Oct. 25, 1966 W. C. DERSCH 3,281,534

NASALITY METER

Filed May 9, 1963 2 Sheets-Sheet 1

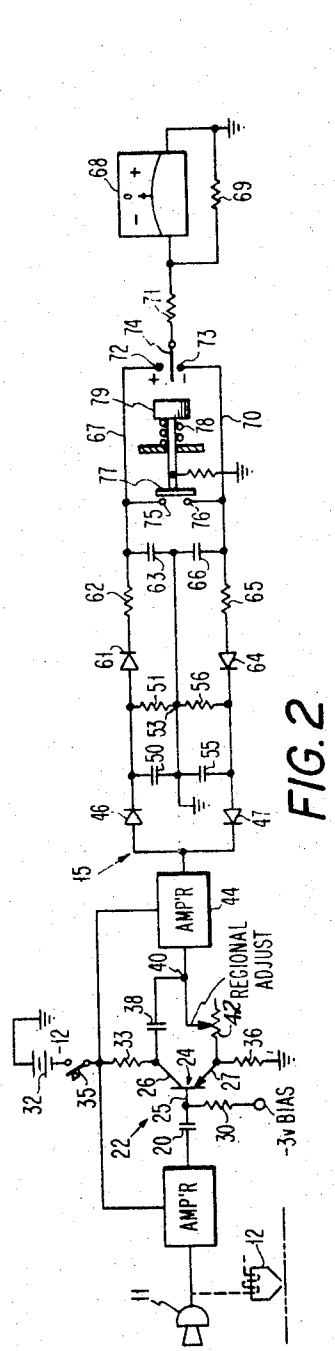


FIG. 2

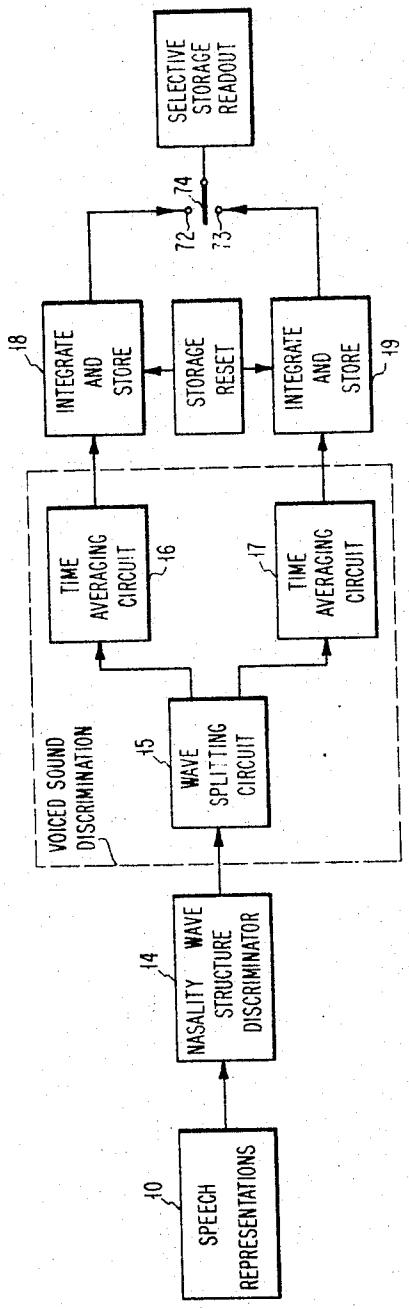


FIG. 1

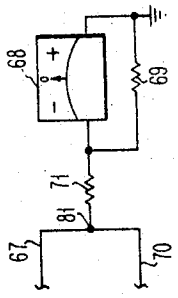


FIG. 5

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NASALITY METER

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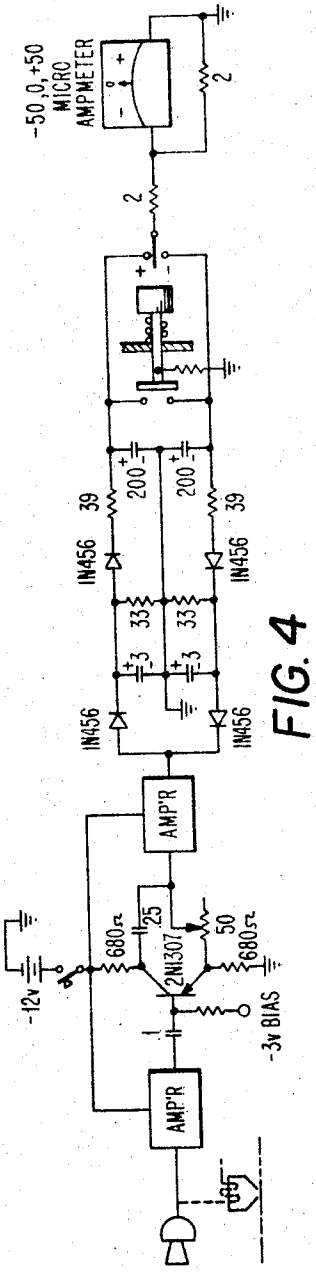


FIG. 4

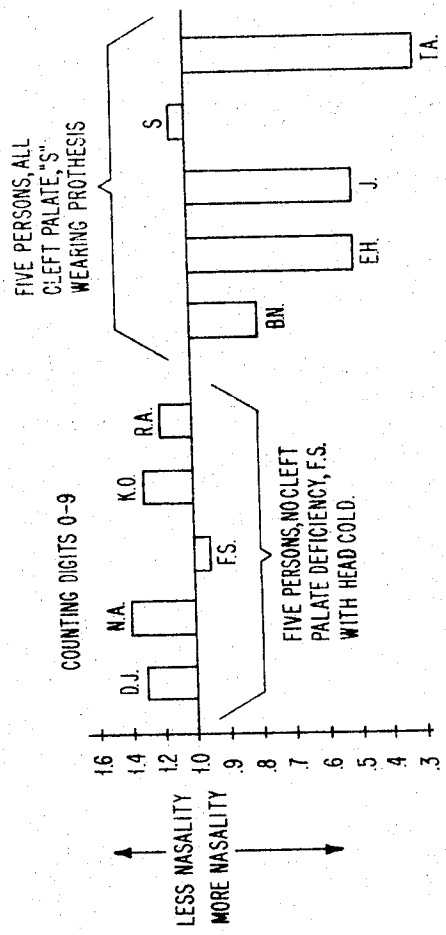


FIG. 3

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NASALITY METER

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This invenion pertains to speech measuring equipment and more particularly to a meter and method for measuring the nasal quality of speech. This measure, in turn, can be significant in evaluating the treatment of cleft palate patients.

Briefly, by way of background, it should be understood that air expelled during speaking escapes through both the nose and mouth. When forming certain sounds, the velopharyngeal valve (i.e., a small flap located to the rear of the throat) serves to block the air passage into the nose. Formation of certain other sounds moves the flap to open the passage permitting air to pass into the nose. Thus, in pronouncing a word such as "oh," little air enters the nasal resonant chamber while "nine" admits considerable air to provide a distinct nasal quality.

Where a person is formed with a cleft palate, the velopharyngeal valve is either missing entirely (as is usual) or badly deformed and inoperative. Thus, the cleft palate patient experiences serious difficulty in controlling the nasal quality of his speech.

In an effort to impart a certain amount of control over the nasality of the patient's speech, a prosthetic device or "obturator" is supported at the roof of the mouth and disposed to serve as something of a substitute for the missing flap. Fitting a patient with such a device is performed on a cut and try basis. The degree of success is measured by listening to the patient speak or by employing oral manometry or cineradiography (X-ray motion pictures), or a combination of these techniques.

One method of treatment of cleft palate patients follows a program employing graduated obturators. Other methods employ surgery. Evaluation of speech competence by merely making a subjective assessment has been sufficiently crude to preclude the reaching of reliable conclusions regarding the merits of the various treatments. Devices to provide "objective" measurement of cleft palate performance, have included oral manometers, the sound spectrograph, and cineradiographic equipment. Each of these measuring tools has been subject to significant limitations. What has been needed, in short, is a simple and reliable method or means for accurately measuring speech competence and particularly the nasal quality of speech.

In general, it is an object of the invention to provide a meter for accurately measuring the nasal quality of speech.

Equipment for the above purpose must, of course, sort out spoken sounds from background noises and the like. A relatively recent but extremely powerful technique which detects the occurrence of certain characteristics and particularly "voiced" sounds is employed herein. "Voiced" sounds are defined in this art as those sounds which originate with air passing through the vocal chords and which are modulated by physical changes in the various resonant chambers in the throat and mouth of the speaker. These sounds are distinguished from "unvoiced" sounds which are formed primarily by air passing through constrictive chambers in the throat, mouth or at the teeth or lips. Voiced sounds are like complex multifrequency waves, but are not truly periodic and have damped oscillatory characteristics. The voiced sounds do, however, have for fundamental as well as harmonic frequency components relatively brief but discernible intervals, and these components can usually be identified. The unvoiced sounds contain little or no such fundamental frequencies, which are usually of the order of a few hundred to a few thousand cycles per second, but are noise-like in character and consist of essentially random amplitude vibrations with time.

By way of providing further background, in the present invention, means are provided which sensitively distinguish voiced from both unvoiced sounds and ambient noise by detecting the occurrence of an asymmetry characteristic in electrical signal representations of human speech. The asymmetry characteristic is present only in voiced sounds, but is present in each case therein, and results in an amplitude difference between positive-going peaks and negative-going peaks in the complex multifrequency voiced sound wave. The complex wave is split into positive-going and negative-going cyclic components and the difference between them provides the asymmetry characteristic.

In a specific example as used herein, electrical signal representations of human speech either prerecorded or from a microphone input are given a phase shift to favor nasal sound frequencies and then applied to a pair of parallel-coupled oppositely-poled diodes. One of the diodes passes the positive-going signal components in the complex multifrequency wave and the other diode passes the negative-going signal components. Each of these component waves is then applied to a peak charging circuit which has a time constant corresponding to a typical syllabic speech interval.

I have discovered that the ratio of the integrated values of each component provides a "nasality quotient" which reliably characterizes the nasal quality of a person's speech.

Another object of the invention therefore is to provide a method and means for deriving a "nasality quotient" which is characteristic of an individual's speech competence.

Accordingly, to derive the nasality quotient of an individual, I form electrical representations of speech as a phase shifted complex wave having two concurrently existing cyclic components. The two components are each time averaged over a predetermined interval to provide a pair of signals respectively representing a first and second nasality factor. Then for the period of a selected spoken message or "speech event" (as defined below) I integrate each signal to derive a value for each factor and store the values derived. I then sense the value of each factor to establish the ratio therebetween. This ratio can subsequently be plotted on a graph for comparison with an established norm or otherwise utilized as desired.

Other objects of the invention will become more readily apparent from the following detailed description of a preferred embodiment when taken in conjunction with the drawings in which:

FIGURE 1 is a block diagram representation of a nasality meter according to the invention.

FIGURE 2 is a schematic electrical circuit diagram according to the invention.

FIGURE 3 shows a typical graph wherein the nasality quotient for each of ten individuals has been plotted.

FIGURE 4 is a schematic electrical circuit diagram similar to FIGURE 2 with the application of associated values to the various components therein.

FIGURE 5 is another embodiment according to the invention.

While the method which is generally followed according to the invention was mentioned above, a meter is provided herein which, in general, includes a voiced sound discriminating circuit for converting electrical speech representations into a phase shifted complex wave having two concurrently existing cyclic components. Means are provided for time averaging each of the components over a predetermined interval to provide a pair

of signals respectively representing a first and second nasality factor. Means for integrating and storing each signal over the period of a selected spoken message or speech event is further provided in a manner to derive and store a value for each of the two nasality factors. Further, means are provided for sensing the values to provide a nasality quotient for the speech representations, as defined by the ratio between the two values.

Referring to FIGURE 1, a preferred embodiment includes means **10** for providing electrical representations of human speech. Thus, the speech to be measured can be examined from either a microphone input **11** or via a playback transducer **12** arranged to play back previously recorded "speech events." A "speech event" for present purposes can be defined as a word, words, phrase or other speech-generated sound for measurement. The recitation of digits 0–9 can be a speech event, as can the pronunciation of "San Francisco."

The electrical representations are fed to a nasality wave structure discrimination circuit **14** adjusted to favor nasal sounds as distinguished from other sounds. It has been observed that changes in phase relation cause the output signal of circuit **14** to vary uniquely and identifiably with time for particular types of voiced sounds. Thus, for different phase shifts the characteristic asymmetry pattern arising during a syllabic speech interval may vary, and with certain adjustments can favor positive-going cyclic components or negative-going cyclic compounds.

In the circuit of FIGURE 2 electrical input signals representative of human speech are amplified as provided from a source such as microphone **11** or transducer **12**. These representations are applied through a DC blocking capacitor **20** to a phase shifter **22**. Here the phase shifter **22** includes a transistor **24**, shown as being of PNP conductivity type, by way of example. Transistor **24** has its base **25** coupled to a minus bias through a resistor **30**, and its collector **26** coupled to a −12 volt supply such as battery **32** via a resistor **33**. A manually controlled main power switch **35** is disposed in the collector circuit and is preferably accessible on the outside of a housing (not shown) enclosing the meter elements. The emitter **27** of transistor **24** is coupled to ground through a resistor **36**.

A selected phase delay may be introduced into the monofrequency components of the amplified signals from transistor **24** by a passive circuit arranged to couple collector **26** and emitter **27**. The passive circuit includes a capacitor **38** coupling collector **26** to a circuit junction point **40**. An adjustable resistor **42** couples emitter **27** to the same point **40**. This phase shifter **22** passes all frequencies of interest but the amount of phase shift introduced for any monofrequency component is dependent both upon the setting of the adjustable resistor **42** and the frequency itself.

As will be further explained below, varying the setting of resistor **42** serves to establish a norm or standard representative of the nasal quality of normal speaking people in a given region or locality. Thus, the nasality of persons with an impaired speech competence can be measured against a regional or localized standard of nasality.

The phase-shifted complex wave appearing at circuit junction **40** is applied through a power amplifier **44** to means for forming the complex wave into two concurrently existing cyclic components.

Thus, a wave splitting circuit **15** includes a pair of parallel oppositely poled semiconductor diodes **46, 47** which perform the wave splitting function. A first of the diodes **46** is poled to pass the positive-going cyclic components, while the second diode **47** is poled to pass negative-going cyclic components. With the reference axis of the waves being substantially at ground potential, this circuit provides accurate but separate representations of the positive and negative cyclic components of the complex multifrequency wave.

Means for time averaging each of the components over a predetermined interval to provide a pair of signals respectively, representing a first and second nasality factor is shown in FIGURE 1 as the time averaging circuit **16, 17**. Thus, the nasality factors can be considered as the rate integrated wave components.

Circuits **16, 17** can be in the form of peak charging circuits. For example, a peak charging circuit is coupled to diode **46** and consists of a shunt capacitor **50** coupled to ground and a parallel resistor **51** likewise grounded via a circuit junction point **53**. The peak charging circuit coupled to diode **47** also consists of a shunt capacitor **55** and a parallel resistor **56** both coupled to ground. Thus, resistors **51, 56** form a grounded, center tap voltage divider whereby signals appearing across resistor **51** represent a first nasality factor and signals appearing across resistor **56** represent a second nasality factor.

Diodes **46, 47** have matched characteristics as do the two peak charging circuits so that like amplitude variations result for signals developed across resistors **51, 56** for like absolute amplitude variations derived from the phase shifter **22**.

The discharge time constants of the peak charging circuits are alike and selected to be on the order of 100 ms. corresponding to a typical syllabic speech interval. Signal variations occurring across resistors **51, 56** appear as relatively slow varying output signals. Signal variations for the positive-going and negative-going components occurring across resistors **51, 56** respectively appear as relatively slow varying output signals which can each be integrated over the period of a speech event and stored. Thus with this arrangement the phase delay can be set by resistor **42** to favor nasal wave structure and thereby provide an asymmetry characteristic representative of nasality whereby the positive-going cyclic component, time averaged over the syllabic interval, will provide a nasality factor which can be integrated and stored. Similarly the negative-going cyclic component will also be time averaged to provide a second nasality factor to be integrated and stored.

Means for integrating and storing each signal (representing one of the factors) for the period of a selected speech event whereby the value of each factor for the period can be derived and stored is represented by boxes **18, 19**. Thus, in FIGURE 2 a pair of summing integrator circuits are provided to integrate and store the signal components appearing across resistors **51, 56** respectively. To integrate and store the positive components, a diode **61** poled to pass positive waves and a series-coupled resistor **62** and relatively large capacitor **63** are disposed in shunt with resistance element **51**. Similarly for integrating and storing native components representing a second nasality factor there is provided an oppositely poled diode **64** series-coupled with resistance element **65** and capacitor **66**. Similarly, diode **64**, resistor **65** and capacitor **66** are disposed in shunt across resistance element **56**.

During the period of time when the signal appearing at the junction between resistor **51** and diode **61** is above ground a charge is built up in the relatively large capacity condenser **63**. As the signal becomes negative with respect to ground, diode **61** serves to block the draining away of the charge and accordingly for each subsequent positive-going component the charging condenser **63** is further built-up. Similarly for negative-going components an opposite charge is built up in condenser **66**.

Means for sensing the stored charge in each of storage elements **63, 66** is provided whereby the value stored in each can be selectively read. Thus, a pair of normally open circuit branches **67, 70** are respectively coupled to the junction points between condenser **63** and resistance element **62** and between condenser **66** and

resistor 65. A meter, such as an ammeter 68, disposed in shunt with a damping resistor 69 and connected to ground is series-connected through a scale factor resistance 71 to a manually operated switching means 74 selectively operable to connect meter 68 to terminal 72 or 73 to read the stored charge in storage element 63 or 66 respectively.

Means are provided for resetting storage elements 63, 66 to a relatively uncharged condition simultaneously. The storage reset means is manually operative, as by a push button. As shown in FIGURE 2 the reset means includes a pair of contact points 75, 76 connected respectively to branches 67, 70. A conductive and grounded armature 77 is spring urged away from contact points 75, 76 by a spring 78 whereby push button 79 can be employed to simultaneously ground the points 75, 76 by contacting same. Thus, in the event that a reading out of the values stored in elements 63, 66 fails to drain them of their respective charges, prior to each subsequent speech measurement, push button 79 can be utilized to virtually instantaneously withdraw the stored factors to reset the storage elements 63, 66 to a predetermined value, namely, to ground.

While the above system has been described in sufficient detail to enable one skilled in the art to practice the invention, a specific example of the complete circuit together with values, voltages and other pertinent identifying information is disclosed in FIGURE 4. Unless noted by the symbol omega (Ω) all resistance values are in kilo-ohms. When indicated by the omega symbol the resistance values are measured in ohms. The capacitors are all measured in microfarads.

Power amplifier 44 can be of conventional construction providing a gain on the order of twenty decibels and adjustable to compensate for the microphone selected. Meter 68 can be of conventional construction such as an ammeter having a range between plus and minus 50 microamperes.

In operation, assuming the switch 35 is closed, a person can be asked to recite into microphone 11 the digits "oh" to "nine" thereby acumulating the storing of the respective values of a first and second nasality factor in condensors 63, 66. These values are then selectively read by moving switch 74 to terminal 73 and then to terminal 72. Dividing the first-read value by the second-read value provides a nasality quotient. For example, as shown in FIGURE 3, "D. J." has a nasality quotient of approximately 1.3. The nasality quotient for five normal persons is shown plotted against unity as a base reference. Of the five normal persons, note that "F. S." had a head cold thereby generating a nasality quotient showing more nasality than the others. Five persons having a cleft palate problem, thereby being precluded from closing the air passage to the nose, showed more nasality with the exception of "S" who was fitted with a prosthetic device, or obturator, for correcting the cleft palate speech deficiency. Thus, a program of progressive obturators can be evaluated by periodically making truly objective measurements of the nasality of the person's speech.

According to another embodiment of the invention as shown in FIGURE 5, nasality in speech can be continuously monitored by direct coupling meter 68 to branches 67, 70 at a junction point 81. Thus, while a person speaks continuously into microphone 11, phase shift control (resistor 42) is varied to "null" the meter 68 at its midpoint. The degree of displacement of the wiper for resistor 42, properly calibrated, then provides a direct reading representing the individual's nasality quotient.

I claim:

1. A method of measuring the nasal quality of speech comprising the steps of forming electrical representations of voiced sounds as a phase shifted complex wave having two concurrently existing cyclic components, time averaging each of the components over a predetermined interval to provide a pair of signals respectively representing a first and second nasality factor, integrating each said signal over the period of a selected speech event to derive a value for each said factor and storing said values, and sensing the value of each factor to provide a ratio between same.

2. A meter for measuring the nasal quality of electrical representations of speech comprising a voiced sound discriminating circuit for converting electrical speech representations into a phase-shifted complex wave having two concurrently existing cyclic components, means for time averaging each of the components over a predetermined interval to provide a pair of signals respectively representing a first and second nasality factor, means for integrating and storing each said signal during speech over the period of a selected speech event to derive a stored value for each said factor, and means for sensing said stored values to provide a nasality quotient, for the representations, defined by the ratio between said values.

3. A meter as defined in claim 2 wherein the last-named means includes switching means for selectively sensing said values.

4. A meter for measuring the nasal quality of electrical representations of speech comprising a voiced sound discriminating circuit for converting electrical speech representations into a phase shifted complex wave having two concurrently existing cyclic components of opposite polarity sense, means for time averaging each of the components over a predetermined interval to provide a pair of signals of opposite polarity respectively representing a first and second nasality factor, means serving to integrate and store each said signal over the period of a selected speech event to derive a stored value for each said factor, and means for sensing said values to provide a nasality quotient, for the representations, as defined by the ratio between said values.

5. A meter as defined in claim 4, further including switching means for selectively sensing each of said values.

6. A meter as defined in claim 4, further including means for resetting said storage means to remove said stored values.

7. The method of measuring the nasal quality of speech comprising the steps of forming electrical representations of speech as a complex wave, shifting the phase of said complex wave, splitting said phase-shifted complex wave into two concurrently existing cyclic components, time averaging each of the components over a predetermined interval to provide a pair of signals respectively representing a first and second nasality factor, integrating and storing each said signal over the period of a selected speech event to derive a stored value for each said factor, sensing the value of each factor to provide a ratio therebetween defining a nasality quotient, and withdrawing the stored factors from storage to reset same prior to receiving a factor for a subsequent speech event.

8. A nasality meter for measuring and indicating the nasal quality of speech comprising means serving to provide a complex multifrequency signal representative of speech, means serving to shift the phase of said complex signal to emphasize a predetermined nasal wave structure, means responsive to the phase shifted complex signal serving to divide the signal into two concurrently existing cyclic components, means for time averaging each of the components over a predetermined interval to constitute said components a first and second nasality factor, means serving to integrate each said factoral component during a selected speech event to derive the value thereof and to separately store said values, and means for indicating the stored value of said each component to provide a nasality quotient defined by the ratio between said values.

9. A nasality meter as defined in claim 8 wherein the last-named means further includes means selectively operable to visually indicate the stored value of each said component independently.

10. A nasality meter as defined in claim 8 wherein the penultimate named means includes means for selectively resetting same to a predetermined value.

11. A nasality meter as defined in claim 8 wherein the last-named means includes electrical measuring means and manually operable switching means serving to selectively couple said measuring means to read out either of said stored values independently whereby the ratio of said values can provide a nasality quotient for said speech event.

12. A nasality meter as defined in claim 11 further including manually operable means for resetting said storage means to a predetermined value.

13. A meter for measuring the nasal quality of electrical representations of speech comprising means for shifting the phase of complex speech waves among said electrical representations to provide a unique asymmetry characteristic thereof, means for splitting the phase-shifted complex wave into two concurrently existing cyclic components, means for time averaging each of the components over a predetermined syllabic interval to provide a pair of signals respectively representing a first and second nasality factor, integrating and storage means including a pair of oppositely poled unilateral conducting elements each series-coupled to an associated resistance-capacitive summing circuit, said unilateral elements being respectively coupled to pass only one or the other of said components to separately derive and store the respective values of the components for the period of said speech event, and means serving to selectively read out and visually indicate each of said stored values, the last-named means including a meter having a visual scale and

manually operable switching means for selectively reading out the stored value of either of said summing circuits.

14. A meter as defined in claim 13 further including means for resetting said summing circuits including manually operable means for simultaneously equalizing the charge on said respective capacitive elements.

15. A meter for measuring the nasal quality of electrical representations of speech comprising a voiced sound discriminating circuit for converting electrical speech representations into a phase-shifted complex wave having two concurrently existing cyclic components, means for time averaging each of the components over a predetermined interval to provide a pair of signals respectively representing a first and second nasality factor, means for integrating each said signal during speech to derive a value for each said factor, and means for sensing said values to provide a nasality quotient, for the representations, defined by the ratio between said values.

16. A meter for continuously monitoring the nasal quality of speech representations comprised as defined in claim 15 and further including means for varying the degree of phase shift applied to said complex wave and connected to vary one of said components with respect to the other to equalize same, whereby the degree of variation required to equalize said components provides a measure of the nasality quotient of the speech.

No references cited.

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