RECORDING DEVICE

Filed Oct. 22, 1952 4 Sheets-Sheet 1

Fig. 1.

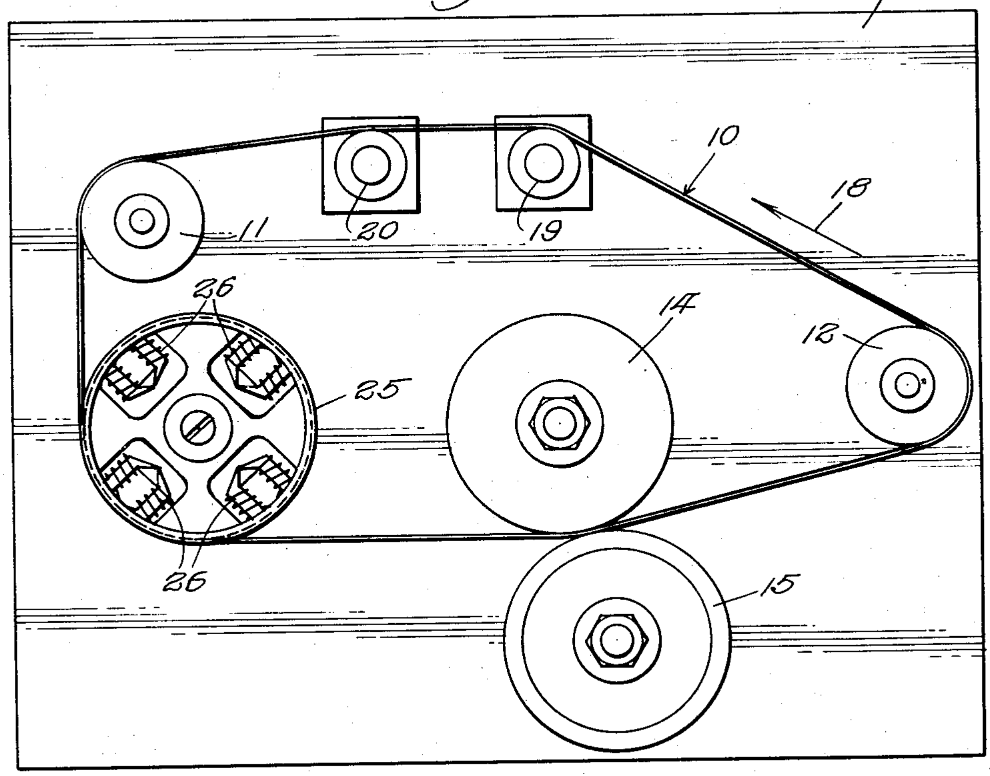

Fig. 2.

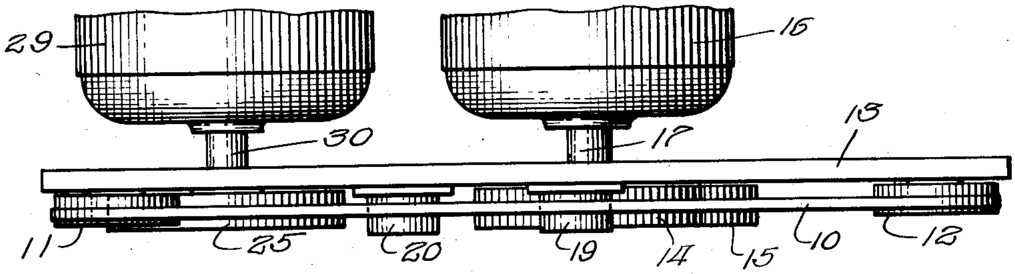

Fig. 3.

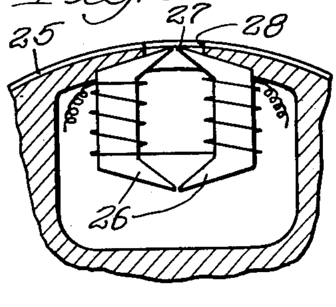

Fig. 4.

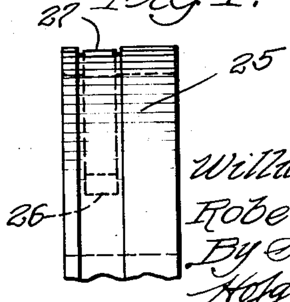

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Fig. 5.

Fig. 6.

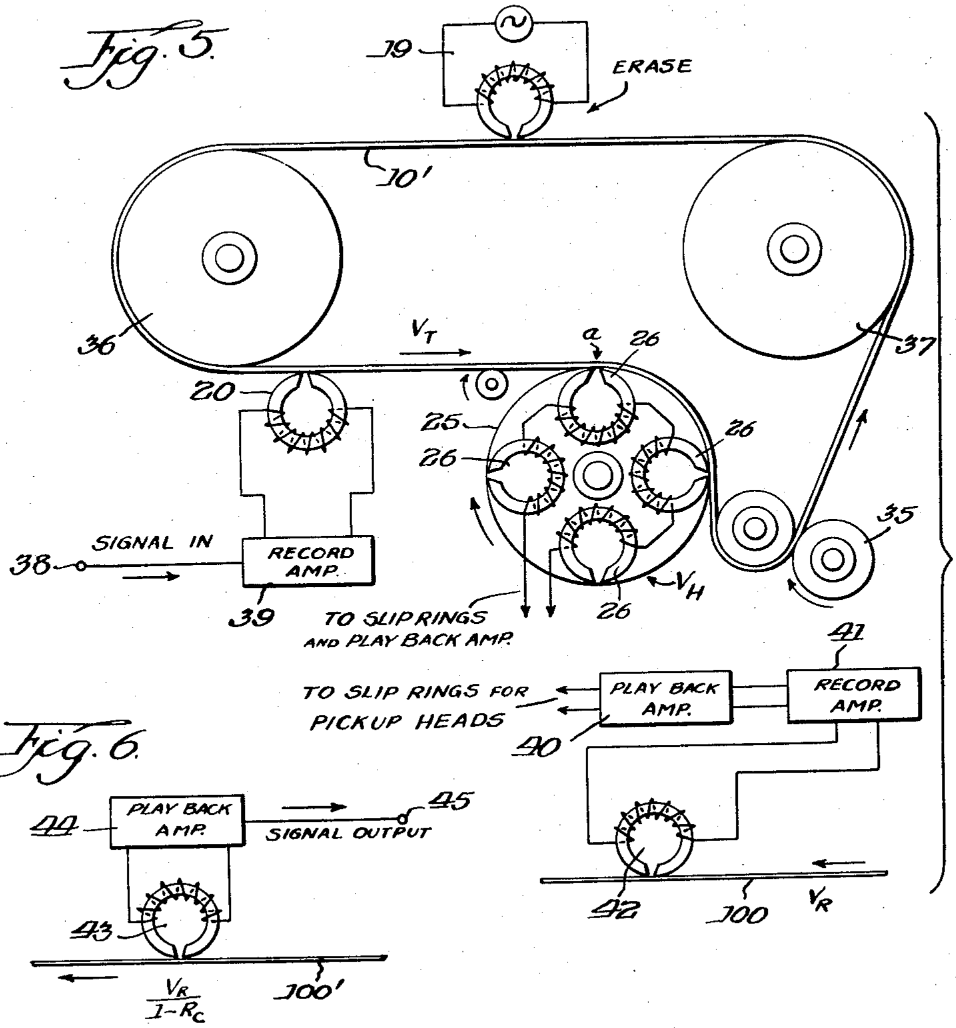
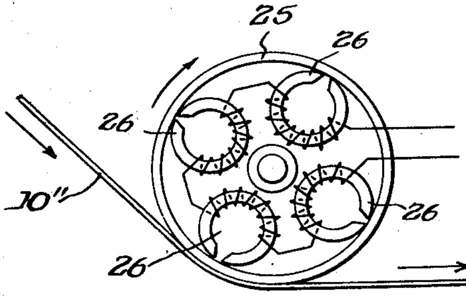


Fig. 7.



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RECORDING DEVICE

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Fig. 8.

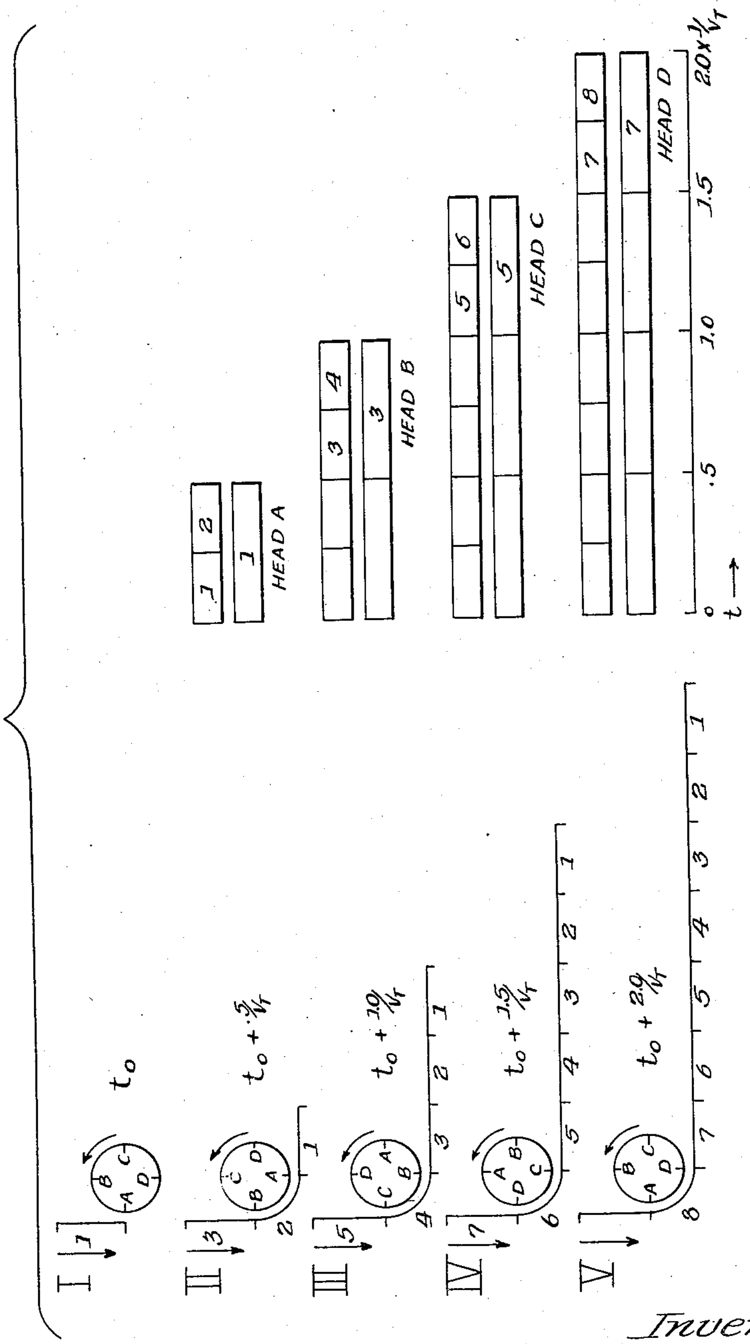

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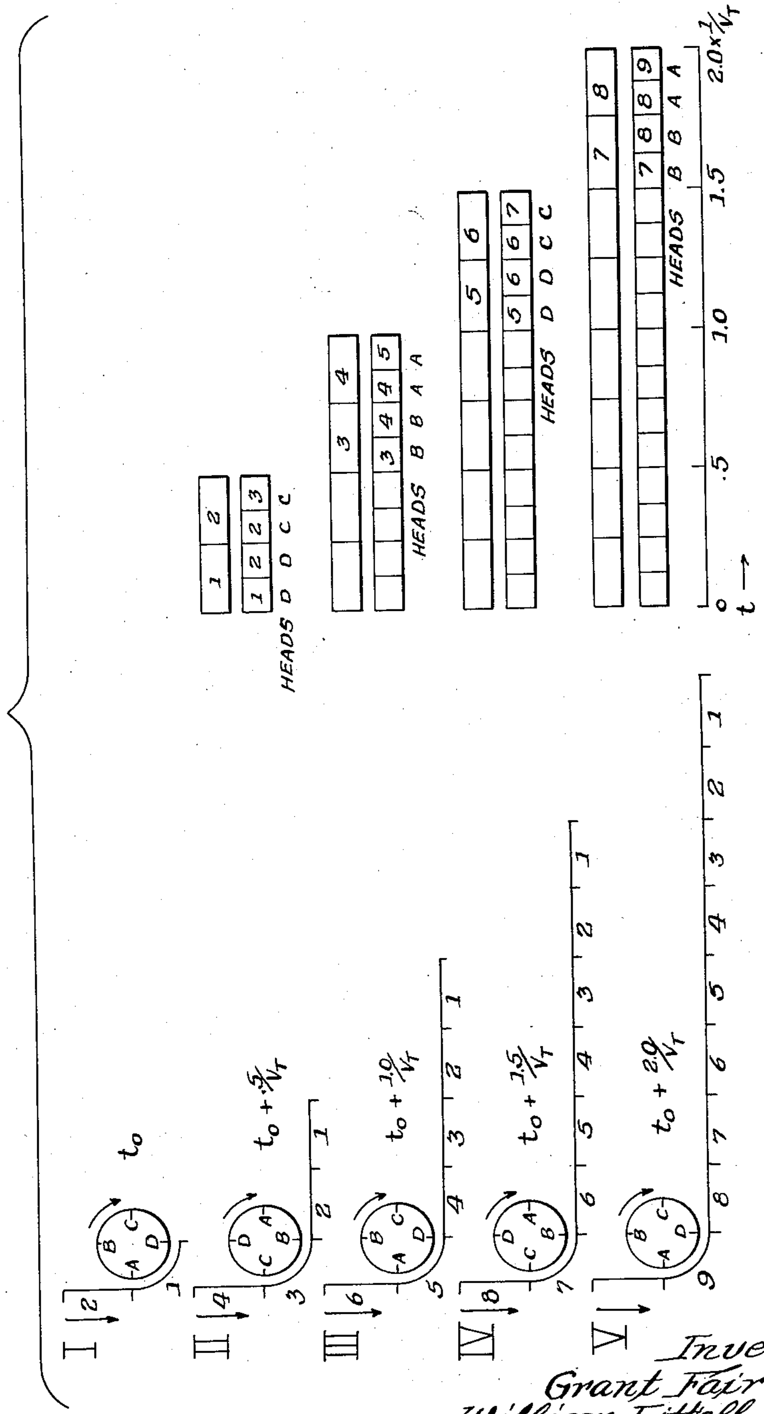
Fig. 9.



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RECORDING DEVICE

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Application October 22, 1952, Serial No. 316,289

10 Claims. (Cl. 179—100.2)

This invention relates to a device for automatically reproducing signals in a different time than originally produced and more particularly to such a means for reproducing information, such as connected speech, in a shorter or longer time than originally delivered without change in pitch that substantially affects the signal.

It has been known for example, that the human ear can accept connected speech at a much faster rate than the human voice can deliver it. Intelligibility of speech that is delivered much faster than originally is not impaired so long as fidelity and frequencies are maintained as in the original. It has also been found that comprehension of material delivered at a much faster rate is easy for most persons. This brings to focus possibilities of educational benefit in that a larger amount of material may be delivered to a listening audience in a much shorter time than ordinarily required. Of course, the application commercially in radio broadcasting is immediately apparent in that much more material could be given to the public in allotted time and that given material could be altered to occupy an allotted time period.

The basic function of the device to be described, is to take information such as connected speech or sounds and reproduce them by leaving out small fragments or portions occurring during very short time intervals. These fragments are so small in time duration that they do not include a whole sound unit, or in other words, a whole syllable or even a sound in a syllable. What remains after the fragments are discarded, is in effect, squeezed together. The final recording is thus made a continuous one from which the original speech or sounds may be played back in a shorter time than required for the original delivery. The shortened material may sound much faster in delivery, but the pitch is unchanged and comprehension is still easily possible.

A particular embodiment of one device for accomplishing the results set out above is shown in the accompanying drawings, in which:

Figure 1 is a diagrammatic front view of the apparatus;

Figure 2 is a partially diagrammatic, broken, top plan view of the same apparatus;

Figure 3 is a diagrammatic, fragmentary, sectional view of one of the pickup heads;

Figure 4 is a diagrammatic, fragmentary, side view of the pickup head shown in Figure 3;

Fig. 5 is a schematic representation to show the relationship between the multiple head transducer and the recording of messages therefrom upon a moving record strip;

Fig. 6 is a schematic representation of one form of arrangement to reproduce recorded signal information following its recording, as for instance by the apparatus of Fig. 5;

Fig. 7 illustrates a modification of the strip contact region relative to the multiple head transducer with the record tape strip being in contact with the drum for an arcuate space less than that corresponding to the arcuate spacing of adjacent respective transducers;

Fig. 8 is a diagrammatic and schematic representation to illustrate operation of the apparatus for signal compression; and

Fig. 9 is a diagrammatic showing, generally similar to Fig. 8, to show the expansion program.

The main purpose of the device of this invention is to sample discrete portions of a recording of connected speech and discard some of the portions so as to record less than the total number of portions. It is important that each discarded portion be so small that a sound unit could not be lost if that portion is discarded. The term "sound unit" as used herein, means any portion of an expression if missing, would interfere with the intelligibility of the whole expression. In the case of human speech, the discarded portions or intervals are so short that words and syllables are not lost in the shortening effect. Each sound is reproduced in sufficient length to make it as intelligible as the original sound, but enough of the sounds are omitted to greatly shorten the time of delivery.

The particular means for accomplishing the instant purpose employs a magnetic recording tape **10** formed in the shape of a loop passing about certain elements including idler wheels **11** and **12**. The idler wheels are mounted in a relatively heavy metal bearing plate **13**. A drive mechanism including a driven wheel **14** clamps the loop of tape **10** against a rubber covered pressure puck **15** to move the tape about the path formed by the loop. In Figure 2, a driving shaft **17** is shown which is connected with a variable speed motor **16** for providing the driving power.

While a tape is shown as the recording element, it should be understood that other magnetic recording elements or other nonmagnetic recording elements could be used. The tape is driven in the direction of the arrow **18** so that it passes first over an erase head **19** and then to a record head **20**. Material from a microphone or from some other source is transposed by means of the record head **20** to the tape **10**. The material is then carried over the idler wheel **11** to a transducer herein shown as a drum **25** which has a number of pickup heads **26** positioned about its periphery. In the instant application the drum **25** has a pickup head **26** which may have a tip portion **27** extending through a slot **28** in the periphery of the drum so that it may pick up material recorded on the magnetic tape.

The drum **25** is separately driven by means of a shaft **30** which may be connected to a separate variable speed motor **29**, so that the speed of the drum may be regulated with relation to the linear velocity of the tape. Since there are four pickup heads **26** shown in the drum, the tape **10** is in contact with the periphery of the drum for about 90° so that only one pickup head will be taking material from the tape at a time. The sampling and discarding of intervals is automatically accomplished by the pickup heads in the drum. If the drum has a peripheral velocity less than the linear velocity of the tape, material will be taken from the tape by one head and then it will quit reproducing and the succeeding head will start to take material from the tape. At the instant when one head leaves the tape and another starts to pick up, there is a physical distance on the tape between the two heads which is not recorded by any of the heads in the drum. In other words, any material recorded on the tape **10** along this particular portion of the tape would be discarded and will not be picked up by any of the pickup heads **26**. Material that is picked up, may be placed on another tape, wire, disc or other record so that it may be subsequently played. It will be noted that one or another of the pickup heads is continuously taking material from the loop or tape and therefore the record made of the material so picked up will be continuous.

As an example, material may be placed on the tape which is moving at a linear velocity of 150 inches per second. (Lower speeds may be used in actual practice.) If it is desired to condense the material by 50%, or in other words, retain 50% of the material so as to be played in one half the time of delivery, the peripheral speed of the drum will be chosen so that the relative speed between the tape and pickup heads **26** will be one half of 150 or 75 inches per second. The material picked up by the heads **26** may be fed to another recording tape moving at one half the velocity at which the tape is to be later played. In this manner the frequencies are proper and the recording when played at the proper speed will produce the connected speech in one half the time.

In order to choose the proper speed for the drum **25**, it will be noted that the relative linear velocity between the pickup heads and the tape is equal to the fractional reduction in time desired. This means that the speed of the tape is equal to V_T which is equal to

$$\frac{d}{I_D}$$

where d is the arcuate distance between heads on the drum in inches and I_D is the discard interval in seconds. The linear head velocity in inches per second is V_H which is equal to $V_T(1-R_R)$, where R_R is the ratio of retention, or the ratio of the retained material to the original. When the device is used to condense material, the effective velocity is the difference between the tape and head velocities and when the device is used to expand material, the effective velocity is the sum of the two since the head is reversed in direction. When the drum is rotated oppositely in direction to the tape direction of movement, some of the material is repeated and will result in a final recording which has been expanded and would require longer time for play back than original delivery. The device may be worked in either manner and will provide a record which may take either longer or shorter than original delivery. This latter view of the device may be important in the field of language study and fields such as voice correction.

In order to use the device for expanding either live material or recorded material, the drum **25** is caused to rotate clockwise as viewed in Figure 1 while the tape proceeds in the direction of arrow **18**. The effective velocity is thus the sum of V_T and V_H and as a result the frequencies from the pickup heads are higher than those on the tape and certain material will be repeated. The reproduction formed with the material picked up may be played at a slower speed to reestablish the proper frequencies and occupy a longer time.

In the modification of Fig. 5 the tape **10'** is shown as traveling in the direction indicated by the arrow at a velocity V_T. In so moving the tape may, illustratively, be driven by the puck **35** rotating in the direction shown by the arrow with the tape positioned between this drive puck and an idler **36**. For illustrative purposes the tape is arranged in a loop form and passes over a second idler **37**. Prior to any recording of sound or other intelligence information on the tape, the tape is erased by any standard form of erase head such as that conventionally shown at **19** which is activated by the indicated high frequency alternating current source.

Subsequent to tape erasure by the head **19** signal or intelligence information is recorded by means of the record head **20** which receives signals for recording which are supplied at a terminal **38** and thence through any standard form of recording amplifier apparatus, conventionally indicated at **39**. Output signals from the amplifier **39** control, in well known fashion, the signal information impressed or recorded upon the magnetic tape.

As was indicated by the apparatus of Fig. 1, the drum **25** turns, for instance, in the direction shown at a speed of V_H (which represents head velocity). The drum includes the indicated four magnetic heads **26**, one of which is shown adjacent to the tape at the position *a*. Energy picked up from the tape, and indicative of the intelligence for recordings thereon scanned, is then supplied in well known fashion to a standard form of playback amplifier conventionally indicated **40** the output of which is supplied to recording amplifier **41**. The record amplifier **41** then provides for recording the information picked up by the multiplicity of scanning heads **26** by the use of a record head **42** similar to that shown at **20**. The recorded information is then impressed upon the magnetizable tape or strip **100** moving illustratively in the direction of the arrow at a velocity V_R (where V_R is the velocity of the recording tape).

Following the recording of the information upon the tape strip **100** in order to reproduce at an output point **45** that signal or intelligence information which was supplied at point **38** the recorded information on the tape **100** is translated (as shown by Fig. 6) in the region **100'** by a pickup head **43** positioned adjacent to the tape or strip **100'** the output from which at convenient times is fed into the playback amplifier conventionally represented **44** which is of standard characteristics and is then supplied as a signal output of the terminal point **45**.

As was explained in an earlier part of the description, the tape when being reproduced and scanned by the pickup head **43** moves by appropriate drive means (not shown), illustratively, in the direction shown by the arrow at a velocity

$$\frac{V_R}{1-R_c}$$

where V_R is the case for the record head **42** and represents the recording tape velocity, and R_c represents the ratio of compression.

For ease of reference and for a better understanding of the feature of compressing signals, the diagrammatic showing of Fig. 8 is provided. In this showing the Roman numerals indicate different initial positions of the multiplicity of recording heads **26** on the drum **25** relative to an assumed moving magnetic tape. The magnetic tape is assumed to be divided into a plurality of adjacent segments, each of a length corresponding to the peripheral distance on the drum **25** carrying the multiplicity of transducer heads **26** which separates any two adjacent heads **26**. The designations to the right of the figure indicate the segments of tape and the recorded message. It can be assumed conveniently that positions can be represented at different positions of the clock and that the various transducer heads of the plurality **26** are designated by letters A through D. So considering Fig. 8, in part I, the segment **1** is shown at a time T_0 when it first comes into contact with the drum **25** and the first transducer head (shown as head "A"). At this moment it is intercepted by the head A moving in the same direction as the tape, as explained in connection with Fig. 5.

If it were to be assumed that the drum **25** were stationary, reproduction would be on a one-for-one basis. if the velocity of the head rotating were equal to the velocity of the tape, of course, no signal could be reproduced because there would be no relative movement between the transducer head and the tape. If, however, between the time periods I and II it could be assumed that the head A moves through one-quarter revolution, it will be apparent that during the same time period the tape will move, so that two complete tape segments, that is, tape segment **1** and **2** pass at 9:00 o'clock point where the head A first contacted the tape, which can be assumed to have occurred at a time T_0. As a result, head A reproduces segment **1** during such time interval and the effective velocity of the tape is then V_T-V_H, where V_T is the tape velocity and V_H is the head velocity. In the assumed condition of Fig. 8, V_H, as already explained in the foregoing material, is assumed to be equal to

$$\frac{V_T}{2}$$

which equals the effective velocity of the tape. Consequently, the frequencies of segment 1 of the tape as reproduced by the head A are divided by two.

Considering now the time II, it will be seen that the head A has rotated in the direction of the arrow to the 6:00 o'clock position and the head B has arrived at the 9:00 o'clock position, with the tape segment 2 lying between these two heads and in contact with the drum. At this time head A is about to leave its position of contact with the tape, while head B is about to begin reproducing because it contacts the tape at the third tape segment. Accordingly, there is no discontinuity in the reproduction, although segment 2 of the tape is not reproduced by any head.

The remaining diagrams of Fig. 8 show how the process continues and with the assumed conditions the assumed odd numbered segments of the tape are reproduced at reduced frequency and even numbered segments of the tape are discarded although there is complete continuity of message reproduction.

In the diagram to the right of the schematically represented multiple transducer heads and the tape the smaller blocks indicate tape segments, as assumed, and the larger blocks indicate the tape segments being reproduced by the related transducer head. The relative enlargement between the lengths of the rectangles schematically designates the proportional frequency reduction occasioned by the operation explained. In this connection it will be seen that between the times I and II, for example, segment 1 is reproduced by head A in the same time which is necessary for both segments 1 and 2 to pass any given point. Following this the head B reproduces segment 3 at the same rate, and so on. As to the duration of the odd numbered segments these may be termed "sampling intervals." Movement, accordingly, by the plan described will bring about frequency compression or reduction.

The showing of Fig. 9 is a generally similar diagram to that of Fig. 8 but is for the purpose of showing the expansion process, as against the compression process of Fig. 8. As is depicted by Fig. 9 the drum carrying the several transducer heads A, B, C, and D is arranged to turn or revolve in the direction opposite to that at which the tape moves, each of which direction is shown by the arrow adjacent either to the drum or to the tape itself. In the illustrated condition of Fig. 9 the example is selected where the velocities are equal so that the effective velocity is equal to their sum.

On this showing at the time T_0 shown at tape segment 1 the segment is in contact with the drum between the heads A and D. During the next interval the head D, as it moves from the indicated 6:00 o'clock position as per Part I to the 9:00 o'clock position will reproduce both segments 1 and 2 and then leave the tape. At this time the tape will be reproduced by the head C which is moved to the 6:00 o'clock position to intercept the tape at the beginning of segment 2. This will then reproduce segments 2 and 3 during its sweep. The result is shown to the right of the figure and indicates that between the times I and II while segments 1 and 2 are passing the 6:00 o'clock point segments 1, 2, 2 and 3 are reproduced.

The remaining portion of Fig. 9 similarly shows how the process continues. From this it will be apparent that since the effective tape velocity with respect to the transducer head has been increased by the opposite movement of the head and the tape, frequency multiplication has been provided. The original frequencies then are restored by reproducing the processed message in an appropriate longer time period. One hundred times the amount of time thus added divided by the original time is known as the "expansion percentage." By the diagram of Fig. 9 it will be noted that this equals 100%.

A condensed recording may be formed by using the multiple head of the present invention as record heads as contrasted to pickup heads as set out above. The heads are capable of interchangeable action and very little need be done to the apparatus to change its function. For this purpose, as represented by Fig. 7, four heads 26 are shown, similar to Fig. 1, and with this number, a tape 10'', not in a loop, is passed in contact with the drum 25 for an angular distance of 360°/8 or 360° divided by twice the number of heads. The direction of head revolution is opposite to the direction of movement of the tape so that each head slowly backs up along the tape. Since with four heads, for example, the tape contacts the drum for 45°, there will be some time while no head is in contact with the tape to record the material that is simultaneously fed to the four heads. During this period, the tape moves forwardly to bring the point where the preceding head quits recording into proper registry for the next head to start recording without leaving a physical gap on the tape. The resultant tape is a shortened recording of the material fed to the multiple heads. The discarded material is that which occurred during the intervals when no head was in contact with the tape.

In some instances, it may be desirable to operate the apparatus as an interrupter. In order to accomplish this function, the heads 25 are hooked up as record heads to place the material fed to them on a tape 10. The heads 25 and tape are caused to move in the same direction with the heads at slower linear velocity so that the material recorded on the tape is separated by physical gaps equal in length to the arcuate distance between the heads 25.

Experiments have shown that connected speech may be reproduced in 80% the time of original delivery without substantial change. If only 50% of the material is retained, a noticeable speed-up of delivery is present while comprehension and intelligibility remain. The limit to which connected speech may be reduced in delivery time will be dependent upon comprehension rather than the ability to remove enough small time intervals to produce a shortened record. In all of the records fidelity and frequencies are retained as in the original delivery.

The foregoing detailed description has been given for clearness of understanding only, and no unnecessary limitations should be understood therefrom, for some modifications will be obvious to those skilled in the art.

We claim:

1. A device for automatically reproducing sounds in a different time than the original delivery without substantial change in pitch, comprising, an impulse recording element having the sounds recorded thereon, an impulse pickup device having a plurality of pickup heads, means providing relative movement between the recording element and pickup device, said pickup device being positioned for sequential and continuous pickup of intermittent portions of the recorded sounds at a frequency different from the original frequency at which recorded, and a record element for receiving the picked-up portions for subsequent audio reproduction, and means to reproduce the record at a different rate of speed to return the frequencies to the original level.

2. A device for automatically reproducing signals in a different time than the original production time without substantial change in pitch, comprising, a moving impulse recording strip element and a transducer having multiple pickup elements adapted consecutively to pick up impulses from intermittent portions of the strip element in continuous form for recording on another recording element and means for driving the strip element past the transducer at a relative speed to change the pitch of the impulses picked up.

3. A device for automatically reproducing sounds in a different time than the original delivery without substantial change in pitch, comprising, a magnetic recording tape adapted to be driven at a predetermined rate, a recording head in proper position to record the sounds on the moving tape, a drum having a plurality of pickup

heads therein positioned with respect to the tape to consecutively take the sounds from the tape, and means for driving the drum at a peripheral velocity at variance with the velocity of the tape whereby the material picked up by the drum recording heads when recorded on a separate record element may take a different time for play back than the original delivery.

4. A device as specified in claim 3 wherein the velocity of the tape is equal to

$$\frac{d}{I_D}$$

where d is the arcuate distance in inches between pickup heads and I_D is the discard interval in seconds of time.

5. A device as specified in claim 3 wherein the drum carries the pickup heads in opposite direction to movement of the tape whereby some of the recorded sound units are reproduced more than once.

6. A device for automatically reproducing sounds in a different time than the original delivery without substantial change in pitch, comprising, a continuous loop of magnetic recording tape, a drive for moving the tape in the path formed by said loop at predetermined speed greatly in excess of the normal recording rate, a recording head positioned adjacent to the tape to record the sounds thereon, a drum positioned adjacent to the path of the tape beyond said recording head, said drum having a plurality of pickup heads therein each positioned to take the sounds from the tape when the tape is against the drum and adjacent to one of the heads, said tape contacting an arc of the drum sufficient to permit only one pickup head at a time to take sounds therefrom, means for driving the drum at a peripheral speed different from the speed of the moving tape, and means for continuously recording the sounds from the drum pickup heads.

7. A device for reproducing sounds in a different time than original delivery without substantial change in pitch, comprising means for delivering a tonal message, means for directly receiving the tonal message, means for reproducing the tonal message at a pitch greatly different from the original pitch of the message, means for altering intermittently at very small intervals of time the number of tonal units in the message without affecting the audible content of the message, and means for receiving the pitch-altered and content-altered message and means for reproducing the message at the original pitch during a different delivery time.

8. Apparatus as set forth in claim 7 in which the means for varying the pitch of the original message is independent of the proportional time change in the message.

9. A device for reproducing sound recorded on a tape in a different time from the original delivery time of the sound, without substantial change in pitch, comprising means for moving the tape in a predetermined path at a rate greatly in excess of the normal play rate of the tape, and a circular rotatable pick-up device positioned adjacent to the path of the tape and having multiple pick-up heads thereon, means for rotating the pick-up device to bring the pick-up heads consecutively into contact with the tape at a speed different from the speed of the tape, means for recording upon a record element the successive picked up portions at a different pitch, the rate of movement of the pick-up device with respect to the movement of the tape being such as to alter the sound content of the picked up message in a predetermined ratio, and means for moving the recording element at a speed relative to its normal playing speed which is a reciprocal of said predetermined ratio, whereby the original pitch may be reproduced by playing the recording element at its normal speed.

10. A device for reproducing sound recorded on a tape in a different time from the original delivery time of the sound, without substantial change in pitch, comprising means for moving the tape in a predetermined path, a circular rotatable pick-up device adjacent the path of the tape having multiple pick-up heads thereon, means for rotating the pick-up device to bring the pick-up heads consecutively into contact with the tape at a speed different from the speed of the tape, means for recording upon a record element the successive picked up portions at a different pitch, the rate of movement of the pick-up device with respect to the movement of the tape being such as to alter the sound content of the picked up message in a predetermined ratio, and means for moving the recording element at a speed relative to its normal playing speed which is a reciprocal of said predetermined ratio whereby the original pitch may be reproduced by playing the recording element at its normal speed.

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