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[54] **SYNTHESIS OF SPEECH FROM A MAGNETIC TAPE MATRIX STORAGE OF PHONETIC SEGMENTS**

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[51] **Int. Cl.** **G10l 1/00**

[58] **Field of Search**.....179/1 SA, 1 AL; 340/407, 340/384 E, 152 R; 35/35 C

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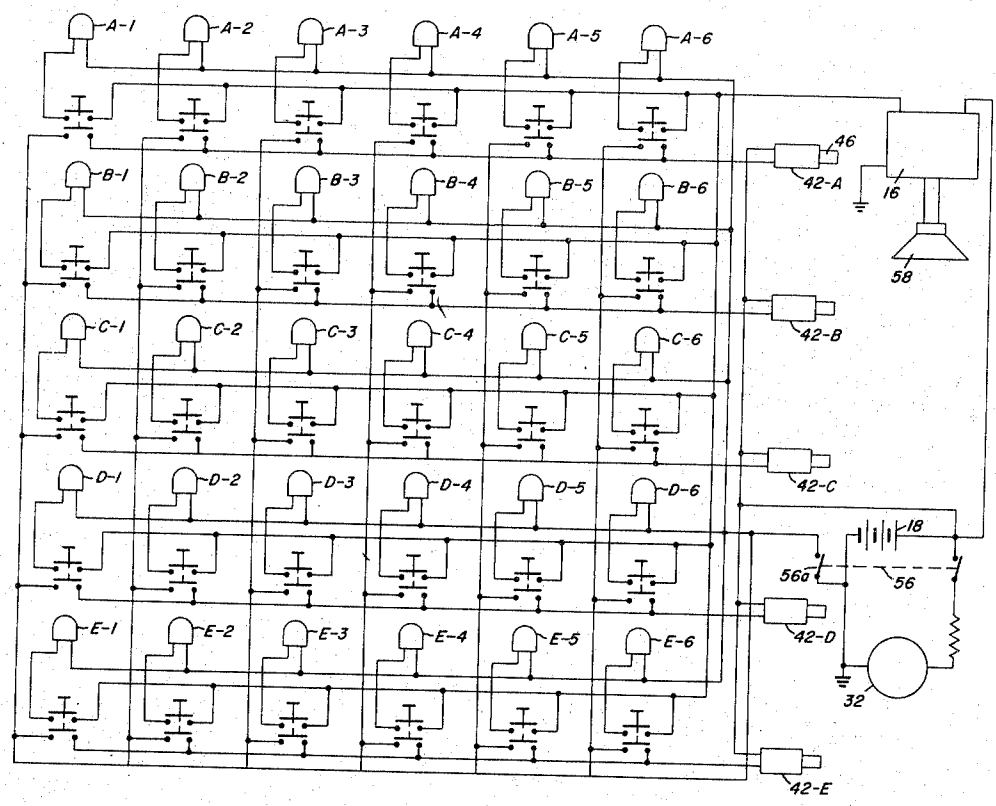
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[57] **ABSTRACT**

Phonetic sounds are recorded on several magnetic tapes, each tape storing a number of different phonetic sounds. A matrix of magnetic heads reads the tapes. Multiplexing of the signals from the heads is obtained and the phonetic sounds thereby combine to produce speech by a key board adapted to be worn by the user. When a key is depressed, the tape, on which is recorded phonetic sounds corresponding to the key, is driven. One of the heads reads the segment of the driven tape on which the selected sound is recorded. The outputs of the heads are combined in a play-back amplifier and fed to an external speaker which may be worn, as on the neck of the user. The user may be a person whose larynx has been removed.

17 Claims, 6 Drawing Figures



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SHEET 1 OF 3

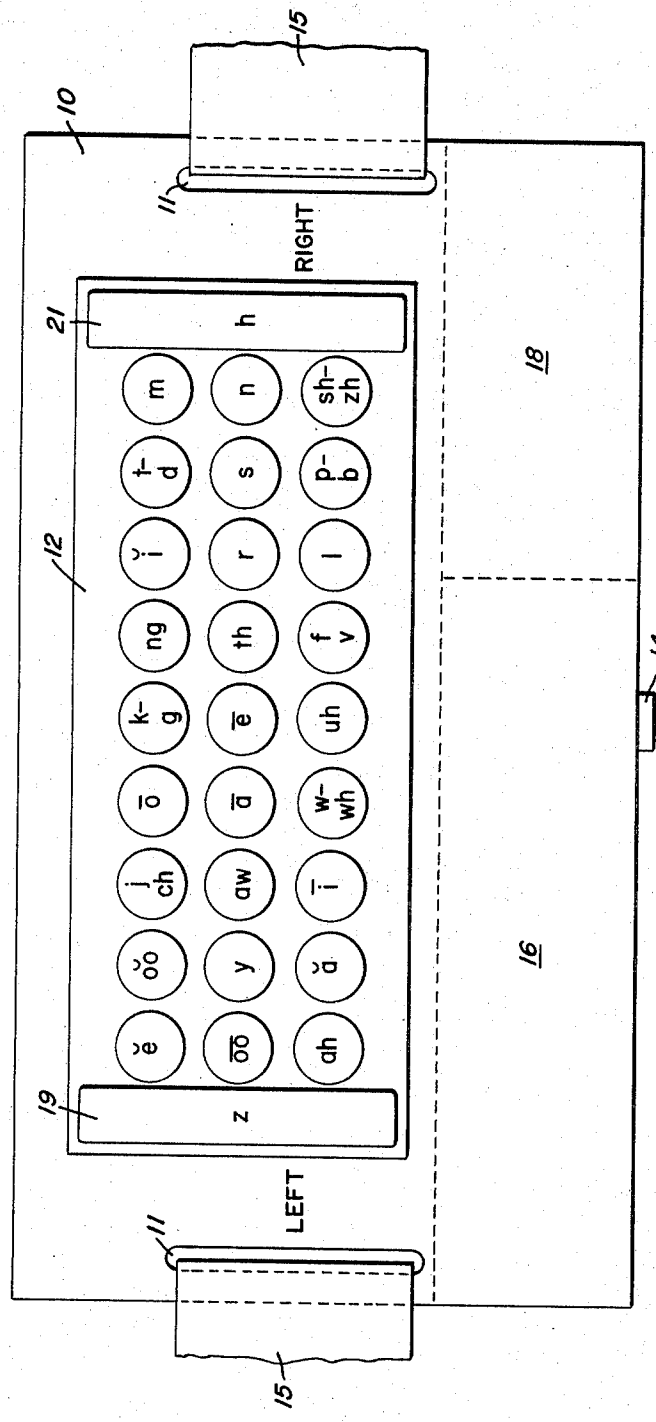


FIG. 1.

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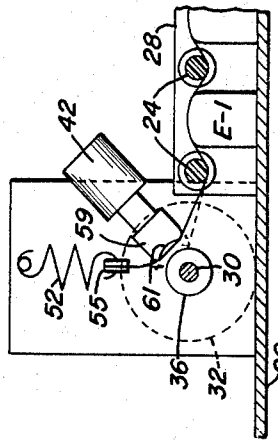


FIG. 3B.

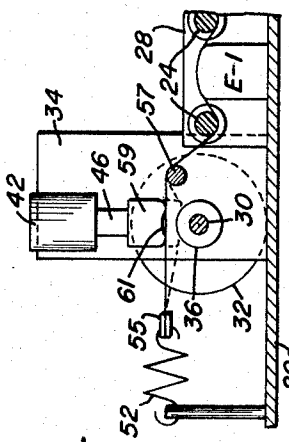


FIG. 3A.

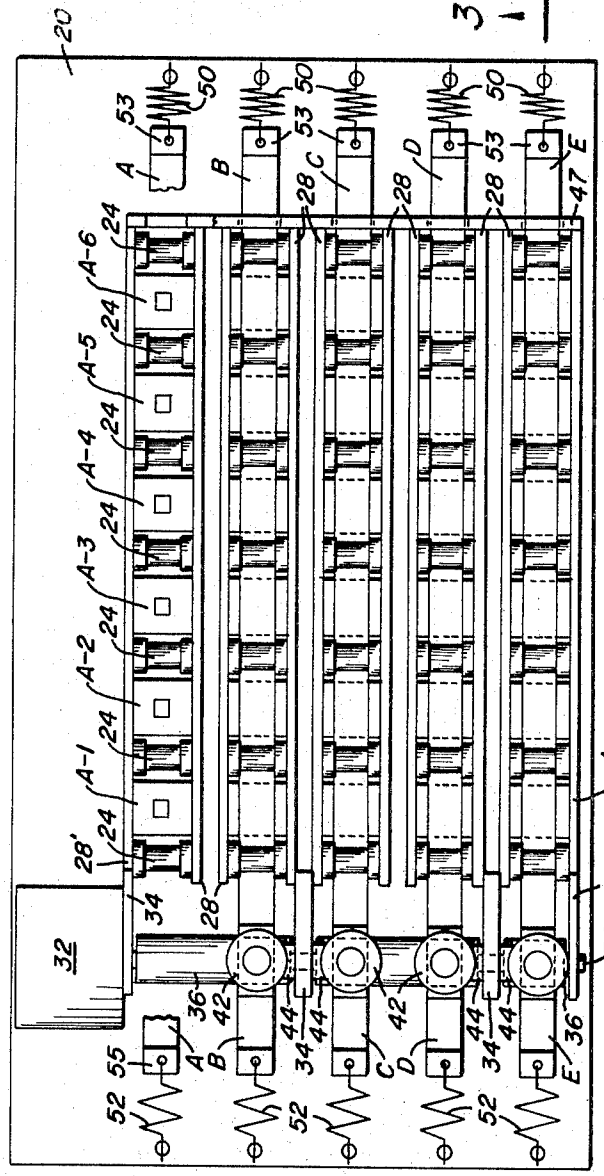


FIG. 2.

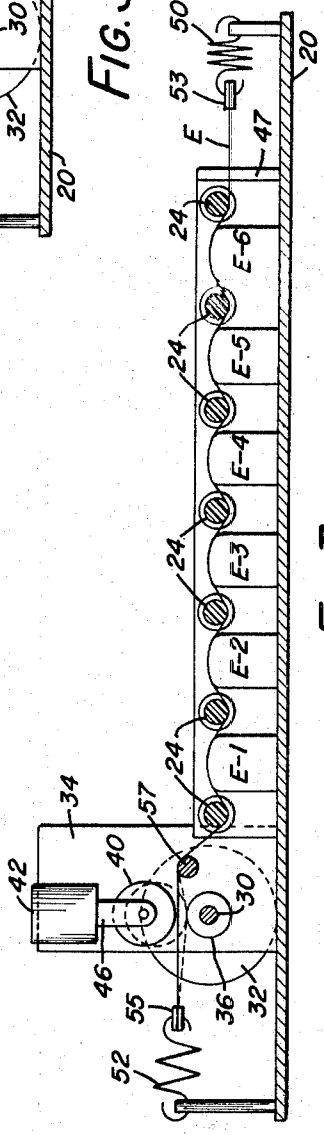


FIG. 3.

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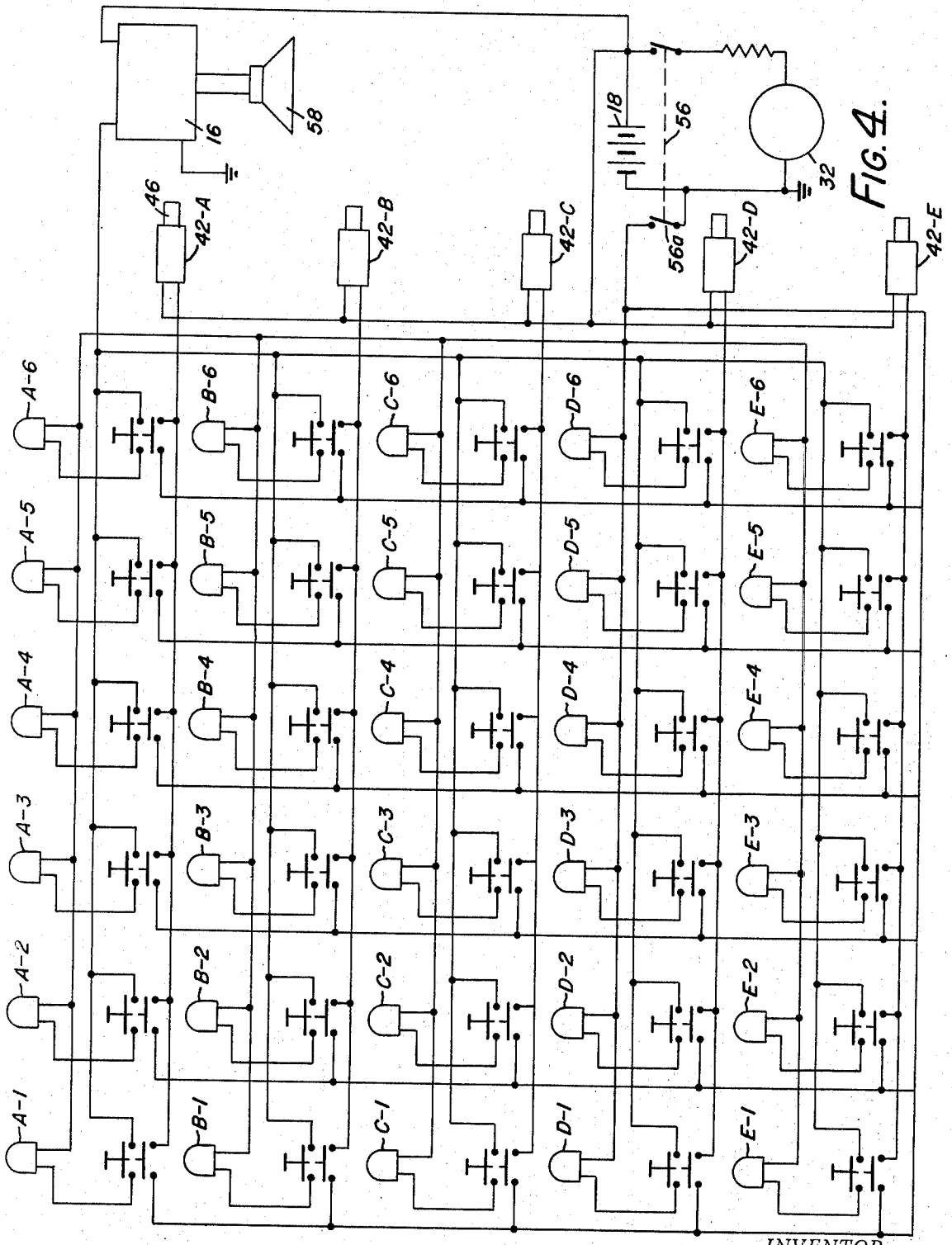


FIG. 4.

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SYNTHESIS OF SPEECH FROM A MAGNETIC TAPE MATRIX STORAGE OF PHONETIC SEGMENTS

The present invention broadly relates to apparatus for producing speech sounds and more particularly to apparatus for generating and combining different phonetic sounds in selected sequences whereby to create speech.

The invention is especially suitable for use by a person whose natural capabilities for speaking have been impaired, as for example, when his larynx has been removed by surgery. The invention, however, is generally useful for producing speech sounds or signals corresponding thereto for various communications purposes. For example, the invention may be used for secure communications by transmitting switch closures corresponding to different phonetic sounds which may be utilized at a remote point to reproduce the sounds.

Various attempts have been made in the past, none entirely satisfactory, for producing speech artifically. Specifically vocoder apparatus, as described in U.S. Pat. No. 2,194,198, which has been proposed for this purpose, operates by generating tones of different sorts when various keys on a keyboard are manipulated. It has also been proposed to provide announcing machines which reproduce individual words. Such prior machines however do not have the flexibility of producing the wide variety of sounds needed to create speech. Also such machines do not have the flexibility to readily combine sounds to produce a large vocabulary of words and phrases needed for human communication. Another important feature lacking in prior machines is in smallness of size and portability. Thus, such prior apparatus was not adapted to be worn on the body of the user in a unobtrusive manner. It is also desirable that the apparatus be relatively low in cost so that it can be afforded by the majority of persons whose speech is impaired.

It is an object of the present invention to provide improved speech producing apparatus.

It is a further object of the invention to provide an improved system for replacing or providing the capability to speak or to produce speech at remote locations.

It is a still further object of the present invention to provide improved keyboard operated apparatus for combining speech sounds so as to reproduce a large vocabulary of words and phrases.

It is a still further object of the present invention to provide improved apparatus for assembling the elements of speech and generating speech or codes representing speech.

It is a still further object of the present invention to provide improved apparatus for selectively multiplexing signals in order to produce speech.

It is a still further object of the present invention to provide an improved artificial larynx.

It is a still further object of the present invention to provide an improved system to select rapidly and in any sequence, the phonetic sounds of speech.

It is another object of the invention to provide improved apparatus for producing speech artificially which permits the user to work and otherwise function in a normal manner.

It is still another object of the invention to provide apparatus for producing speech artificially which is light in weight, which is easy and convenient to carry on the person, and which leaves the persons hands free (except when speaking) thereby permiting the person to work normally in many jobs.

Briefly described an apparatus for producing speech embodying the invention includes means which provides storage for a plurality of different groups of phonetic sounds. Each group includes a series of phonetic sounds. The storage means may for example be an electrical or magnetic signal storage medium such as a plurality of magnetic tapes on each of which different phonetic sounds are recorded on adjacent segments which are disposed along the length of each of the tapes. A selector, for individually choosing different sounds in desired succession to make up words of speech, can be a keyboard. The apparatus is adapted to be worn on the front side of the waist of the user. When a key corresponding to a desired sound is actuated, the stored group of sounds containing that sound is first selected, as by translating one of the magnetic tapes across a magnetic head in a matrix of heads, in which several heads are disposed for scanning each tape. The tape need only be driven a short distance to produce the sound; thus rapid operation in the selection of sounds is achieved. The particular head which correspondes to the sound selected by the key is connected to a playback amplifier, and the selected sound is reproduced, as by a loudspeaker which is driven by the amplifier. Successive different sounds are reproduced in the same manner, thus a sequence of sounds making up different words of speech selected by the keyboard can be produced. The sounds, which in normal speech are often paired (viz which follow one another) are desirably recorded on different tapes so as to facilitate rapid selection of the sounds. Successive use of two sounds from the same tape is therefore rare.

Reference is made in the following description to the accompanying drawings in which:

FIG. 1 is a plan view of apparatus embodying the invention showing the keyboard arrangement; the view being taken such that the bottom thereof would be closest to head of the user when the apparatus is worn at the users waist;

FIG. 2 is a plan view showing phonetic sounds storage apparatus embodying the invention;

FIG. 3 is a sectional view of the apparatus shown in FIG. 2, the section being taken along the line of 3—3 of FIG. 2;

FIGS. 3A, and 3B are fragmentary sectional views, similar to FIG. 3 showing other embodiments of the driving means for the tapes; and

FIG. 4 is a schematic diagram of the apparatus shown in FIG. 2 and 3.

Referring first to FIG. 1, there is shown a housing 10 which contains phonetic sound selection means in the form of a keyboard 12 together with the other apparatus provided in accordance with this embodiment of the invention, except for a loudspeaker, facilities for which are provided by means of a connector 14 which is attached to the housing 10. The housing 10 may be worn around the waist of the user as by means of a belt 15 which extends through slits 11 in the housing 10. The left and right side of the housing, as shown in the drawing, are as viewed from the bottom. In other words, the left hand of the user is positioned on the side of the keyboard 12 adjacent to the legend "LEFT," while the right hand of the user is on the side of the keyboard adjacent to the legend "RIGHT."

In addition to the keyboard **12**, the housing contains the phonetic sounds storage means which in this embodiment of the invention utilizes five lengths of magnetic tape and will be described more fully hereinafter in connection with FIGS. **2** and **3**. This storage means is desirably located in the housing immediately below the section thereof containing the keyboard **12**. Also included in the housing are an amplifier **16** and a holder **18** for a battery.

The keyboard **12** has 27 pushbuttons arranged in three parallel rows of nine pushbuttons each. There are keys in the form of bars **14** and **21** located on the left and the right side of the keyboard **12**, respectively. Each of the pushbuttons and bars is shown and described with a symbol designating the phonetic sound which is produced when that pushbutton or bar is depressed. The following phonetic sounds are presently preferred; it will be appreciated that other sounds may be added or substituted and the nature of the sounds presently preferred may be modified, in equipment which practices this invention.

oo a soft and short sound as in cook.
a short *a* sound as in apple.
ah broad *a* sound as in harness.
a long (or hard) *a* sound as in grape.
o long (or hard) *o* sound as in hope.
oo long (or hard) sound as in boot.
i long (or hard) sound as in eye.
aw sound as in bawl.
y sound as in yard.
j-ch a combination sound which serves as the *j* sound in job and as the *ch* sound as in church.
w-wh combination sound which serves at the *w* sound in wear and the *wh* sound as in where.
e short sound as in get.
k-g combination sound which serves as the *k* sound as in skill and the *g* sound as in green.
uh a grunt like sound as represented by the letter *u* in the word but.
e hard sound as in heed.
ng the sound of the *ng* combination as in song.
f-v combination sound which represents both the *f* sound as in full and the *v* sound as in veal.
th combination sound which represents both the *th* as in theater or throw and the softer *th* sound as in thus.
r the sound of either of the letters *r* as in river.
i the sound of the letter *i* as in until.
l the sound of *l* as in little.
t-d combination sound which serves to represent the *t* sound as in trunk and the *d* sound as in drunk.
s the sound of the *s* as in somewhere. *p-b* combination sound which represents both the *p* as in peach and the *b* as in beach.
m the sound for the *m* as in manner.
n the sound of the letter *n* as in never.
sh-zh combination sound representing both the *sh* as in shot and the *s* as in pleasure.
h this sound provides a consonant represented by the letter *h* and the vowel which follows, when the *h* bar **21** which is depressed at the same time as a vowel pushbutton. For example, *at* becomes hat; if the *h* bar **21** is depressed along with the *a* button and eat becomes heat when the h bar is depressed along with the *e* button.
z this sound is a soft *s* as in buzz and is used to provide plurals.

Each of the pushbuttons and bars on the keyboard **12** actuates a separate switch having two normally open contacts. The arrangement of these contacts and their cooperation and circuit relationship with the other elements of the apparatus is discussed hereinafter in connection with FIG. **4**. It is a feature of this invention to combine the phonetic sounds stored in groups whereby the group containing the desired sound is conditioned for read out and the sound in that group selected, all by the single operation of the pushbutton or bar for the desired sound. In this manner, the entire alpha-bet of sounds can be selected. By choosing the proper order of sounds, they are assembled or multiplexed into words of speech. In other words speech is assembled by the manipula-tion of the keyboard by the user.

The groupings of sounds are arranged so that sounds in the same group do not follow each other in ordinary speech. Thus sounds selected successively in the course of normal operation of the apparatus will be selected from different groups. This provides restoration time, a feature of the invention enabling rapid selection and assembly of phonetic sounds into the words of speech. Five groups of six phonetic sounds in each group are used in the illustrated embodiment of the invention. Each group corresponds to and is recorded on, a different length of magnetic tape A, B, C, D, or E which is used in the apparatus shown in FIGS. **2** and **3**. Each phonetic sound has its own corresponding pick-up head; a separate group of six heads being provided for each group of sounds. The following table represents the arrangement of the groups of sounds in accordance with their corresponding tapes and heads which are provided in accordance with a preferred embodiment of the invention.

TABLE I

Tape	Head (1)	Head (2)	Head (3)	Head (4)	Head (5)	Head (6)
A.....	o͞o	uh	o͝	ā	ĕ	h
B.....	ă	ē	ĭ	ah	aw	ī
C.....	th	s	z	o͞o	j-ch	sh-zh
D.....	t-d	l	y	m	f-v	k-g
E.....	n	ng	w-wh	r	p-b	spare

Referring to FIGS. **2** and **3** there is shown a support plate **20** which is mounted in or may be the bottom plate of the housing **10** (FIG. **1**) and on which the mechanism for storing and selectively reading out the various phonetic sounds is also mounted. The storate of sounds is obtained by recording the sounds on six adjacent segments of magnetic tape; the sounds being separated from each other by a short gap. A 5 × 6 matrix of magnetic heads is mounted on plate **20**. Thus a row of heads **A-1** to **A-6** is provided for scanning the tape A; **B-1** thru **B-6** is provided for scanning the tape B; **C-1** to **C-6** is provided for scanning the tape C; **D-1** to **D-6** is provided for scanning the tape D; and **E-1** to **E-6** is provided for scanning the tape E. Tape A is shown broken away to illustrate the heads **A-1** thru **A-6**, and the spacing of the heads which permits the heads to scan the segments of the tape A on which the six sounds in the first grouping are recorded.

The tapes are guided over the heads by rods **24** disposed between adjacent heads and at the end of the rows of heads. Seven rods **24** are provided as shown more clearly in FIG. **3.** The bars are desirably of plastic material which provides drag without moving parts. The plastic, polytetraflouroethylene, sold under the trade name "Teflon" by E. I. Dupont of Wilmington, Del., is suitable.

The rods are mounted in support bars **28,** a pair of such bars being provided for each tape. The bars **28'** at the outer side of the matrix of heads also provides support for a shaft **30** of a motor **32** which extends transversely across all of the tapes A thru F. Extensions **34** from some of the bars **28,** including the bars **28',** provide bearings for the shaft **30.** Tubular sleeves **36** of vinyl material are disposed around sections of the shaft **30** which underlie the tapes. These sleeves and shafts thereby act as a capstan for driving the tape, when pinch rollers **40** are brought into contact therewith. The mass of the motor and shaft has a flywheel affect. However, an additional flywheel may be provided on the shaft **30** if desired. It has been found that with only very light pressure of the tape against the vinyl sleeve, good tape driving contact is achieved.

The pinch rollers **40** are actuated by solenoids **42.** A separate solenoid and pinch roller is provided for each tape. The solenoids **42** have springs which bias the pinch rollers **40** away from the tape. Brackets **44** extend laterally from the extensions **34.** The solenoids are mounted on these brackets **44.** The pinch rollers **40** are journald on the armatures **46** of the solenoids. A bar **47** mounted on the plate **20** and extending laterally across the plate provides lateral support for the bars **28** and **28'** and also serves as a stop to limit the travel of the tapes toward the left when the tapes are driven. The opposite ends of the tape are held by springs **50** and **52.** Tabs **53** and **55** on the ends of the tapes provide attachments for the springs. The tab **53** also cooperates with the bar **47** to provide the stop limiting travel of the tape to the left. The limited tape travel assures that each head will read only its corresponding record phonetic sound.

The solenoid only provides light pressure against the tape. Thus, if a solenoid is actuated, as by keeping a key on the keyboard depressed too long, the capstan merely slips with respect to the tape.

As shown in FIG 3 the tape, itself may be used to lift the pinch roller **40** off the capstan, when the limit of travel toward the left, as determined by the stop provided by the bar **47** and tab **53,** is reached. Another teflon rod **57** is mounted between the extensions **34,** such that the tape path is out of contact with the capstan sleeve **36.** Increasing the tension in the tape, as occurs after its travel to the left is limited by the stop causes the tape to tend to return to its out of contact path shown by the solid line depicting the tape in FIG. **3A.** The tape then overcomes the light bias of the solenoid **42** and moves out of driving contact with the capstan sleeve **36.**

FIG. **3A** shows a simlar arrangement. Instead of a pinch roller a shoe **59** is attached to the armature **46** of the solenoid **42.** The shoe has a Teflon sole **61,** curved to conform to the capstan. When slight pressure is applied by the shoe, forcing the tape against the vinyl sleeve **36,** the tape is driven at the sleeve while slipping across the shoe. At the end of the tape travel the tape automatically lifts the shoe and releases the driving contact.

In FIG. **3B** the solenoid **42** and shoe **59** are mounted at an acute angle to the tape path about 45° being suitable. The shoe then serves a dual purpose of tape guidance and tape drive control.

The operation of the apparatus will become more apparent from FIG. **4.** FIG. **4** illustrates the matrix of heads A-**1** through A-**6,** B-**1** through B-**6,** C-**1** through C-**6,** D-**1** through D-**6,** and E-**1** through E-**6.** Immediately below each head is a schematic representation of the switch operated by a different one of the pushbutton or bars on the keyboard **12.** The phonetic sound which is produced by each key switch will be apparent from TABLE I; for example, the switch connected to the head A-**1** produces the sound oo, and the switch connected to the head A-**2** produces the sound uh. Each switch contains two contacts which are closed simultaneously when it is depressed. These contacts are normally open, as shown in the drawing. the bottom contact of each switch is associated with the solenoids **42.** The solenoid 42A which is located above Tape A is connected to the bottom contact of the switches associated with the heads A-**1** to A-**6** while the solenoid 42B is associated with the bottom contact of the switches for the heads B-**1** to B-**6.** The solenoids **42**C to **42**E are similarly connected with the bottom contacts of the switches in the third through fifth rows of the matrix, respectively.

The apparatus is turned on by closing the ganged switches **56–56***a*. This connects power to the motor by way of a current limiting resistor **34.** The capstan then turns, however, the tapes are not driven because the pinch rollers **40** or shoes **59** are withdrawn as shown in solid lines in FIGS. **3,** 3A, 3B, and 3C.

Consider the case where the sound uh is selected. Then, the switch connected to the head A-**2** is depressed. The lower contacts of the switch provide the circuit from the positive terminal of the battery through the solenoids 42A, then through the bottom contact of the switch for head A-**2,** and back to system ground at the negative terminal of the battery **18.** The solenoid 42A armature then extends so as to bring the Tape A into driving relationship with the capstan **36.** The Tape A is then drawn from right to left. Before the pinch roller is released, the Tape A is driven across the head A-**2.** The head A-**2** is at this time connected to the input of the amplifier **16** by way of the upper contact of the switch. The sound uh is then reproduced by the amplifier **16** and played back thru the speaker **58.** Similarly any of the other keys when next depressed cause like scanning of different tapes and connection of the head corresponding to the selected sound to reproduce that sound. Note that different tapes are driven in sequence so as to permit the tapes to be restored by the springs **50** to their initial position between successive sounds. The loudspeaker **58** may be worn on the user. It may be mounted in the housing **10** (FIG. **1**) or worn near the throat of the user as on a lavilier.

From the foregoing description it will be apparent that there has been provided improved apparatus which produces phonetic sounds for reproducing speech as may be used by persons whose larynx has been removed or is impaired. Other applications for the invention as in remote signaling of speech sounds as well as modifications and variations of the herein described apparatus will undoubtedly suggest themselves

to those skilled in the art. Accordingly, the foregoing description should be taken merely as illustrative and not in any limiting sense.

What is claimed is:

1. Speech producing apparatus which comprises:
   a. a plurality of separate record mediums,
   b. each of said record mediums having a group of speech sounds recorded longitudinally thereof, and each sound being located in a separate successive segment thereon, each of said record mediums having a group of speech sounds recorded thereon which do not follow each other successively in ordinary speech,
   c. means for individually selecting separate ones of said sounds to make up words of speech to be produced,
   d. means operated by said selecting means for simultaneously scanning each segment on any of said plurality of record mediums, and
   e. means also operated by said selecting means for reproducing only one of said segments on which said selected sound is recorded whereby different ones of said plurality of recording mediums can be successively scanned and different ones of said speech sounds reproduced in rapid succession so as to make up the words of speech.

2. The invention as set forth in claim 1 wherein said speech sounds are phonetic sounds.

3. The invention as set forth in claim 1 wherein said record mediums are separate magnetic tapes.

4. The invention as set forth in claim 1 wherein said scanning means includes a plurality of groups of pick-up means each corresponding to a different one of said sounds in each group and each pick-up means in each group being spaced along the one of said plurality of record mediums on which its respective group is recorded for scanning the segment of said record medium in which its corresponding sound is recorded.

5. The invention as set forth in claim 4 wherein said plurality of recording mediums are each a separate magnetic tape strip, said strips being disposed in side-by-side relationship, and wherein said pick-up means are each different magnetic heads, said heads being disposed in a matrix containing a plurality of rows of said heads each along a different one of said tape strips.

6. The invention as set forth in claim 1 wherein said plurality of record mediums are a plurality of equal lengths of magnetic tape, and wherein said scanning means includes a plurality of groups magnetic heads, each corresponding to a different sound in each of said groups, and means for translating said tapes individually such that the segment thereof on which said sounds are stored moves across its corresponding magnetic head.

7. The invention as set forth in claim 6 wherein said translating means includes a capstan extending across all of said tapes, and means for separately engaging different ones of said tape into driving relationship with said capstan.

8. The invention as set forth in claim 7 wherein said engaging means includes a plurality of pinch rollers, and means for maintaining said pinch rollers, in contact with said tapes for predetermined periods of time whereby the portions of said tapes having said sounds thereon can traverse said heads whereby to enable reproduction of said sounds.

9. The invention as set forth in claim 7 wherein said capstan has a surface of vinyl material, and wherein said engaging means is disposed for applying light pressure against tape in a direction toward said capstan.

10. The invention as set forth in claim 7 including stop means for limiting the travel of said tapes, said stop means being disposed on said tapes near the end thereof which is driven toward said capstan, whereby said tapes can lift said engaging means away from said capstan at the limit of the travel of said tapes.

11. The invention as set forth in claim 7 wherein said engaging means for each tape includes a pressure shoe disposed at an angle of about 45° with respect to the direction of travel of said tape.

12. The invention as set forth in claim 1 wherein said selecting means is a keyboard having a plurality of manually operable keys each for a different one of said sounds, and a separate pair of switch means operated by each of said keys for respectively operating said scanning means and said reproducing means.

13. The invention as set forth in claim 12 wherein said keyboard is adapted to be carried at the waist of a person using the speech apparatus, whereby to leave the hands of the person free when the apparatus is not in use.

14. The invention as set forth in claim 13 wherein said keyboard has a plurality of rows of button keys, each corresponding to a different one of said phonetic sounds, and a pair of bar keys at opposite ends of said rows of buttons each for a different consonant sound, whereby to permit use of the thumbs for pluralizing certain sounds and so that simultaneous sounds can be produced.

15. The invention as set forth in claim 12 wherein said plurality of record mediums are a plurality of separate magnetic tapes, and said scanning means includes a matrix of magnetic heads arranged in a plurality of rows and each row being disposed along a separate one of said tapes with each head in spaced relationship with a different one of said segments, each of said switches corresponding to a different one of said heads.

16. The invention as set forth in claim 15 wherein said switch means pairs each have two normally open contacts, means operated by one of said contacts when closed to translate the tape scanned by the head to which said switch corresponds, and means operated by the other of said contacts when closed to enable the reproduction of said sound scanned by the head to which said switch corresponds.

17. The invention as set forth in claim 16 wherein said apparatus includes a housing having said keyboard, said switch matrix, said tapes, said head matrix, an amplifier, and a battery holder all being mounted in said housing, a loudspeaker connected to the output of said amplifier, said housing and said loudspeaker all being adapted to be worn by the person making use of said apparatus.

* * * * *