequency thereof, an intermittent contact vibrator having a movable armature, means carried by said armature and cooperating with said inductor to vary the frequency of said variable frequency

oscillator, means including a vibratable mirror for focusing a spot of light on an area to be scanned, a coil associated with said mirror and connected to said vibrator for vibrating said mirror in synchronism with the movement of said armature, means for combining oscillations produced by said fixed and said variable frequency oscillators to produce a beat note; and means for varying the intensity of said beat note in accordance with the amount of light reflected from the said area, whereby the frequency and amplitude of said beat note defines the reflectance of points along said area.

7. A device of the character described in claim 6 in which said inductor is mounted on a laminated iron core and said armature carries a powdered iron element which cooperates with said core to vary the inductance of said inductor.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,320,366	Houskeeper	Oct. 28, 1919
1,350,954	Stroud et al.	Aug. 24, 1920
1,352,940	Brown	Sept. 14, 1920
1,848,882	Hausrath et al.	Mar. 8, 1932
1,873,926	Centeno V.	Aug. 23, 1932

OTHER REFERENCES

"Reading Aid for the Blind," by V. K. Zworykin and L. E. Flory, RCA Labts., Radio Corp. of America, Princeton, N. J.