Sept. 15, 1936.

W. W. FULLER

2,054,216

SYNTHETIC SPEECH MACHINE

Filed July 6, 1935

3 Sheets-Sheet 1

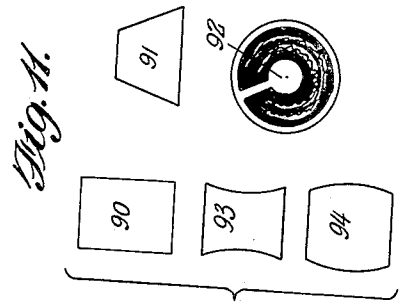


Fig. 4.

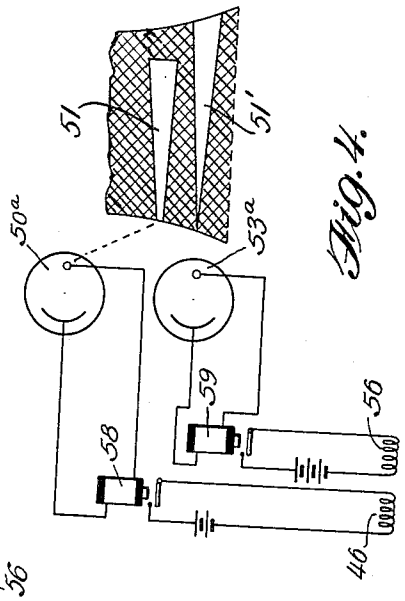


Fig. 1

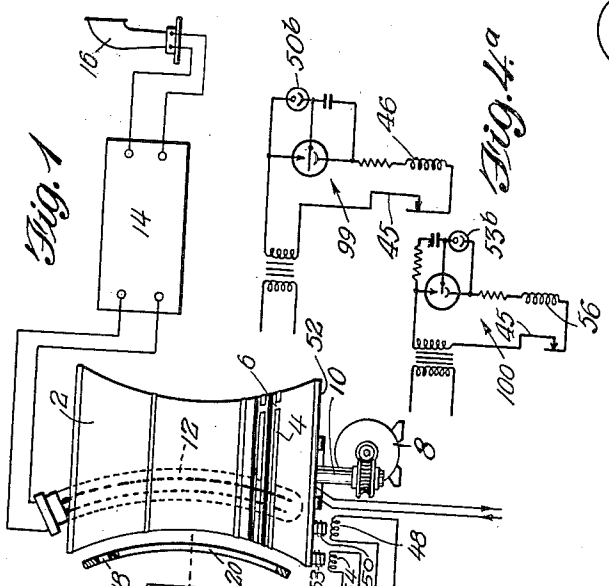


Fig. 4a

Fig. 2.

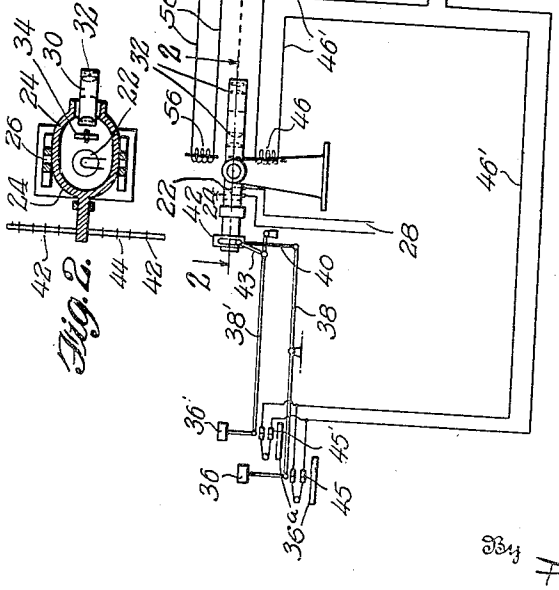
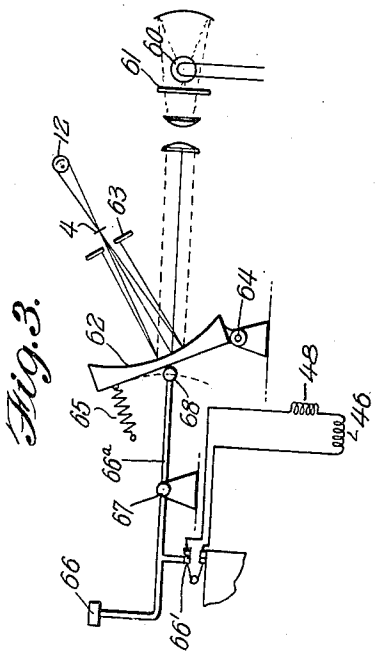


Fig. 3.



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Fig. 6.

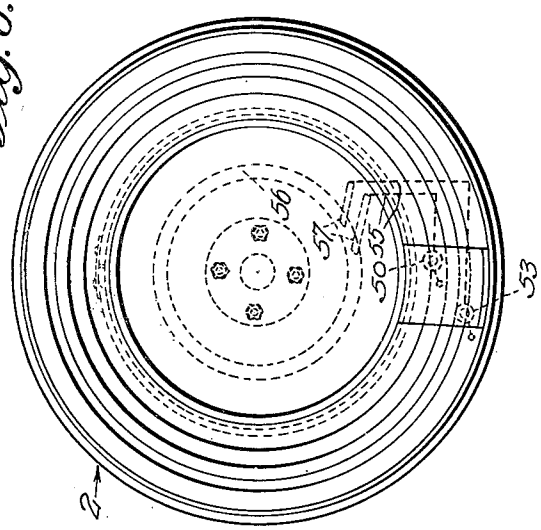


Fig. 5.

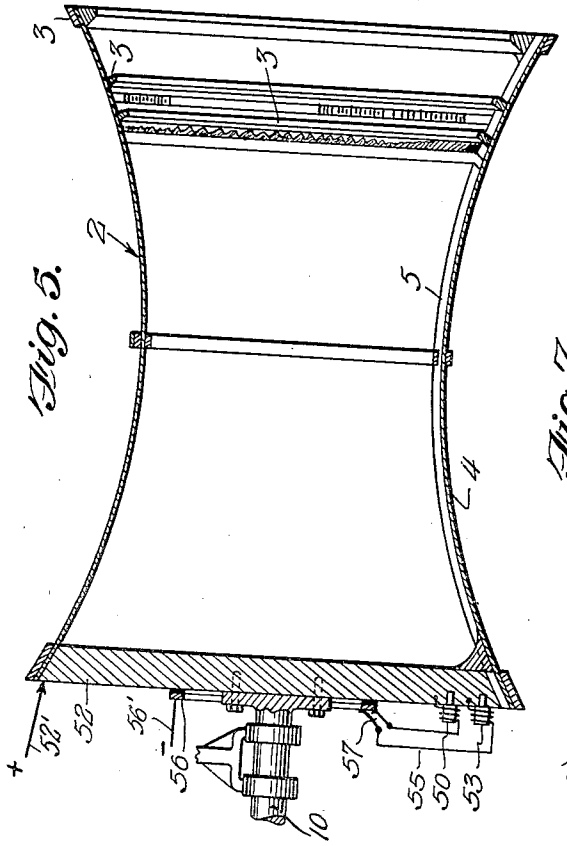
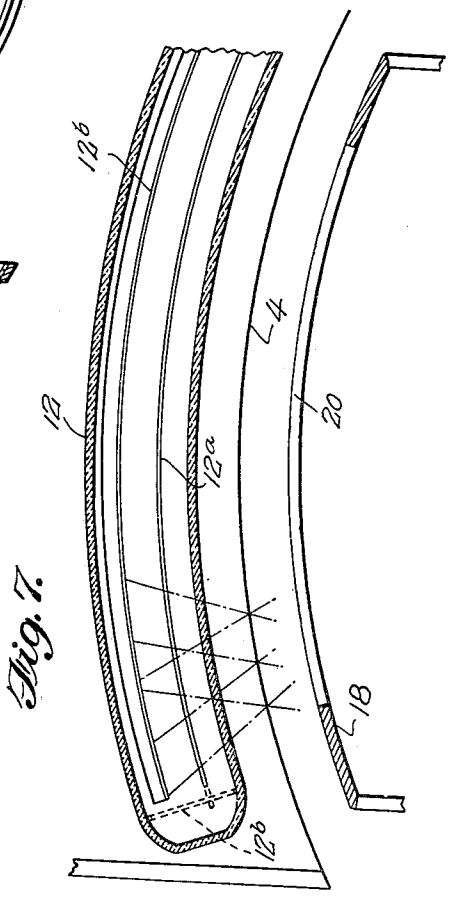


Fig. 7.



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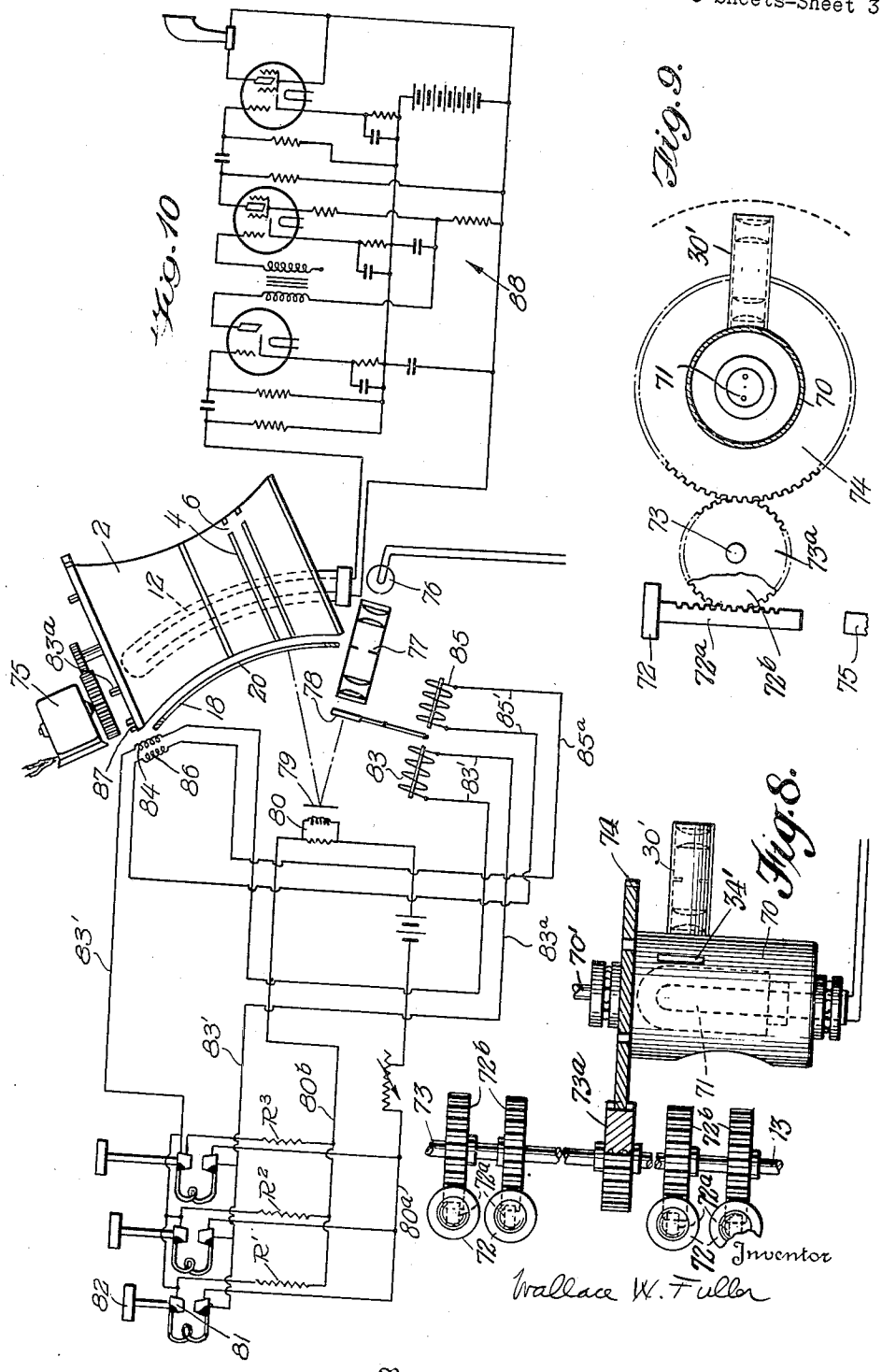
W. W. FULLER

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SYNTHETIC SPEECH MACHINE

Filed July 6, 1935

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Patented Sept. 15, 1936 2,054,216

UNITED STATES PATENT OFFICE

2,054,216

SYNTHETIC SPEECH MACHINE

Wallace W. Fuller, New York, N. Y.

Application July 6, 1935, Serial No. 30,201

11 Claims. (Cl. 274—46)

This invention is a method and machine for producing sounds. The invention utilizes the known principle of light passing through a photographic sound track on a film or the like, in motion. The sound track, as in the talking motion picture is of a density, area or contour photographically modulated for the sound it is to produce.

The invention, being concerned only with producing sounds of the spoken voice, may be termed a synthetic speech machine, in that by producing sounds of the letters of the alphabet, vowels, consonants, diphthongs, etc., in proper sequence and time relationship words may be built up from such elemental sounds. It is of particular value to the dumb as a means of communication, for example, in making themselves articulate over the telephone.

This invention comprises, in its essentials, a manually operable keyboard, preferably arranged in a manner of the keys on a typewriter, which through either mechanical or electrical means, or both, directively controls a beam of light onto any of a plurality of photographic sound tracks. The beam of light, after passing through the appropriate sound tracks, in proper sequence as determined by the operation of the keys on the keyboard, passes to a photoelectric cell, setting up therein currents having the characteristics of the corresponding modulation of the sound track, which currents are electrothermionically amplified, as is well understood in the art, to produce sounds from a loud speaker corresponding to the keys and sound records.

One of the important features of the invention is a record cylinder that may be driven at constant speed, this cylinder being made of suitable material and carrying prerecorded sound tracks corresponding to the various phonetic sounds or letters of the alphabet that go to make up words. An important feature of the invention is that these sound tracks are not continuous but on the contrary have definite starting and stopping points. This is necessary because any sound, say that of the letter *h*, for example, has a definite starting and stopping point and a definite duration. The duration of the sound is controlled by making the sound track of the proper length, considered with respect to its placement in the control member.

In one embodiment of the invention, the rotating control member is not a true cylinder, but may have a convex or concave surface, so that its radius varies slightly continually from one end to the other; a section through the rotating control member would be a circle. The rotating member may be in the form of a disk. In any case rotation is used to produce modulation of a beam, pencil or slit of light. It is well known that optical reduction printing, or variable speed or intensity recording, or geometrical optical means may be employed to simplify construction and functioning of such machines. Variable speed of reproduction is also feasible if desired. The result of this is that sound tracks at various points along the cylinder would be of different lengths and accordingly the longer sounds would be on that part of the cylinder where its diameter is greatest while the shorter sounds would be at that part of the cylinder where the diameter is least with the other sounds arranged in between according to their length. The rotating member carrying the sound tracks may also be in the form of a disk, with the sound tracks concentric about its center.

In order to scan the different sound tracks, a light ray is controlled by suitable means, either electrical or mechanical, so that it is directed or reflected onto the appropriate sound track, passing through that sound track into contact with a photo-electric cell, where it sets up currents which are suitably amplified and delivered to a loud speaker which gives off a sound corresponding to a pre-recorded sound track and corresponding key. In one form of the invention where the control of the light rays is electrical, light from a suitable source is directed onto a mirror controlled by a galvanometer which deflects the ray according to the strength of the current passing through the galvanometer and in this way the ray is directed through the appropriate sound track.

Where the light ray is controlled mechanically, a mirror may be moved angularly by suitable mechanical means through a suitable angle for directing and/or focusing the light ray onto the proper sound track from whence it passes to the photo-electric cell as before.

In another aspect of the mechanical control of the light, a barrel or the like through which a light ray is passed is moved through a suitable angle for directing and focusing the light ray onto the appropriate sound track.

The purpose of both the electrical and mechanical control is simply to direct the light ray angularly onto the appropriate sound track.

This directional control of the light ray is effected manually from a keyboard where each key corresponds to a particular sound, or to a particular sequence of sounds, such as a sound

of a letter of the alphabet, phonetic speech sounds such as phones, diaphones and phonemes. The keys of this keyboard are preferably arranged in the same way as the keys in a standard typewriter keyboard. Their markings are letters or phonetic symbols.

The invention further comprises details of structure and operation illustrated and described in connection with the accompanying drawings, showing, more or less diagrammatically, several possible ways of carrying out the invention. In these drawings:

Fig. 1 is a diagrammatic view, showing the complete apparatus, where the connection between the keyboard and the light directing elements is mechanical;

Fig. 2 is a section on the line 2—2 of Fig. 1;

Fig. 3 is a diagrammatic view showing another type of mechanical control of the light directing means;

Fig. 4 is a diagrammatic view of a modified detail;

Fig. 4a is an electronic control detail;

Fig. 5 is a sectional view through one form of sound track carrier;

Fig. 6 is an end view of the same;

Fig. 7 is an enlarged sectional view through the rotating sound track carrier and associated parts;

Fig. 8 is a view of a modification;

Fig. 9 is a sectional view of the modification of Fig. 8;

Fig. 10 is a diagrammatic view showing a complete apparatus where the keyboard is electrically operated; and

Fig. 11 is a diagrammatic view showing several possible shapes for the rotating carrier for the sound tracks.

Referring first to Fig. 1, the carrier or the "cylinder" for carrying the sound track is shown at 2. This member 2 is not a true cylinder but varies in diameter as shown, its exterior surface being concave as shown in Fig. 1, although such exterior surface may be convex as will be described later. Other shapes for this sound track carrier are shown in Fig. 11. One shape for the carrier is as shown in Fig. 5, which may be defined as that of a surface of revolution generated by the segment of a circle rotated about an exterior axis parallel to the chord of the segment. This member 2 is made of transparent material such as glass, photographic film, etc., and carries on its surface a plurality of sound tracks or strips of film carrying sound tracks 4, each sound track 4 being designed to reproduce a particularly previously recorded speech sound. These sound tracks are not continuous but are broken as shown at 6 for providing definite starting and stopping points for each sound. Member 2 is reenforced by inner and outer annular bands 3 and a longitudinal stiffening strut 5.

This sound track carrier is rotated at constant speed by a suitable constant speed motor 8, which is geared to the shaft 10 of the cylinder 2.

The speed of translation of sound film commonly used in the talking motion picture art is an arbitrary value representing not the optimum speed but merely a compromise with the speed of the picture sequences which is based upon the persistence of vision of the human eye.

Therefore, variable speeds of recording can be used in a purely sound apparatus making it possible to rotate a record, bearing a plurality of sound tracks of different radii, at a constant speed.

Varying optical reduction printing for individual sequences may be resorted to and achieve a similar result.

Variable speed control for the motor is an alternate method of accomplishing the motion.

Arranged within the cylinder and concentrically with or parallel to its walls is diagrammatically shown a photo-cell 12, in such a position that a ray of light coming from the outside and passing through the sound tracks will excite the cell which is connected to an amplifier 14 of well known type and the sounds are emitted from a loud speaker 16. This may well be a number of small cells in parallel. The anode 12^a of the cell is supported by a mica disk 12^b. Anode 12^a and cathode 12^b are substantially concentric with and curved so as to be parallel to the surface of the rotating member 2.

A mask 18 also concentric with the curvature of the cylinder 2 is arranged exteriorly thereof and is provided with a slit or apertures 20 for directing light from the light source 22 onto a particular sound track 4.

A means for directing light from the source 22 at a particular angle and through a particular sound track will now be described. The light source 22 is mounted in a suitable housing 24 which is pivoted about an axis through the trunnions 26. Power is supplied to the light 22 from the wires 28.

In one end of the housing there is mounted a barrel 30 provided with a lens system diagrammatically shown at 32 and which may comprise a condenser and objective for producing a pencil of light. Any suitable optical system may be used here. Additional lenses could, for example, be mounted in the aperture 20. Interposed between the light source 22 and the barrel 30 is a shutter 34, the control of which will be described later.

A mechanical means for moving the housing 24 and barrel 30 about its axis will now be described.

A plurality of keys 36 and 36', arranged as in a typewriter keyboard, are respectively connected to levers 38 of the first class or 38' of the second class. Each lever of the first class is connected to an arm 40 terminating in a slotted plate 42, which are arranged on one side of the housing 24, while the levers of the second class are connected to arms 43 which terminate in similar slotted plates on the other side of the housing 24. A bar 44, carried at the left end of the housing 24, passes through all the slots in the slotted plates 42, the slots providing a lost motion connection between the bar 44 and the slotted plates. Referring to Fig. 1, when the keys 36 operating the first class levers are pressed, barrel 30 is moved down a distance depending upon the key pressed, this distance being determined by the length and vertical positions of the slots in the plates or members 42. When the keys 36' operating the second class levers are pressed, barrel 30 is moved up a distance depending upon the key pressed, and depending upon the length of the slot in the corresponding plate 42. In other words, each key 36 or 36', when pressed, will move the barrel 30 an angular amount, downwardly or upwardly, respectively, individual to that key. The lost motion connections provided by the slots in plate 42, allow such movement of bar 42 and housing 24.

It is important, while the light is being moved from one angular position to another, that it does not engage the several sound tracks, as evidently this would produce a medley of sound. Various

means of control circuits for this purpose will suggest themselves to one skilled in the art. The means shown below is illustrative only, and I do not wish to be limited to the specific means disclosed. To prevent this medley, there is provided a shutter 34 shown diagrammatically in Fig. 2 which is operable so as to move out of the light path 32, or to intercept it, so as to control the passage of the light. To this end there is provided a solenoid diagrammatically shown at 46, which when energized, moves shutter 34 out of the path of the light ray and allows it to pass through the barrel 30 only when a key 36 or 36' is depressed. Associated with each key 36, 36' are individual switches 45, which are in parallel, and in series with solenoid 46, so that depression of any key closes a circuit through 46. Suitable stops 36a for the keys are provided. However, solenoid 46 is also in series with a coil 48 which is mounted adjacent one end of the member 2 in a position such that a magnet 50 on the moving end plate 52 of member 2 will induce a surge of current in this circuit. The magnets are so positioned with relation to the beginnings and ends in the sound tracks as to give a surge of current in their circuits just before the beginning and just at the end of each track and hence control the light beam for these points. This surge operates solenoid 46 provided a key 36 has been pressed. From this arrangement it will be seen that sound reproduction always commences at a definite point, namely, at the beginning of each sound track.

In order to stop the sound at its completion, a second magnet 53 is provided on the moving end plate 52 of carrier 2, so positioned as to cause a surge of current in a coil 54 in series with solenoid 56, thereby closing the shutter 34.

Referring to Fig. 5, the magnets 50 and 53 are preferably mounted on the end plate 52 and their coils are connected by wires 55 to brushes 57 which bear on a ring 56 insulated from the end member 52. The magnets are grounded through end plate 52. Brushes 52' and 56' supply current respectively to the end member 52 and ring 56 for continuously energizing the electro-magnets 50 and 53.

The control of the shutter 34 by photo-electric means will now be described. To this end and referring to Fig. 4, there is provided a photo-electric cell 50a, which is analogous in function to the magnet 50; it is placed in a position to receive light when the sound track 51 which varies in width. This photo-electric cell 50a, which may be of the photo E. M. F. type, actuates the relay 58, in the power circuit of which is the solenoid 46. A second photo-cell 53a is in a position to receive light through the sound track 51' of varying width and is in circuit with the relay 59, in the power circuit of which is the solenoid 56. Solenoids 46 and 56 control shutter 34, Fig. 2. The sound track 51 is so placed on carrier 2 that cell 50a is energized so as to energize solenoid 46 for opening the light shutter, when the ray of light reaches the beginning of a sound track, while the sound track 51' is so designed and placed as to actuate cell 53a and magnet 56 to close the shutter after the desired sound has been produced. Any suitable light source is provided for cooperation with sound tracks 51 and 51' and their cooperating photo-cells.

In place of relays 58 and 59, it will be apparent that electronic relays such as forward and reverse grid glow discharge, photo-electric, impedance potentiometer circuits could be used. Also in place of the special tracks shown, these relays may operate from any point on a recorded sound track as shown diagrammatically at Fig. 4a. These circuits for instance may be set to operate at a maximum or minimum light value, corresponding to the light transmitted through the recordings at any particular point along any photographic sound recording thus actuating the shutter at that instant. In Fig. 4a, 99 is the forward circuit and is in series with key switches 45 and solenoid 46; the actuating photo cell is shown at 50b; 100 is the reverse circuit and is in series with solenoid 56; the actuating photo cell is shown at 53b. These two photo cells are excited in the same way as cells 50a and 53a.

Another type of a mechanically operated selection mechanism, that is to say a mechanical means for directing the light ray onto a particular sound track is shown in Fig. 3. In this form, light from a source 60, which is controlled by shutter 61, passes onto a concave or focusing mirror 62 from whence it is reflected through the opening in a mask 63 through a sound track 4 and thence to a photo-electric cell 12. The mirror 62 is pivoted on an axis 64 and is retracted by spring 65. It may be set in any angular position by any one of a plurality of keys 66 pivoted at 67, the other end of the key lever having a roller 68. The depression of a particular key 66 moves the mirror through a certain angle, individual to that key, and also closes a circuit through contacts 66' for opening shutter 61, the operation of this shutter being by a coil 48 and solenoid 46 just as shutter 34 is operated in Fig. 2. The vertical movement and hence the angle of the mirror is determined by the length of extensions 66a which differ for each key.

Another type of mechanical selector is shown in Figs. 8 and 9. In this form, a housing 70 is freely movable on a vertical axis 70'. A light source 71 is mounted in the housing, the light beam passing outwardly through a lens barrel 30'. The angular setting of housing 70 and barrel 30' is effected through a plurality of manually operated keys 72, each of which is provided with rack and gear connections 72a, 72b. Gear wheels 72b are fixed to and control a shaft 73 which carries a gear 73a geared to a wheel 74 which in turn controls the angular movement of the housing 70. Each key 72 cooperates with a stop 75. The several stops 75 are placed different distances from their respective keys, so that when a given key is depressed it travels a particular distance to its stop. Each key therefore gives a different angular rotation to the housing 70 and to the light ray coming from the barrel 30'. The keys 72 are normally disengaged from their respective gear wheels 72b. With this form of the invention a shutter 34' is used, controlled just as in Fig. 2.

The modification shown in Fig. 10, in which the keyboard control is electrical, will now be described. In this form, many of the elements are the same as shown in Fig. 2 and have the corresponding function, and such elements are similarly numbered. The member 2 is driven by a suitable constant speed motor 75. Light from a source 76 passes through barrel 77 containing suitable lenses, past a control shutter 78, onto a galvanometer mirror 79, from which it is reflected through an aperture or slot in mask 18, into engagement with the appropriate sound track as determined by the angular position of the mirror 79. One purpose for which this mask

may be used is to provide means whereby the vibrations of the machine or slight wandering of the galvanometer may be eliminated. The rays of light striking the mask aperture may be of greater area than the aperture and thus allow for these factors. The galvanometer **80** is in circuit in parallel through leads **80a** and **80b** with one side of plurality of key switches **81** operated by keys **82**. A series of graded resistances R', R^2, R^3 etc., are in the individual key circuits, respectively, so that the depression of a particular key sends a current of particular value through the galvanometer, turning the mirror **79** an amount dependent upon the key pressed. The ohmic value of these resistances each give a definite value of current to produce different angular positions of the galvanometer mirror. The galvanometer is damped and of a type not affected by heat. Its action or period is appropriate for speech. A solenoid **83**, adapted to open shutter **78** when energized, is in circuit through leads **83'** with a key **82** and with a coil **84**, positioned adjacent the end plate of member **2** so that when a magnet **83a** on the rotating end plate of carrier **2** passes near it, such magnet creates a surge of current to actuate solenoid **83**, provided also that the circuit has been completed by depression of a particular key **82**.

Therefore, when a particular key **82** is depressed and when the magnet **83a** passes adjacent coil **84**, the shutter **78** is opened. Magnet **83a** is so positioned with relation to the breaks **6** in the sound tracks as to open the shutter only when the light ray from **79** engages with the beginning of the sound track, thus initiating the production of sound at the proper instant.

The shutter **78** is closed by a solenoid **85** which is in circuit through leads **85'** with another coil **86**, mounted in such a position that another magnet such as **87**, on the rotating carrier, will create a surge of current for closing of the shutter. Magnet **87** is so placed with relation to the sound tracks to close the shutter after the light ray has completed its traverse of a particular sound track.

Currents from the photo-electric cell will be amplified through a suitable amplifier circuit indicated generally at **88**, the output of which goes to a loud speaker.

Fig. 11 shows several possible shapes for the transparent rotating carrier for the sound tracks to intercept or modulate a beam of light. The carrier may be cylindrical as shown at **90** or in the shape of a frustrum of a cone, as shown at **91**, or in the form of a disk, as shown at **92**. Each of these forms will have sound tracks with definite starting and stopping points and each may have a light source positioned on one side of the sound tracks, with a photo-electric cell or cells on the other side. With the concave cylinder as shown at **93**, the light would be on the outside with the photo-electric cell on the inside, while in the convex cylinder shown at **94**, the reverse arrangement is used.

The interspaces between and around the translucent sound recordings do not permit the passage of light, as shown at **92**, Fig. 11. It is part of this invention that such method may be used to effect rapid action in any of the shapes of record bearing mediums illustrated.

I have illustrated several different means of directional selection.

It should be apparent to anyone versed in the art that electrical selection might be substituted for optical or mechanical selection and that resistors and filters could be substituted in the electrical network controling the selection mechanism, and thus actuate or effect selection through the multiple frequency method of alternating electrical currents to produce sounds.

While the invention has been described in some detail, it should be understood that such details are merely illustrative, but are not restrictive of the invention; it may be carried out in other ways, as falling within the scope of the following claims.

I claim as my invention:

1. An apparatus for manually producing speech sounds comprising a keyboard, a plurality of prerecorded photographic sound tracks mounted on a rotating member, a source of light, means, controlled by the keyboard, for selectively directing the light beam from said source to the several sound tracks, photo-electric means and cooperating amplifier, actuated by the light beam after modification by a sound track, and means on the rotating member operating jointly with said keyboard, for initiating the production of sound when the light beam reaches a definite point in the rotation of any given sound track.

2 A machine for producing speech, comprising in combination a continuously rotating member provided with sound tracks thereon, a source of light, keyboard-controlled means for selectively directing the beam from the light source onto the several sound tracks, photo-electric pick-up and amplifying means cooperating with the several sound tracks, and means on the rotating member operating jointly with said keyboard-controlled means for initiating the production of sound only when the light beam reaches a definite point on any given sound track.

3. A machine for producing speech, comprising in combination a continuously rotating member provided with phonetic sound tracks thereon, said sound tracks being provided with definite starting and stopping points, a keyboard, means controlled by the keyboard for selectively directing a beam of light onto the several sound tracks, photo-electric pick-up and amplifying means cooperating with the several sound tracks and means on the rotating member operating jointly with the keyboard for initiating the production of sound when the light beam is at the beginning of a particular sound track.

4. A machine for producing speech, comprising in combination a continuously rotating member provided with phonetic sound tracks thereon, said sound tracks being provided with definite starting and stopping points, a keyboard, means controlled by the keyboard for selectively directing a beam of light onto the several sound tracks, photo-electric pick-up and amplifying means cooperating with the several sound tracks and means on the rotating member operating jointly with the keyboard for initiating the production of sound when the light beam is at the beginning of a particular sound track and for stopping the production of sound when the light beam has reached the stopping point for that sound track.

5. In a machine for producing speech sounds synthetically, in combination, a manually operated keyboard, a rotating control member provided with sound tracks thereon, said sound tracks having definite starting and stopping points, means controlled by the keyboard for selectively directing a beam of light onto said sound tracks and means, carried by the rotating member and cooperating with the light-directing means, for initiating the production of sound from any given

sound track only from the starting point of that sound track.

6. In a machine for producing speech sounds, in combination, a manually operated keyboard, a continuously rotated control member provided with sound tracks thereon, said tracks being non-continuous and provided with starting and stopping points, means, controlled by the keyboard, for selectively and sequentially directing a beam of light onto the respective sound tracks, photo-electric pick-up means and cooperating sound amplifier, means, jointly controlled by the keyboard and by the rotating control member, for initiating the production of sound from a particular sound track only when the beam of light engages the starting point of that sound track.

7. In a machine for producing speech synthetically, a manually operated keyboard, a continuously rotating member, in the shape of a solid of revolution, the radius of which varies gradually and continuously along its axis, sound tracks on said rotating member, said tracks having definite starting and stopping points, means, controlled by the keyboard, for selectively directing a beam of light onto the several sound tracks, photo-electric cell means for picking up the light beam after it has passed through a particular sound track, and means, controlled by the rotating member, for allowing the beam of light to reach the photo cell only when said beam engages a sound track at the beginning thereof and traverses its length.

8. A method of producing speech sounds synthetically, comprising the steps of manually controlling the angular position of a beam of light, for selectively causing it to pass through photographically recorded, moving sound tracks onto a light sensitive cell, and controlling the light ray so that it acts on the light sensitive cell only when it engages the beginning of the sound track, and then scans the sound track.

9. An apparatus for manually producing speech sounds comprising a keyboard, a plurality of prerecorded photographic sound tracks mounted on a rotating member, a source of light, means, controlled by the keyboard, for selectively directing the light beam from said source to the several sound tracks, photo-electric means comprising an elongated photo-electric cell extending for the length of said rotating member, an amplifier cooperating with said cell, and means for initiating the production of sound when the light beam reaches a definite point on any given sound track.

10. An apparatus for manually producing speech sounds comprising a keyboard, a plurality of prerecorded photographic sound tracks mounted on a rotating member having a curved surface, a source of light, means, controlled by the keyboard, for selectively directing the light beam from said source to the several sound tracks, photo-electric means comprising an elongated photo-electric cell having an anode and cathode curved so as to be parallel to the surface of the rotating member, and extending lengthwise thereof, an amplifier cooperating with said cell, and means on the rotating member for initiating the production of sound only when the light beam reaches a definite point on any given sound track.

11. In a machine for producing speech sounds, a continuously rotating carrier having the shape of a surface of revolution generated by a segment of a circle rotated about an exterior axis parallel to the chord of the segment, a plurality of sound tracks on said carrier, a keyboard, means controlled by the keyboard for selectively directing a beam of light onto the sound tracks, and means on said carrier operating jointly with the keyboard, for initiating the production of sound at a definite point in the rotation of the carrier.

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