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The Use of Low Cost Dual Nostril Airflow Anemometer for the Measurement of Nasal airflow In Normal Subjects

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Abstract:

Arabic Letters Phonetics can be divided from the point of view of nasal airflow, into nasal and non-nasal letters. A practical measurement has been carried out to define some nasal and non-nasal words. Two sets of word (nasal and non-nasal) have been selected. A new production of sensors is used to measure the airflow in each nostril during each word. The measurement is achieved over 25 normal subjects. The results are used to define the range of airflow for each nostril in each word. These ranges are considered as the standardization of the method to be used later with abnormalities. The system used in the measurement is a low cost dual nostril anemometer and the software is an objective tool for the diagnosis of nasal airway for each nostril.

Introduction.

Many and various techniques have been used to detect the presence of nasal escape during speech, such as fogging a mirror, deflection of threads, tissue paper or soap bubbles placed in front of the nostrils, or pinching the nostril to detect changes in voice quality.. The need for a device to measure nasal airflow, objectively and preferably quantitatively, has been well recognized for a number of years. Nasal airflow meters (nasal anemometers)[1] have been described by several authors, but have the disadvantages that they are expensive, custom-built devices and require the full technical backup facilities of a large department to be available at the time of assessment. Accordingly, only specialized studies with such devices have been made and non-of them have become tools available to smaller department or to individual speech therapists. In 1979, Ellis designed a device, developed in Exceeter, capable of quantitative assessment of simultaneous nasal airflow during speech [2]. In this system there are some drawbacks such as:

- No compensation for the environment
- The analysis requires an additional instrument to get that result.
- Analysis occurs in subject dependent.

In 1990 another technique for nasal airflow measurement by using thermistor anemometer has been described [3]. In this technique several problems for the previous have been solved such as:

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- Environment compensation
- No additional instruments are required because the system is computer dependent.

This system also has some draw backs such as [4]:

- Arbitrary reading units have been used depending on the output voltage.
- Measures the overall nasal airflow.

To overcome the previous disadvantages of these anemometers, a dual nostril airflow anemometer is presented. A study has been carried out to select the Arabic words to be part of the test Ref [5]. There is a need to standardize the method of testing. The standardization is the measurement of the airflow for each nostril during the Arabic words in normal subjects'. This research describes the method, the measurement, and the result analysis of the normal subjects airflow during the Arabic speech.

The System Description

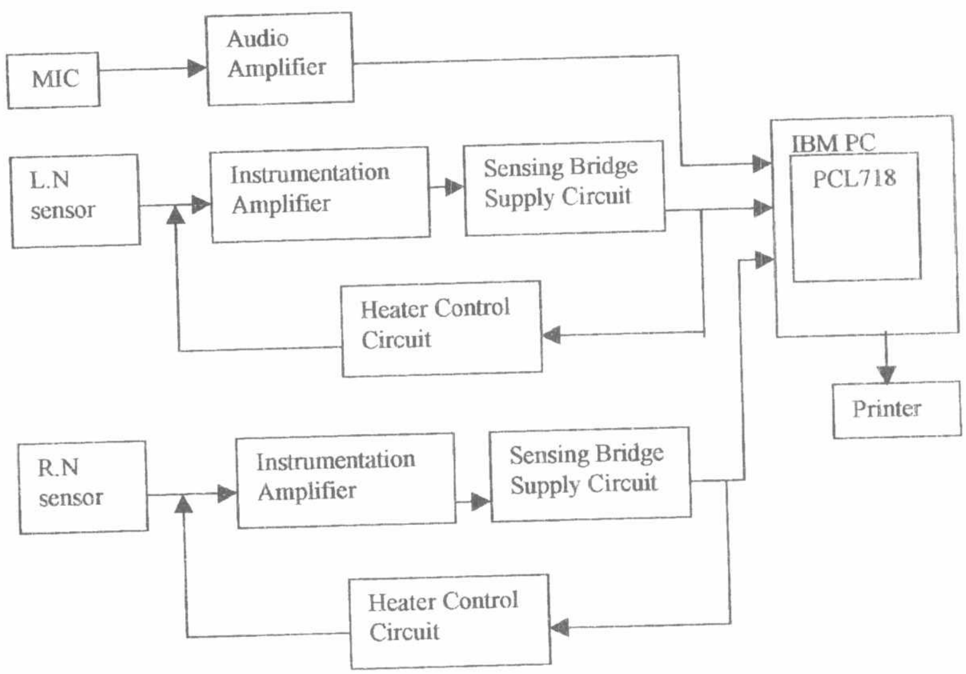

Figure (1) Block Diagram of the System

The system consists of the sensors holder to support the sensor for each nostril, Mic for Audio signal, signal recovery and signal processing unit (signal Conditioning unit), a personal IBM compatible computer configured with data acquisition card type PCL 718 and a special software package written in Turbo Pascal. As shown in figure (1). The system has three channels the first is the audio amplifier channel, which has been used to record the speech signal. The second and the third channels is the nasal airflow channel for dual nostril (left nostril–right nostril). Both the nasal airflow and the speech signals are fed to the data acquisition card PCL718 type placed in one of the free slots of the P.C. computer [6].

New Technology Airflow Sensors

A new technology airflow sensor relies on the extremely low heat capacity of an unsupported thin film. Two sensing elements flanking a central heating element allow the indication of direction of flow as well as flow rate as shown in figure (2).
Air flowing from left to right carry heat away from the first permalloy sensor thereby cooling it and reducing its electrical resistance. Before the air reaches to the second sensor however it warmed by the heating element and it transfers some of this heat to the second sensor. The temperature variation between the two sensors gives rise to a resistance difference proportional to the airflow velocity [7].

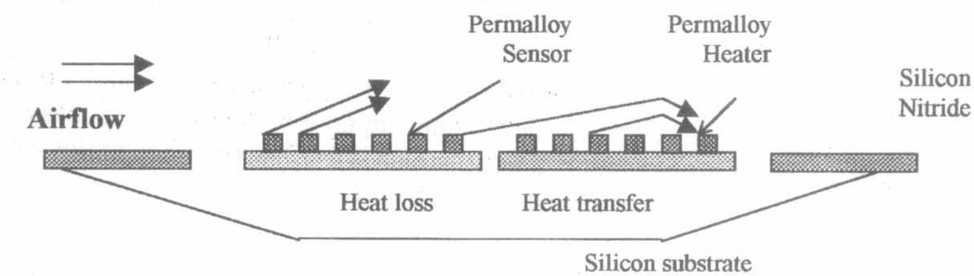

Figure (2) Airflow sensor

The sensor operating from a 10 VDC supply, consumes only 30 mW of power. Ratometric voltage output varies from 0 to 45 mV as the mass airflow varies from 0 to 200 standard cubic centimeters per minute (SCCM). The corresponding voltage output can also be calibrated to measure average channel flow velocity, or dynamic differential pressure across the channel ports. The sensor is comprised of two wheatstone bridges:
One for closed loop heater control, and one for the twin sensing elements. There is three additional circuits necessary for proper sensor operation:
The heater control circuit in figure (3) is required for operation per specification and provides temperature compensation. It is uniquely adapted to the flow sensor and provides an output proportional to mass flow by minimizing errors due to ambient temperature changes.

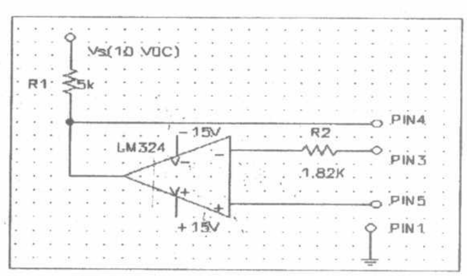

Figure (3) Heater control circuit

This circuit keeps the heater temperature at a constant differential above ambient air temperature under varying temperature and airflow. The sensing bridge supply circuit in figure (4) is also required for operation per specification. This is conventional whetstone bridge circuit where the dual sensing resistors make up the two active arms of the circuit. Ratiometric voltage output of the device corresponds to the differential voltage across the whetstone bridge circuit.

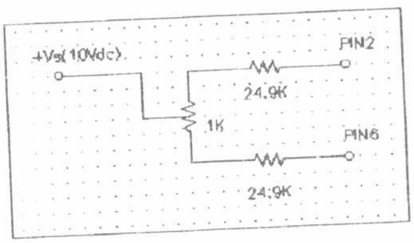

Figure (4) Sensing bridge supply circuit

As the direction of the airflow through the device is reversed polarity of the differential voltage goes negative, as does the voltage output of the Microbridge mass airflow sensor. The differential instrumentation amplifier also is a useful interface to the sensing bridge. It can be used to increase the gain and to introduce voltage offset to the sensor output.

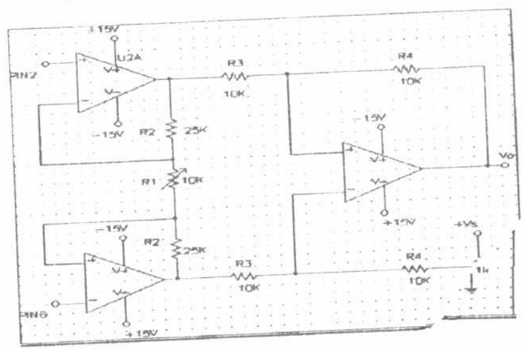

Figure (5) Differential instrum· ·cation amplifier

Mass flow Sensor Operation

The mass flow sensor circuit figu·· (6) consi·ts of two indepen·ent circuits which include two main subcircuits [8].

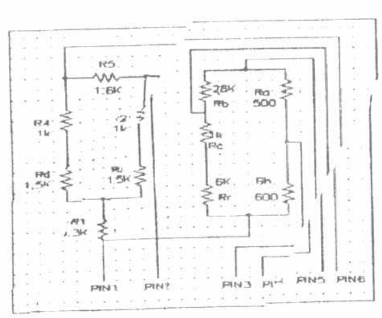

Figure (6) Mass fl·w sensor

- Heater control bridge:

This circuit is a Wheatstone bridge used to set the bridge temperature at 160^{0}C over ambient. The ambient temperature resistor sensor (Rr) and the heater resistor (Rh) have high TCR permalloy composition and the set resistors (Ra, Rb, and Rc) have low TCR spreads. Rc merely compensates for the not quite linear behavior of the Permalloy, while Ra and Rb is set to equal the microbridge temperature. Rb is set to equal the value of the ambient sensor resistor (Rr) at 25^{0}C. Ra is set to equal the value of the heater resistor Rh at 160^0 over 25^0 For the bridge to balance, the heater must dissipate enough power to heat it 160^0 over ambient; the op amp provides this power. This entire subcircuit is on the chip. Rb is thin film laser trimmed.

- Sensor Wheatstone bridge.

Upstream resistor (Ru) and downstream resistor (Rd) are located on the chip, upstream and downstream designations are arbitrary, since the sensor is bi-directional. Both Ru and Rd are high TCR Permalloy. As air flows past them, the upstream resistor cools and the downstream resistor heats up generating a voltage difference as much as 50 mV proportional to mass airflow. The other half of the bridge consists of two low TCR current-limiting resistors. They prevent more than 1mA from flowing into the sensor resistors. More than 1mA causes self-heating and distorts the signal. The current–limiting resistors are also used to null the bridge (set output to zero volts at zero flow.) Ru and Rd are on the chip, the others are not.

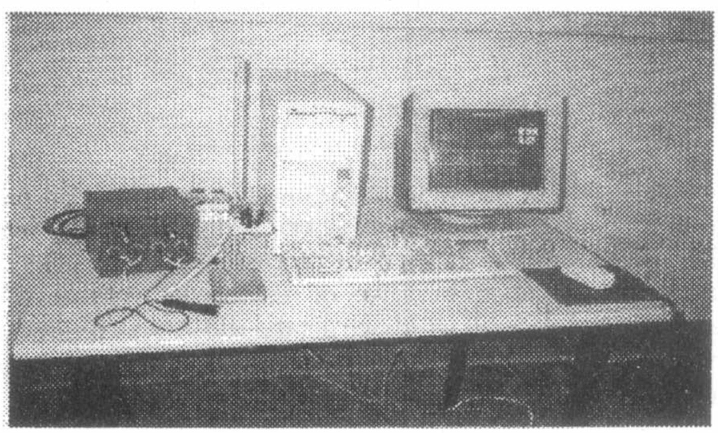

Figure (7) Photographic diagram for each part of the system

System Calibration Procedure.

The main advantage of the system is that it has been calibrated in (SCCM) [7]. This is done by transforming the measured voltage from the airflow sensor into nasal airflow in (SCCM) through the calibration curve represented in figure (8) which permit the output data to be stored directly in (SCCM).

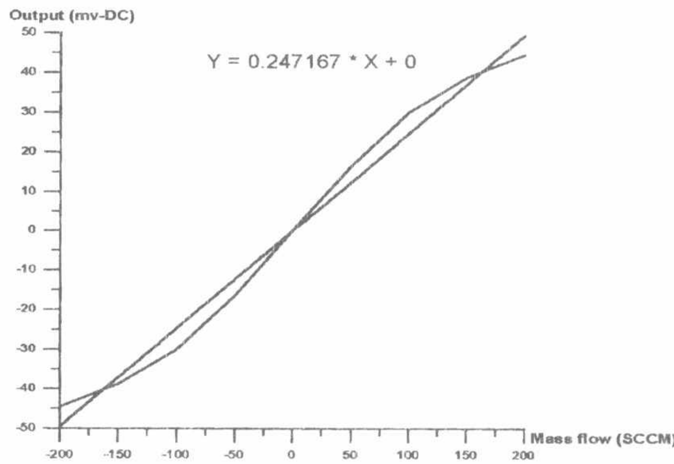

Figure (8) The relation between the output voltage (mV) and the flow rate (SCCM) Curve.

System Measurement.

This research is undertaken in attempt to quantify the airflow for each nostril in normal subjects during speech based on the Arabic articulatory phonetic. The Arabic speech sound can be divided into nasal and non-nasal speech sounds. In nasal speech the majority of the airflow is produced through the nasal passage, while in the non-nasal one the majority of the airflow is produced through the oral ways. Two groups of Arabic words are used non-nasal group contains the words [1] :

كاكي – سال – ساح – سار – تيس

While the nasal group contains the words:

من – قناة – نمور – ميزان – مرمر

At first, the subject put the sensor facing to the anterior nostril, then the software will guide him for saying the words through the screen. After saying each word the signals are acquired. Later on the recorded data will be processed.

Our program measures the mean value of the amount of nasal airflow during the Arabic speech for each nostril. For each word, we get the min & max mean value to get the range of Airflow for normal subject during speech [9]. So the system can be used to distinguish the abnormal subject.

Sample of Result.

In our sample of result we define the range of the amount of the airflow in each nostril for each word in the two set. Inclusion criteria for individuals sharing this study are :

- Ear nose and throat examination revealed no abnormalities are regards the phono-Articulatory system.
- Arabic speaking, Egyptian from Cairo locality.
- Age ranged between 18 and 30 years old.
- male subjects.

The test was repeated 6 times to get rid of the human errors and to establish a confidence in the measurements. The average of the 6 runs for each subject is the basis of the statistical evaluation of the test.
Table (1) shows the max. and min. value for the sample of the non-nasal word
Table (2) shows the max. and min. value for the sample of the nasal word.
Figure (9) show the nasal flow rate of the one of the tested subject during the pronunciation of the non-nasal word كاكى.
Figure (10) show the nasal flow rate of the same subject during the pronunciation of the nasal word من.

Words	كاكى		سال	
Mean value in (SCCM)	Mean of the left nostril (SCCM)	Mean of the right nostril	Mean of the left nostril (SCCM)	Mean of the right nostril
Min	21.08	22.65	19.97	21.64
Max	28.31	29.68	27.91	28.67

Table (1) The max. and min. value for the sample of the non-nasal word

Words	من		قناة	
Mean value in (SCCM)	Mean of the left nostril (SCCM)	Mean of the right nostril	Mean of the left nostril (SCCM)	Mean of the right nostril
Min	32.35	33.69	25.78	28.91
Max	41.55	43.27	38.77	41.22

Table (2) The max. and min. value for the sample of the nasal word

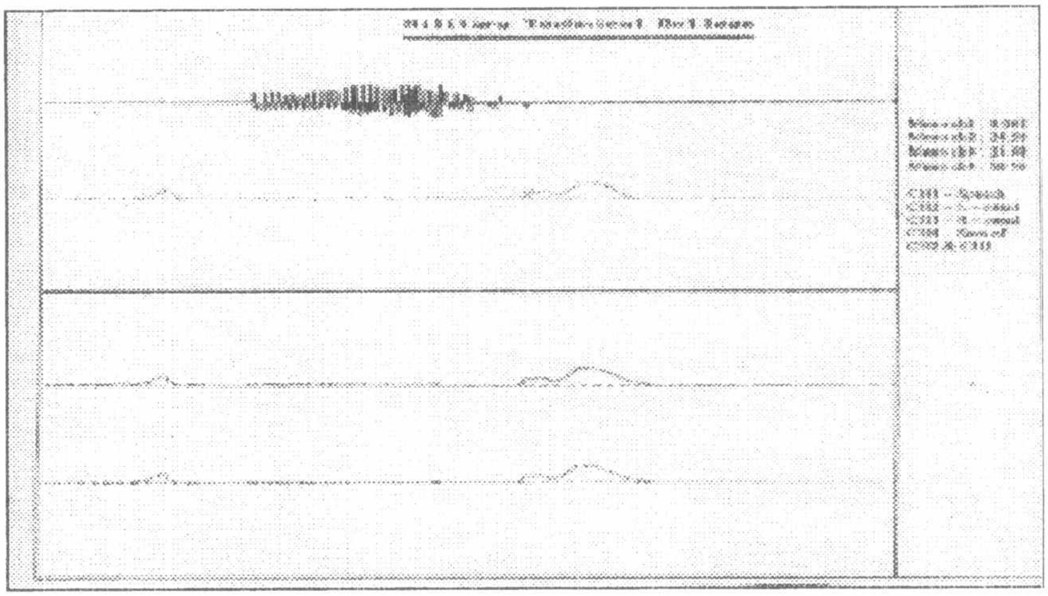

Figure (9) The nasal flow rate of one of the tested subject during the pronunciation of the non-nasal word كاكى.

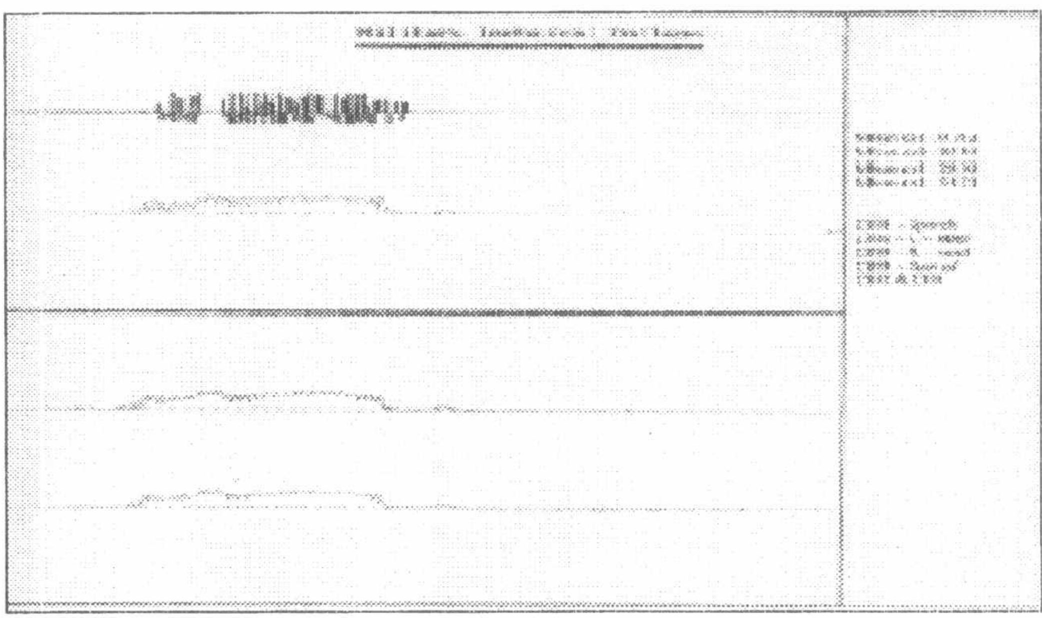

Figure (10) The nasal flow rate of the same subject during the pronunciation of the nasal word من.

As seen at the graph of figure (9) the mean value of the airflow for each nostril is presented at the right side of the graph where:

Channel '1' represent the graph of the audio signal during the pronunciation of the non-nasal word كـاكى Channel '2' represent the graph of the left nostril signal during the pronunciation of the non-nasal word كاكى .

Channel '3' represents the graph of the right nostril signal during the pronunciation of the non-nasal word كاكى

Channel '4' represent the graph of the summation of the right and left nasal signal during the pronunciation of the non-nasal word كاكى .

While figure (10) shows the result for the same person while pronunciation of the nasal word مـــن. The results of the sample of subjects have been collected. From these results, the range of the mean airflow during each word for each nostril is calculated. So we can get the max. and min. mean for each nostril during each word, which represent the range for the normal subject. The result of any other subject out of this range means that the subject is abnormal.

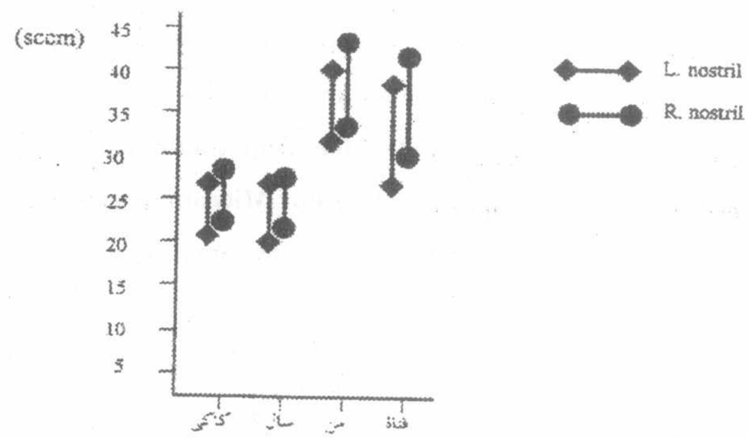

Figure (11) Graph for the min. and max. mean value for each nostril in different word

Discussion and conclusion.

The Egyptian army physicians have been faced with a problem in the medical tests during the selection of new personal for the military collages. This problem is that the physician can not study the activity of the air passages in the nose and nasopharyngel. They satisfied by the visual comparison studies. Sometimes, there are some physical abnormalities, but it does not affect the air passages and no method to justify it. This technique will help the choice of the optimum treatment for the nose and nasopharyngeal diseases. The advantages of using this system are calibrated (sccm), easy, low coast, accurate, environment independent and diagnose the defect for each nostril.

Our system examining the upper air passages for each nostril during Arabic words. The research is carried away to measure the mean of the amount of nasal airflow for each nostril during Arabic speech for the normal subjects. With the achieved results, the system can be used for distinguishing the abnormal subjects. Our future work is the measurement of the nasal airflow during the normal respiration for the normal subject.

The domain of normal subjects in (SCCM) is demonstrated in figure (11). Subject out of these ranges considered as abnormal subject

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