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A NEW METHOD FOR DETERMINATION OF MENSTRUAL CYCLE AND FERTILE PERIOD

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ABSTRACT

The World Health Organization (WHO) established in 1972, a special programme to assess and improve the safety and effacacy of existing methods of fertility regulations. The task force supported research on variety of methods based on determination of fertile period.

An attempt was made by authors to identify physical parameters which could be used to, precisely and reliably predict ovulation, having Bio-Engineering approach.

The approach is based on non-invasive technique that is monitoring the frequency-response of sound utterences. Probably this approach will be first of it's own kind in evaluation of menstrual cycle and the fertile period.

It was found that out of 54 Hindi segments the Vowel 'A'(अ), e(ए) and consonants Chh(छ), Jh(झ), b(ब) and R(र) were able to represent menstrual cycle.

It is concluded that with this new approach, the woman herself can determine the fertile phase of menstrual cycle. Further the deviation in the frequency are indicative of cervical and vaginal status.

The suggested new method will be helpful for family planning programme as well as for health care due to menstrual irregularity.

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KEY WORDS

Menstrual cycle and Fertile Period, Frequency response of sound utterences, Hindi segmentals vowel and consonants.

INTRODUCTION

Unlike Medicine, Engineering has had only a brief history. Though medicine and surgery have had a very long existance but Bio-Engg had been in vogue for only few decades. These facts are amply justified by the widespread usage of ECG, EMG, C-T scan etc.

Biological rhythems are known to characterize many physiologic variables of plants, animals including humans(1). The fertile period is that part of menstrual cycle during which insemination may lead to pregnancy. It is generally assumed that this period occupies about 3-4 days before, and 1 day after, the event of ovulation(2). Providing reliable methods which would permit women themselves to predict and detect ovulation could be have a major impact on family planning programme(2). During Geneva meeting (1973) a number of additional approaches for determination of fertile period were suggested e.g.changes in breast temperature, blood flow to nipple etc.

Attempts have made by the authors to assess the posibility of frequency-response of sound utterences for monitoring the menstrual cycle and fertile

period. Probably this approach will be first of its own kind in this direction of Bio-Engg. field.

MATERIALS AND METHOD

In the present non-invasive method the Hindi segmental vowel and consonant utterences were recorded on a philips-tape using philips recorder. The utterence of vowel and consonants, that of number of women on every day basis was recorded with a note of physical menstrual condition status as reported by them. The recorded sound was subjected to a bank of filters for peak frequency determination(3). Each vowel and consonent utterence of every woman was analysed for frequency-response.

RESULT

It was found that out of 54 Hindi segmental having vowels/consonants only vowel 'A'(आ) and 'e'(ऐ) and consonants 'Chh'(छ), 'Jh'(झ), 'b' (ब) and 'r' (र) were found to represent truely the menstrual cycle with the marking of fertile period accurately. The attached Graphs(No.1,2) clearly indicate this period of manstrual period as well as ovulation.

CONCLUSION

It is concluded that with the new approach and the non-invasive method of determination of menstrual cycle, the women can easily know themselves the fertile and infertile phases of their menstrual cycle. Further the deviation in the frequency response are indicative of cervical and

vaginal status.

The new method suggested will be helpful for family planning programme too.

ACKNOWLEDGEMENT

Authors are thankful to authorities for providing facilities to work in the laboratory.

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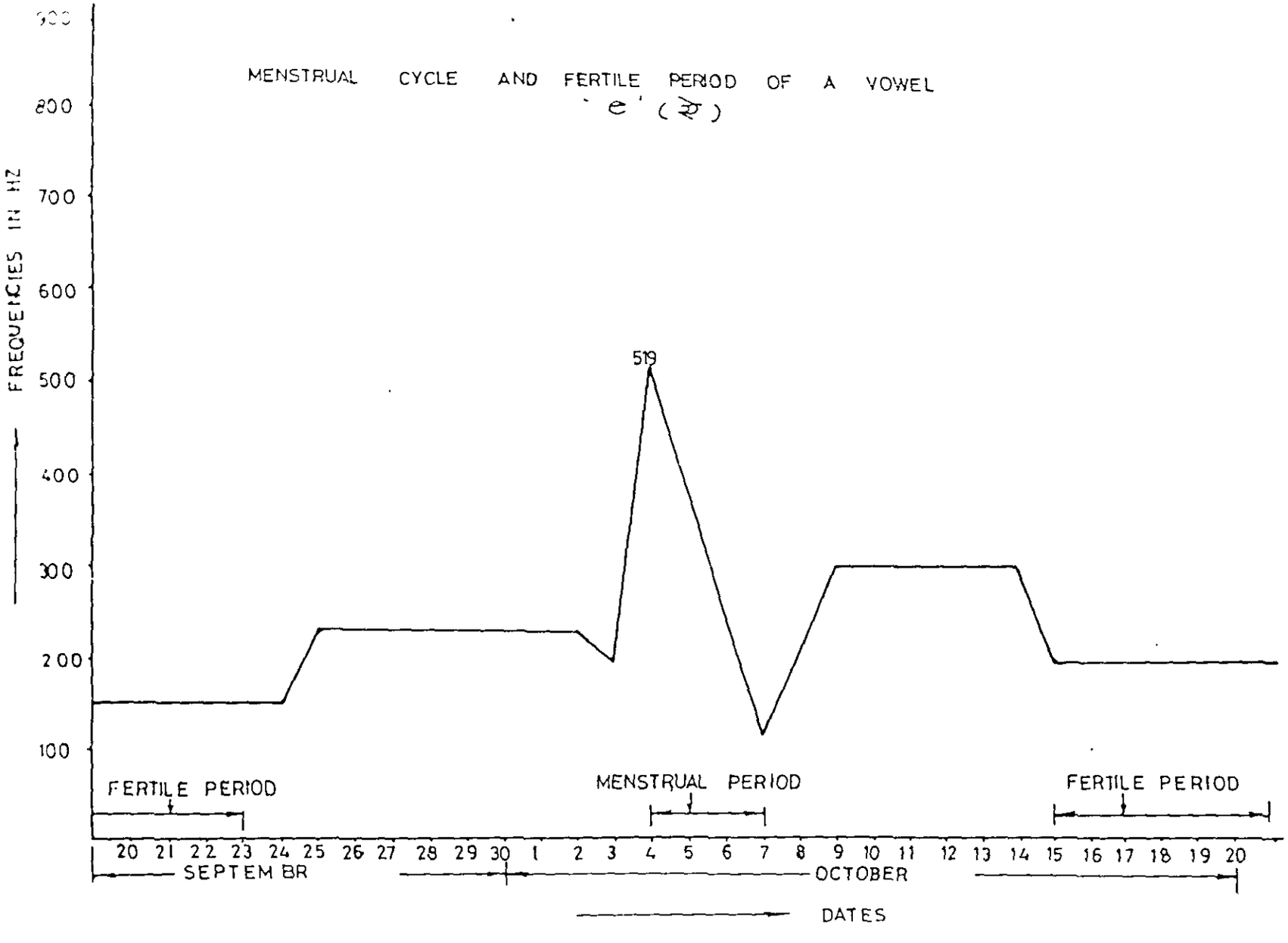
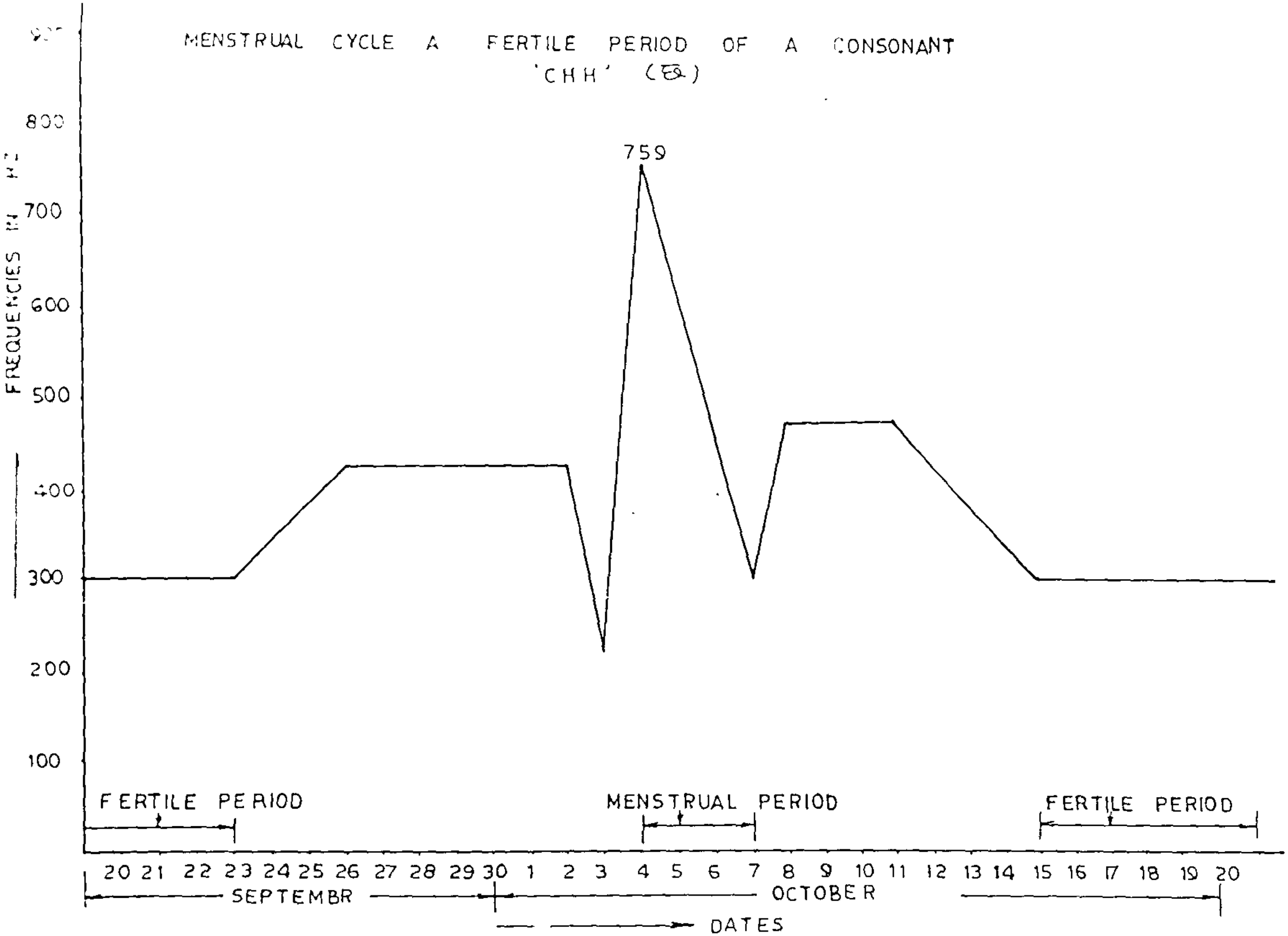

MENSTRUAL CYCLE AND FERTILE PERIOD OF A VOWEL
'e' (ए)
FREQUENCIES IN HZ
900
800
700
600
500
400
300
200
100
519
FERTILE PERIOD
MENSTRUAL PERIOD
FERTILE PERIOD
20 21 22 23 24 25 26 27 28 29 30 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
SEPTEMBR
OCTOBER
DATES


MENSTRUAL CYCLE A FERTILE PERIOD OF A CONSONANT
'CHH' (छ)
759
FREQUENCIES IN HZ
800
700
600
500
400
300
200
100
FERTILE PERIOD
MENSTRUAL PERIOD
FERTILE PERIOD
20 21 22 23 24 25 26 27 28 29 30 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
SEPTEMBR
OCTOBER
DATES

CARDIO - FUNCTIONAL ASSESSMENT FROM SPEECH SEGMENTALS

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ABSTRACT

ECG patterns are extensively used for the assessment of Heart-muscular functioning. Electrical events precede the mechanical contraction of heart. In the present paper the feasibility of assessing the heart functioning from uttered speech segmental is reported. It is found that the time-frequency response of Palatal-Velar consonant utterances of Hindi segmental can be used for assessment of cardiac functioning. Further the information can be transferred on phone for expert opinion This is first time in the world that phonic information is being used for cardiac assessment by the authors.

BACKGROUND OF DEVELOPMENT

It is mentioned in the Hindu mythological literature (1,2) that the Cardiac plexus has bearing with the utterances of Twelve Hindi consonants mainly the palatal-velar one i.e. Ka(क), Kha (ख),Ga(ग),Gha(घ),Anga(ङ),Ch(च),Cha(छ),Ja(ज),Jha(झ),Y'a(ञ), Ta(ट), and Tha(ठ).

This has inspired authors to think, whether there can be any relationship with these speech segmental with the functioning of heart. For the first time in the history of World these Hindi speech Segmental mentioned above were monitored scientifically for development of relationship with cardiac functioning.

HEART FUNCTIONING MONITORING

There are various methods of tracking the heart functioning (3). The phono cardiograph was developed earlier to monitor the heart sound but could not be used due to non-availability of appropriate instruments in the lower range of heart-frequency (25-50 Hz). The electro cardiograph (ECG) is much more popular and is extensively used. According to rhythmic contraction of heart the electrical pulses are generated, they are sensed by electrode and are recorded, normally it is known as ECG.

ECG

The human heart contains four valves - Mitral, Tricuspid, Aortic and Pulmonic. These valves regulate blood flow between different cardiac chambers and out of heart to main blood vessels. These events are reflected by ECG Pattern (4) as -

(I) A first positive P wave, due to artial Sytole preceding QRS complex.
(II) Q - beging of Ventricular Excitation.
QRS - Spread of Excitation in the Ventricle.
PR - duration of cycle (A-V interval)

(iii) A second peak at the end of QRS due to closure of A.V. valve.
QT - spread of concentration in the Ventricle
T - end of Ventricular Systole.
(iv) A rise after T Wave, due to filling of artrium.
(v) Sudden fall of pressure due to mitral valve opening.
(vi) Rise due to Ventricular having been completed.

These events are depicted in the Graph No.1

PHONETIC METHOD

The cardiac plexus phonetic nearing consonants were uttered by the patient and were recorded using a SONY TAPE recorder and PHILIPS TAPE. The ECG patterns were also recorded with cardiac medical report.

The recorded tape was subjected to digital frequency instrumentation system for measurement of peak frequency and time duration. The frequency - time response pattern is shown in Graph No.2

RESULT

The resemblance of the two patterns clearly indicate that the cardiac assessment can also be made from the phonetic information.

If a person is suffering the QRS duration. Similarly diastole can be reflected by QT period (5) The same ailment will be reflected by the frequency-time curve of phonetic utterances, see Graph No.2.

CONCLUSION

It is concluded that just by monitoring time-response, the cardiac status can be assessed. Further using phonetic base, the patient can directly transfer his cardiac-status to expert on phone, while ECG can not be transferred. The proposed method is cheap, reliable and convenient for mass care centre and distant treatment too.

ACKNOWLEDGEMENT

Authors are thankful to medical authorities for providing the facilities foe experimentation and discussion.

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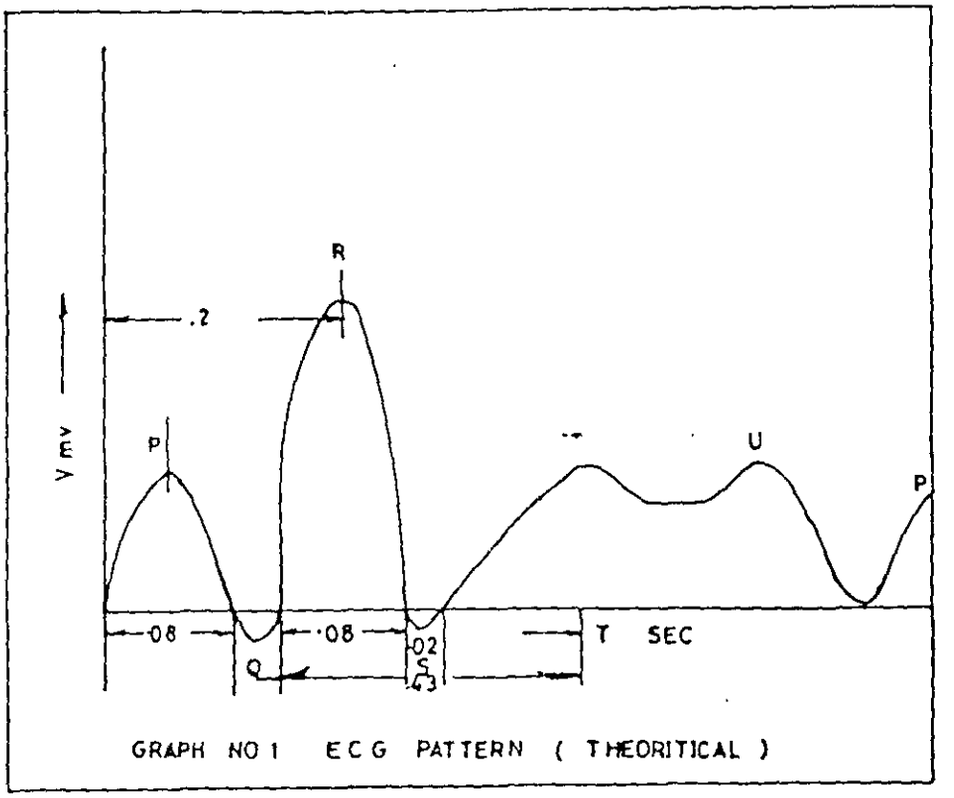
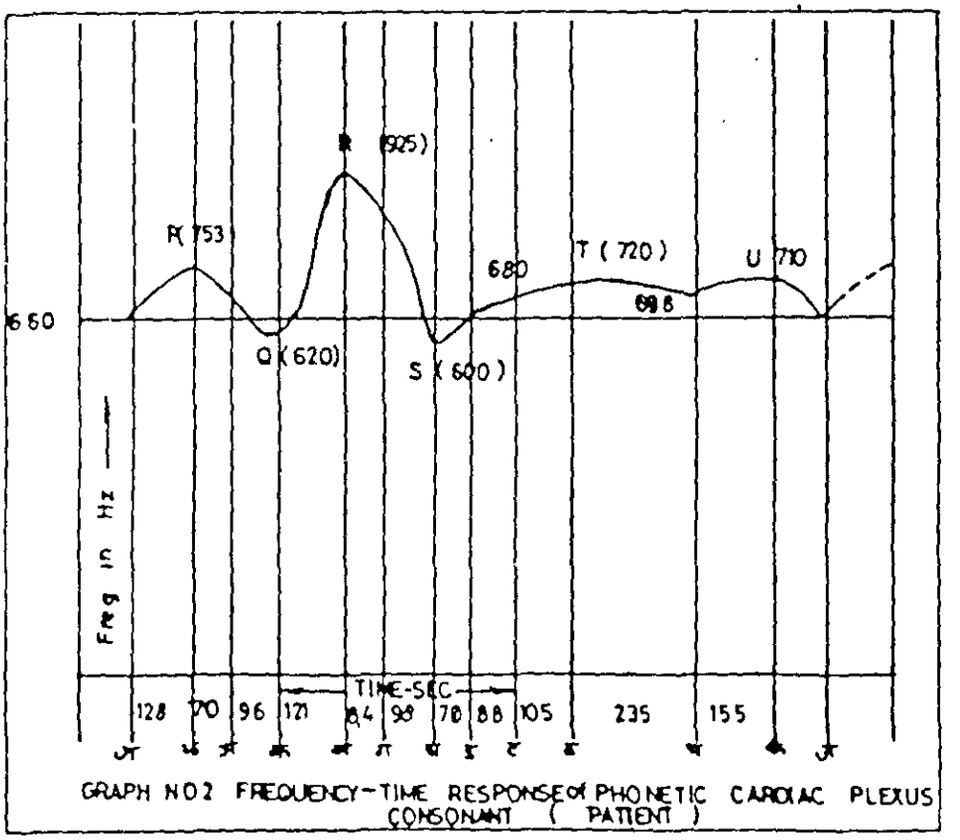


GRAPH NO 1 E C G PATTERN (THEORITICAL)



GRAPH NO 2 FREQUENCY-TIME RESPONSE OF PHONETIC CARDIAC PLEXUS CONSONANT (PATIENT)

Non Invasive Assessment of Foetus Weight Gain using Speech parameters

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ABSTRACT

In the production of speech the muscles of abdominal wall functions as expiration muscles. The most important of them are rectus abdominis muscles and obliquus abdominis muscles. These when contracting, draw the abdominal wall inwards, thereby increasing the cavity pressure, forces diaphragm back, thus reducing the volume of lungs and vice-versa. A Change in the myoelastic pulse will be reflected in the change of speech parameter namely the formant frequency. It is well known that the formant frequency can represent the prosodic features as well as the tonal one. However it is termed as grave/actute. The physical meaning of grave is related with the weight aspect. The same is represented by the ratio F1/F2. In the present study the aim of this information i.e. F1 F2 is used to assess the weight gain of foetus during pregnancy period, ranging from 8 weeks to 38 weeks. It is observed that there is a gradual weight gain of foetus during 12 weeks onwards. But the weight gain is with steep rate of rise during 28 to 36 weeks. It is concluded that the proposed non-invasive method of assessing the foetus weight growth is unique and is being developed for the first time in the history of Bio-Medical Engineering science. This technique will facilitate the Gynaecologists for proper care of pregnant women. Further this technique can be used for mass care.

Keywords:Foetus weight, Frequency, Speech Prosodic features

INTRODUCTION

The history of medicine and surgery can be traced since long ages But the span of history of Engineering is brief one. The existence of Bio-Engg. had been in voygue for only few decades The use of ECG, EMG, C-T SCAN, Ultrasound etc. justify the venture of Bio-Engineering The mythological books of Indian origin have reported that speech has generating centers in the body of human being and energy is drawn in the utterances of speech from the various parts of body representing the myoelastic nature In the present venture authors have tried to make use of the knowledge of such parameters of speech for the assessment of gynaecological condition of a pregnant lady. Thus truly it is use of speech in the field of Bio-Engineering Though Less [7] and co-workers have investigated the weight-height of speaker from speech parameter Kluckhohn et al [6] have presented the personality formation from speech Lynggard et al [8] has used the speech as diagnostic tool in medical science

But to the best of our knowledge so for none has used the speech parameter for status recognition of pregnant mother in the world for the First time in the history of medical field. authors have used the speech parameters for determination of menstrual cycle and fertile period of women [10].

In the present paper authors have used the prosodic feature of speech for assessment of weight gain of foetus. This will be an non-invasive investigating tool for mass care too.

BACK GROUND OF EXPERIMENTATION

The prosodic aspect of speech is with the problem of discovering the relation between physical properties of speech-sound-waves and the linguistic and psychological consequences of prosodic feature [2].Voice quality is one of the important features of speech which carries mainly information about the individual speaker who happens to be talking [9]. It seems probable, however, that much might be learned about physiology and psychology of an individual from study of voice quality.

The distinctive features [4] are divided into two classes- (1) Prosodic Features and (2) Inherent

The three types of prosodic features which we term Force, Quantity and Tone corresponds to Intensity, Time and Frequency as physical correlates. The prosodic features may be either intersyllabic or intrasyllabic. The intrasyllabic variety of features, a difference is produced by the sublaryngeal mechanism, in particular by the abdomen diaphragm movements.

In case of tonality features grave/acute gives a plane of predominance of low (vs high) parts of frequency spectrum. Thus the ratio of high to low frequency registers will be indicative of grave i.e. weight gain register component of frequency [4].

THEORITICAL RELATIONSHIP WITH FREQUENCY AND WEIGHT GAIN

At the earliest period of development, the fertilized ovum is dependent for it's nourishment on the remains of cell of discus proligerus adhering to it or the fluid of fallopain tube in which it is immersed. From second month onwards the close relationship with maternal blood is formed, from which the whole growth of foetus is subsequently maintained, inside the abdomen space [1]

Thus the myoclastic behavior of abdominal cavity of mother having foetus, will have it's reflection in the prosodic features of speech of mother, indicating the weight gain of foetus

MATHEMATICAL REPRESENTATION OF FOETUS GROWTH

The abdomen cavity is like a diaphragm, on out of which is air and inside some medium, in contact with it When such a diaphragm vibrates due to added mass contact (foetus weight gain), the inertia of the diaphragm is increased, lowering the frequency of vibration. This lowering of frequency will be reflected in the lowering of formant frequency.

According to Wood [11] the frequency is given by

$$N = \cdot 4745 \frac{h \times c}{a^2} \cdot \frac{1}{\sqrt{1 + \beta + \frac{5m}{M}}} \qquad (1)$$

where $\beta = \cdot 6689 \frac{\rho_1}{\rho} \cdot \frac{a}{h}$ (2)

c = velocity of sound in medium

h = thickness

a = radius of diaphragm

ρ_1 = density of contact material

ρ = density of diaphragm material

N = frequency of vibration

M = mass of diaphragm

m = mass of load at the center of diaphragm

Thus by way of measuring the ratio of frequency spectrum the weight gain of foetus can be evaluated

$$Hence \quad \frac{f_1}{f_2} = \sqrt{\frac{1+\beta_2}{1+\beta_1}}$$

$$\cong \sqrt{\frac{wf_2}{wf_1}} \qquad (3)$$

where

wf_2 = weight foetus at some pregnancy level (say fifth month)

wf_1 = weight of foetus at some prequency level (say second month)

EXPERIMENTAL OBSERVATIONS

The speech utterances of many pregnant ladies with various months of pregnancy from 8 weeks to 35 weeks (as certified by Gynaecologist) have been recorded on a good quality Sony tape, using Philips tape recorder, in a noise free room The recorded sound was subjected to a bank of filters to find F1, F2 and F3 range of speech frequencies and was recorded The variation of F1/F2 is drawn with the weight of foetus (as reported by Gynaecologist)

RESULT

The graph No 1 depicts the acoustical frequency response ratio of F1/F2 Thus indicating the weight gain of foetus increases with the advancement of pregnancy and this confirms the weight gain of foetus in actual practice [5]

CONCLUSION

It is concluded that with the non-invasive method proposed by authors, the weight of foetus can be assessed at any stage of pregnancy

This will help not only the mother but to the Gynaecologist as well to trace the growth of foetus This instrumentation will also be helpful for mass care at rural centres.

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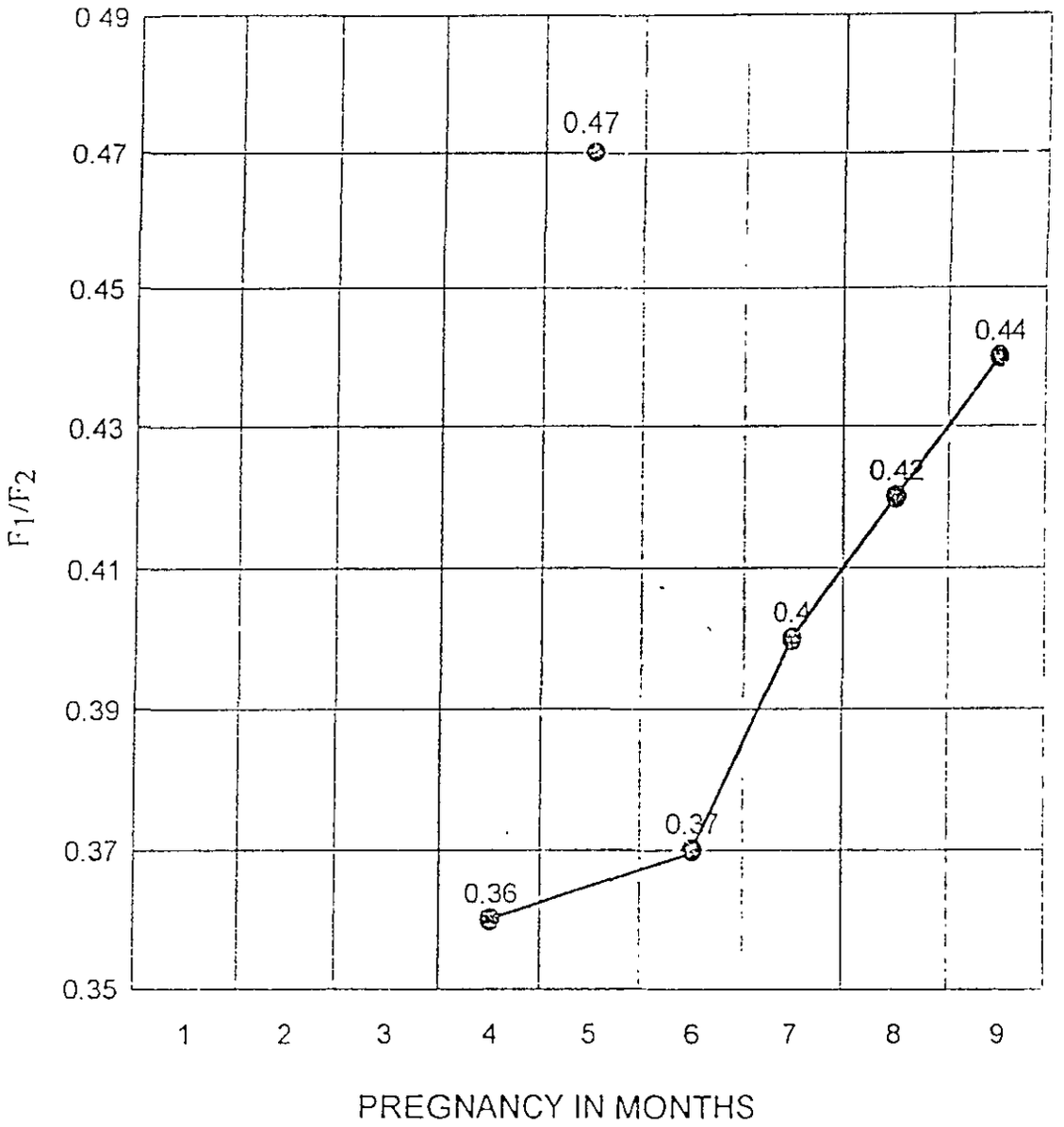

GRAPH SHOWING THE FOETUS WEIGHT GAIN AT DIFFERENT LEVELS OF PREGNANCY USING F_1/F_2 RELATIONSHIP

GRAPH NO 1

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ACOUSTICAL SPEECH METHOD FOR MONITORING THE FOETUS GROWTH

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ABSTRACT

The voice production and laryngeal vibrations have been a subject of research. The theory proposed by Hussain (1950) is based on Neurochronaxics, i.e. laryngeal vibrations are produced by nerve impulses. Further the mechanism of larynx and laryngeal vibrations have been explained on myoelastic theory by Ferrein (1971). It is a matter of general observation that when a blow or pressure is applied to stomach, there is sudden increase of pitch during phonatation. This is due to myoelastic impulse.
Based on above facts authors have developed a non-invasive technique to monitor the growth of foetus in the womb of mother.
The acoustical speech utterances of Hindi linguistic segmentals, that of the pregnant women are recorded on a good quality tape, in the experimental room free from external noise. The recording is made for number of pregnant ladies ranging from 8 weeks to 35 weeks of pregnancy (as certified by gynecologist the consultant Doctor) irrespective of cast and creed.
It is observed that the Acoustical frequency response of pregnant women changes with the growth of foetus. There is decrease in the frequency level upto 16-20 weeks of pregnancy almost by 65-70%. Later on the frequency level increases till the 32 weeks almost by 50-60%. However there is sudden drop in frequency level (by 50% to 75%) as the delivery time is approached. The same will be reported in the present paper with suggested theoretical discussion.
It is concluded that this approach of authors using Acoustical speech method for monitoring the growth of foetus non-invasively is being tried for the first time in the medical history known to us. Further this technique will be helpful for mass checking of pregnant women for foetus growth, even at the rural base centre. It can be used easily by layman or by the lady herself.

KEY WORDS

Speech, Foetus Growth ,Monitoring, Acoustical

BODY AND THE SPEECH

In dealing with the voice (speech) of a man, we must not fall into habit of separating the body behavior and calling it a sort of outward symbol of private thought (1). In fact the air we breathe, the air we talk and hereby is not merely an outside air.
The voice of man is one component in a whole body postural scheme (5). In this sense a man speaks with his breathing apparatus, his body muscle and head. The physical affords has its accompaniment in vocal efforts. Thus all with their own vocal and muscular obligates in harmony with characteristics in a speech.
The voice production have been a subject of research. The theory based on Neurochronaxics have been proposed by Hussain (1950) Ferrein (1971) have explained the characteristic behaviour of speech based on myoelastic theory. According to Hindu mythology (India) as well, speech sound have different body centers of generation and has the roots of characteristics of their body behaviour as phonetic information.

The change of pitch in speech with a blow on stomach is a matter of general observation and is due to myoelastic impulse.

PRODUCTIVE MECHANISM.

The vocal apparatus consists of different parts some of which belongs to the elementary tract and others of respiratory organs. These embrace the oral, nasal, pharynqeal, pulmonic and esophangeal (including stomach) cavities (4). The size and shape of these cavities can be modified by the action of the muscles, thus producing current if compressed air from lungs to the larynx. (*See figure 1*)

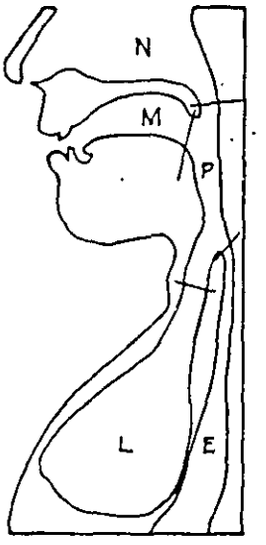


FIG. 1. Cavities
E, esophagus; *L*, lungs; *M*, mout
N, nose; *P*, pharynx

THE STOMACH AND SPEECH

The chest is composed of 12 pairs of Nibs, held in place by elastic connective tissue and muscles, which through their contractions raise or lower the ribs, thus increasing or decreasing the volume of chest cavity and lungs (4). The diaphragm forms the horizontally set dome shaped floor of the chest cavity. At contraction the diaphragm is lowered whereby the volume of chest cavity and lung is increased. At the same time the pressure in the abdominal cavity increases and the abdominal wall protrudes more or less. The muscles of abdominal wall functions, when contracting draw abdominal wall inwards, there by increasing the cavity pressure.
The elastic connective tissue forms an important element of lungs and bronchial tree. Thus in the phase of phonatation, the muscles of abdominal wall also participates.

FOETUS DEVELOPMENT

At the earliest period of development, the fertilized ovum is dependent for it's nourishment on the remains of cells of discus proligerus adhering to it, or on the fluid of the fallopian tube in which it is immersed. From the second week on wards, blood vessels traversing the chorionic villi come into close relation with the maternal blood, from which the whole growth of foetus is subsequently maintained by special development of these connection in the placenta. The placenta represents the foetal organ of respiration, nutrition and excretion (3)

In the fully formed foetus, blood passes from the foetus to placenta by umbilical arteries and is returned by umbilical vein. As the pregnancy advances, the foetus grows more rapidly, due to maturation of placenta after 16-18 weeks of pregnancy.

COMMUNICATION & ABDOMINAL ELASTIC BEHAVIOUR

The elastic connective tissues of abdominal cavity regulates the flow of air stream while phonatation, The abdominal cavity can be represented (2) as a resonating cavity, with elastic muscular material which operates with a resonating vibrating frequency given by

$$f = \sqrt{\frac{E}{\rho}}$$

where E = Elasticity constant.
r = Density of muscular membrane

From the above mathematical representation it is obvious that if the muscular membrane have different density (mass) more or less, accordingly the frequency of chest cavity or phonatation will be changed.

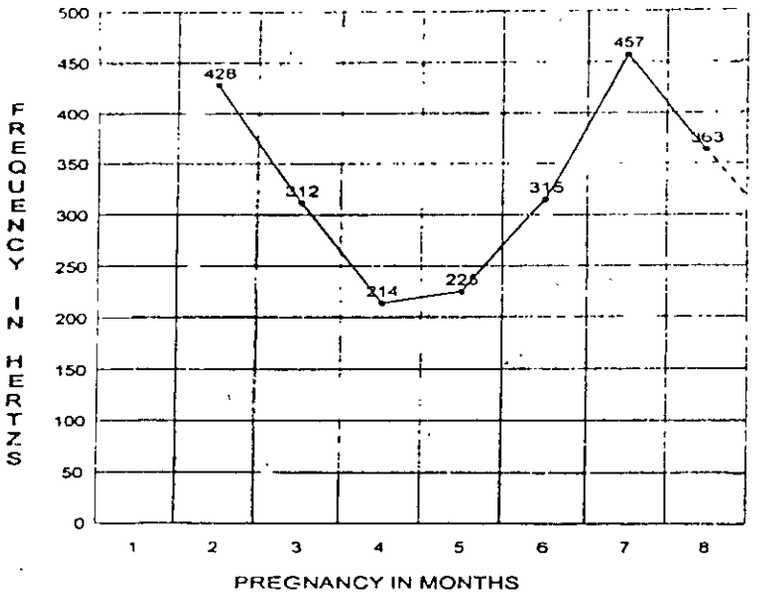
EXPERIMENTAL OBSERVATION

The speech utterances of many pregnant ladies with various months of pregnancy i.e. from 8 weeks to 35 weeks (as certified by Gynecologist) have been recorded on a good quality of Sony tape, using Philips tape recorder, in a noise free room.

The recorded sound was subjected to a bank of filters to find peak frequency (6). Each vowel and consonant of each informant was analyzed and the analysis is reported, for an average pregnant women behavior for phonetic segment (see Graph No.2) and that of individual one (See Graph No.1)

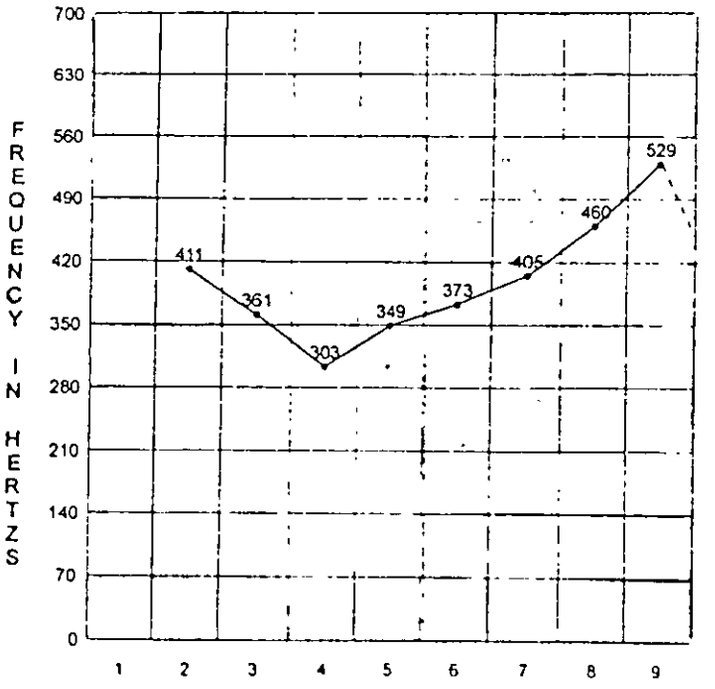
RESULT

The Graph No. 2. depicts the acoustical frequency response of pregnant women with the growth of foetus. There is decrease in frequency level upto 16-20 weeks of pregnancy almost by 65-70%. Lateron the frequency level increases till the end of 32 weeks almost by 50-60%. However there is drop in frequency as the delivery time is approached. Refer Graph No. 1 in which case the delivery has taken place 15 days ahead than the scheduled date.



GRAPH NO. 1

TITLE : GRAPH SHOWING THE FREQUENCY RESPONSE OF LINGUISTIC SEGMENTAL (ɪ) WITH THE PREGNANCY STATUS OF AN INDIVISUAL LADY.



GRAPH NO. 2

TITLE . GRAPH SHOWING THE AVERAGE FREQUENCY RESPONSE OF LINGUISTIC SEGMENTAL (ɪ) WITH THE PREGNANCY STATUS

DISCUSSION OF RESULT

The foetus has a direct link with the placenta. The placenta is a muscular part of abdominal cavity having an elastic nature. The frequency response can be given by

$$f = \sqrt{\frac{E}{\rho}}$$

It is obvious that at the initial stage of pregnancy (16-20 weeks) the growth of placenta as well as the foetus is taking place. Thus there is increase of density (r) of the abdominal cavity. This increase in mass causes the phonatation frequency to come down as indicated in the Graph No. 1 and 2.

After 18-20 weeks of pregnancy the placenta matures and the nourishment growth of foetus takes place which increases the elasticity constant of abdominal cavity, thereby increasing the phonatation frequency of pregnant women as seen in the Graph No. 1 and 2.

Thus it is obvious that by monitoring the frequency response of pregnant women the foetus growth can be monitored as effective as with other medical tools, rather more conveniently.

CONCLUSION

It is concluded that with the frequency analysis of speech of pregnant women the foetus growth can be monitored non invasively. It is for the first time in the history of medical science that the integration of speech has been made with the foetus growth by the authors.

Further this technique will be helpful for mass checking of foetus growth even at the primary health centre level. It can be used by layman or pregnant lady herself.

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NONINVASIVE ASSESSMENT OF FOETUS GROWTH USING SPEECH PARAMETER

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ABSTRACT

The mechanism of larynx and laryngeal vibrations have been explained on myoelastic theory by Ferrein (1971). It is a matter of general observation that when a blow or pressure is applied to stomach there is sudden increase of pitch during phonation. This is due to myoelastic impulses. In the production of speech the muscles of abdominal wall function as expiration muscles. The muscles when contracting draw the abdominal wall inwards, there by increasing the cavity pressure, forces diaphragm back, thus reducing the volume of lungs and vice-versa. A change in the myoelastic pulse will be reflected in the change of speech parameter namely the formant amplitude.

Based on above facts authors have developed a noninvasive technique to monitor the growth of foetus in the womb of a mother.

The acoustical speech utterances of Hindi linguistic segmental, that of the pregnant women are recorded on good quality tape, in the experimental room free from external noise. The recording is made for number of pregnant ladies ranging from 8 weeks to 35 weeks of pregnancy (as certified by gynaecologist the consultant doctor) irrespective of caste and creed.

It is observed that the acoustical formant amplitude response of the pregnant women reflects the growth of foetus in the womb. The increase in formant amplitude from 3rd to 5th months of pregnancy is due to the growth of foetus volume. This in turn causes the change of stomach diaphragm pressure and thus the formant amplitude characteristic and there-after it decreases indicating the gain in foetus mass till the stage of the full term.

KEYWORDS

SPEECH, FOETUS GROWTH, ACOUSTICAL, DIAPHRAGM, FORMANT AMPLITUDE

BODY AND SPEECH

In dealing with the voice (speech) of a man, we must not fall into habit of separating the body behaviour and calling it a sort of outward symbol of private thought (1). In fact the air we breathe, the air we talk and hearby is not merely an outside air.

The voice of man is one component in a whole body postural scheme (5). In this sense a man speaks with his breathing apparatus, his body muscle and head. The physical efforts has its accompaniment in vocal efforts. Thus all with their own vocal and muscular obligates in harmony with characteristics in a speech.

The voice production have been a subject of research. The theory based on Neurochronaxics have been proposed by Hussion (1950). Ferrein (1971) have explained the characteristics behaviour of speech based on myoelastic theory. According to Hindu mythology (India) as well, speech sound have different body centers of generation and has the roots of characteristics of their body behaviour as phonetic information. The change of pitch in speech with a blow on stomach is a matter of general observation and is due to myoelastic impulse.

PRODUCTIVE MECHANISM

The vocal apparatus consists of different parts some of which belongs to the alimentary tract and other of respiratory organs. These embrace the oral, nasal, pharyngeal, pulmonic and esophagal (including stomach) cavities (4). The size and shape of these cavities can be modified by the action of the muscles, thus producing current of compressed air from lungs to the larynx.

THE STOMACH AND SPEECH

The chest is composed of 12 pairs of ribs, held in place by elastic connective tissue and muscles, which through their contractions raise or lower the ribs, thus increasing or decreasing the volume of chest cavity and lungs (4). The diaphragm forms the horizontally set dome shaped floor of the chest cavity. At contraction the diaphragm is

lowered whereby the volume of chest cavity and lungs is increased. At the same time the pressure in abdominal cavity increases and the abdominal wall protrudes more or less. The muscles of abdominal wall function, when contracting, draw abdominal wall inwards, there by increasing the cavity pressure. The elastic connective tissues form an important element of lungs and bronchial tree. Thus in the phase of phonatation, the muscles of abdominal wall also participate.

It is well known that diaphragm in the human body separates the body in two compartments, upper part having the heart, lungs, throat etc. and the lower part containing abdominal and associated pars. (4). The close connection between the modulations of pharynxand the diaphragm movement have been established and analysed by Zinkin (1). The size of diaphragmal oscillations decreases lungs volume and increase of cavity pressure results in an increase in the speed of utterance and also the amplitude.

FOETUS DEVELOPMENT

At the earliest period of development, the fertilized ovum is dependent for it's nourishment on remains of cells of discus proligerus adhering to it, or on the fluid of the fallopian tube in which it is immersed. From the third month onwards blood vessels traversing the chorionic villi come into close relation with the maternal blood, from which the whole growth of foetus is subsequently maintained by special development of these connections in the placenta. The placenta represents the foetal organ respiration, nutrition and excretion (3). Further with growth of pregnancy, the placenta as well as foetus growth takes place and it matures round about 20-22 weeks of pregnancy. There after only the growth of foetus takes place till the birth time (8).

EXPECTED OF OBSERVATIONS

It is shown in Graph No. 1 The amplitude of pregnant woman speech signal increases form third month to fifth month and there after it decreases up to seven month. At the time of delivery it again increases.

DISCUSSION

The observations of formant Amplitude variation clearly indicates the change with tone of a pregnant lady. During the first 12 weeks the embryo is formed and it draws

energy from the human body for it's survival in the fallopian tube etc. This with drawing of energy reflects in the contraction of abdominal muscle thereby raising of diaphragm in the cavity. This increased level of diaphragm, increases the amplitude of speech sound wave (2).

However during 12 to 20 weeks of pregnancy period the growth of placenta as well as foetus is taking place and the baby gets weight gain. This situation is like increasing the weight of obscillatin on one hand and lowering of diaphragm due to weight gain in cavity on the other hand. This particular behaviour of diaphragmal movement is reflected in the increase of chest volume thus increasing the time duration of speech segmental, and consequently due to increased energy of oscillations due to increase in the mass (1/2 mv^2) the amplitude of speech segmental will also increase. The same is observed during this period of pregnancy (6).

Further during 20 weeks to 30 weeks of pregnancy, this amplitude behaviour is still more amplified due to weight gain but due to lowering of diaphragm the time duration is reduced, due to decrease of wave velocity. The energy content is reduced proportional to square of wave velocity. Thus amplitude shows slightly lowering of peak value (see Graph No. 1)

After this period the amplitude may increase as the delivery time is approached due to restoration of diaphragmal position, transients may occur (7).

CONCLUSION

Thus from the observation of format frequency and amplitude characteristics of pregnant women, not only the growth of foetus can be monitored but also the position of foetus in the womb can be assessed. Further through the critical analysis of a particular formant behaviour, the micro-foetus growth can also be checked.

With this non-invasive technique of speech amplitude monitoring way, the health rural centre can give better mass service to people.

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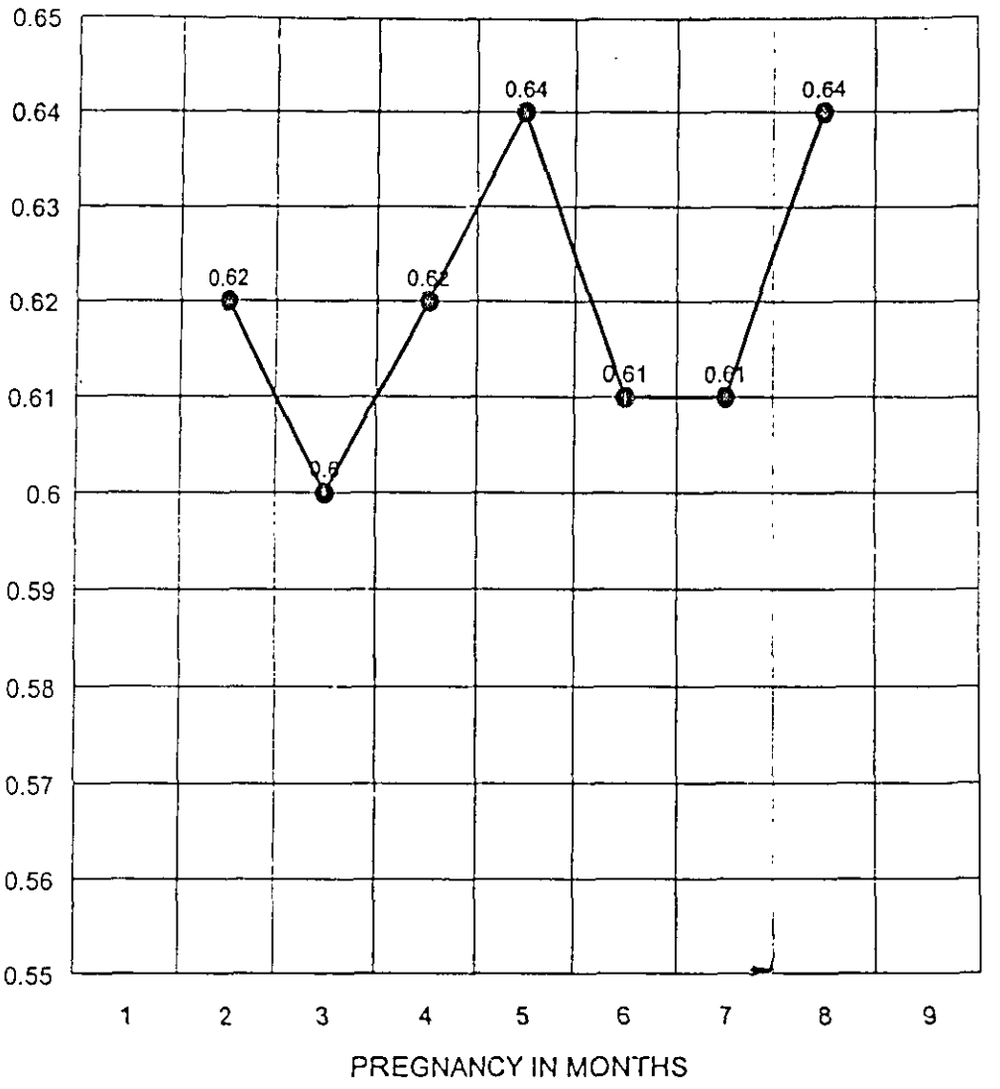

GRAPH 1

FORMANT

TITLE : GRAPH SHOWING THE AMPLITUTE RESPONSE OF LINGUISTIC SEGMENTAL (प) WITH PREGNANCY STATUS

NCB(6th)

EFFECT OF PREGNANCY DEVELOPMENT ON THE DIAPHRAGMAL MOVEMENT AND SPEECH SIGNAL TIME DURATION

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INTRODUCTION

The history of medicine and surgery can be traced since long ages. But the span of history of Engineering is brief one. The existence of Bio-Mech-Engg. had been is voygue for only few decades. The use of ECG, EMG, C-T SCAN, ultrasound etc. justify the venture of Bio-Med-Engineering. The mythological books of indian origin have reported that the speech has generating enters in the utterances of speech from the various parts of body representing the myoelastic nature. In the present venture authors have tried to make use of the knowledge of such parameters of speech for the assessment of gynaecological condition of a pregnant lady. Thus truly it is use of speech in the field of Bio-Med-Engineering. Less (7) and coworkers have investigated the weight-height of speakers from speech parameter. Kluckhohn etal (6) have presented the personality formation from speech. Lyreggard etal (8) have has used the speech as diagnostic tool in madical science.

But to the best of our knowledge so for none has used the speech parameter for status recognition of pregnant mother, in the world. For the first time in the history of medical field, authors have used the speech parameter for determination of menstrual cycle and fertile penod of women (10).

In the present paper authors have used speech signal time duration and tried to show the effect of pregnancy develpment on the diaphargmal movement. This will be an non-invasive investigating tool for mass care of prenant ladies.

BODY AND SPEECH

In dealing with voice (speech) of a man, we must not fall into habit of separating the body behaviour and calling it a sort of outward symbol of private thought (1) In fact the air we breathe, the air we talk and here by is not merely an outside air.

The voice of man is one component in a whole body postural seheme (5) In this sense a man speaks with breathing apparatus, his body muscles and head. The physical affords has its accompaniment in vocal efforts.Thus all with their own vocal and muscular obligatis in harmony with characteristics in a speech.

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FOETUS DEVELOPMENT

At the earliest period of development the fertilized ovum is dependent for its nourish-

ment on remains of cells of discus proligerus adhering to it or on the fluid of the fallopian tube in which it is immersed. From the thrid month on wards blood vessels traversing the chorionic villi came into close relation with the maternal blood, from which the whole growth of foetus is subsequently maintained by special development of these connection in the placenta. The placenta represents the fotal organ of respiration nutrition and excretion (3). Further with growth of pregnancy the placenta as well as foetus growth takes place till the birth time (9).

EXPERIMENTAL OBSERATIONS AND RESULT

The speech utteranees of many pregnant ladies with various months of pregnancy i.e. from 8 weeks to 35 weeks (as dirtified by gynaecologist) have been recorded on a good quality of sony tape, using philips tape recorder in a noise free room.

The recorder sound was subjected for time duration measurement. Vowel and consonant time duration of each informant was analysed and the analysis is reported for an average pregnant women behaviour for phonetic segment and is shown in Graph no. 1.

DISCUSSION

In the production of speech the muscles of abdominal wall function as expiration muscles. The most importane of them are rectus abdominis and obliquus abdominis muscles. These when contracting draw the abdominal wall inwards thereby increasing the cavity pressure forces diaphragm back thus reducing the volume of lungs and visa-versa. The close connection between the modulations of pharynx and the diaphragm movement have been established and analysed by Zinkin (1968) (1). The size of diaphragmal oscillations decreases lungs volume and increase of cavity pressure results in an increase in the speed of utterence and consequently the less time duration requirement of speech utterences.

With the development of pregnancy i.e. during first 12 weeks the embryo is formed and the formation is like a froth in the cavity. Thus during this period the diaphragmal movement is more sensitive and since during this penod the entire energy is drawn from the body, the over all effect of this is the reduction of muscle power i.e. less volume in lungs creating less time duration for utterence of speech segmental.

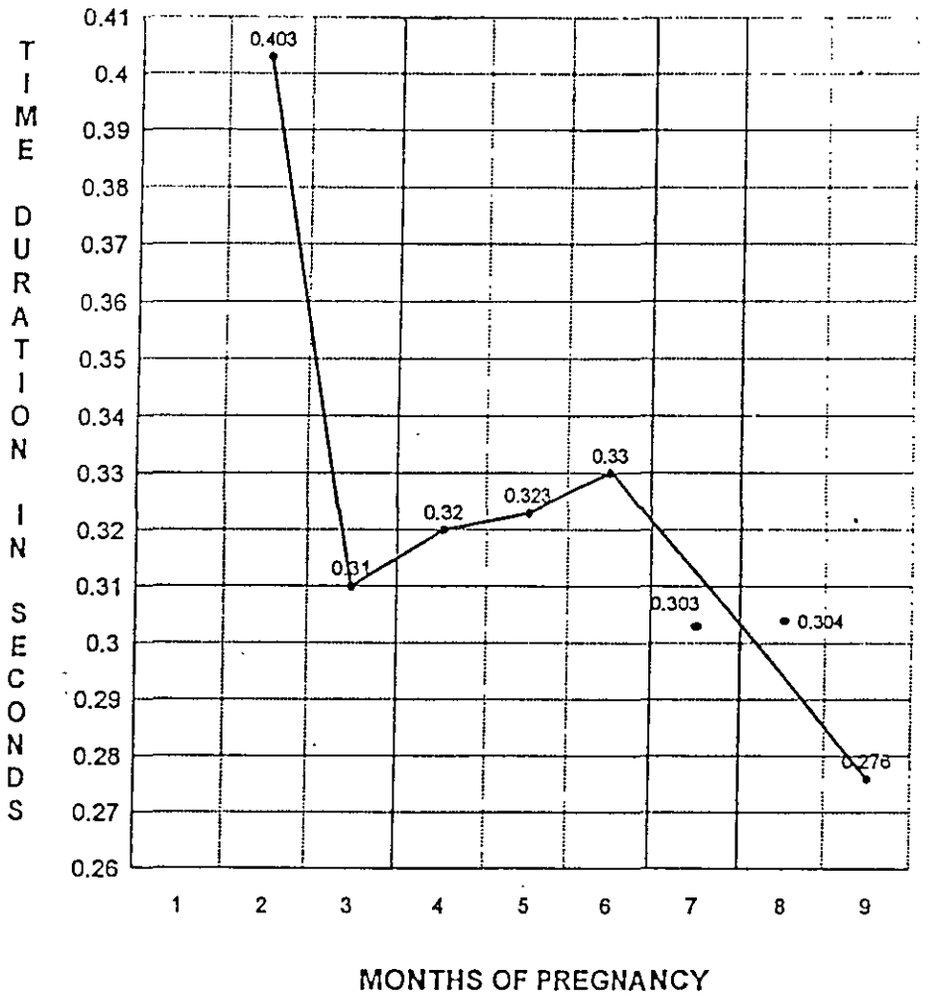

FIG. NO. 1 : AVERAGE GRAPH SHOWING THE RELATION BETWEEN TIME DURATION AND PREGNANCY STATUS OF AN AVERAGE PREGNANT WOMEN FOR LINGUISTIC SEGMENTAL "Chh".

However during 12 weeks to 24 weeks of pregnancy period, the growth of foetus takes place, i.e. the weight gain takes place at rapid rate. Thus the diaphragm has a virtual mass on it. This added mass means the diaphragmal displacement will be reduced i.e. lungs volume increases. Thus for the same speech utterance the time duration requirment will be more.

Further during 24 weeks to 36 weeks of pregnancy till the delivery of baby, the movement and displacement of foetus takes place within the cavity, this movement some time increases the diaphragmal pressure some times reduces and finally it goes on reducing due to lowering of whole mass towards delivery port. This behaviour of foetus reflects in the reduction of time duration in speech utterences. This is in agreement with other observation (11, 12).

CONCLUSION

It is concluded that there exist a close relationship between the level of pregnancy or foetus growth with the time duration requirment *for the speech segmental utterences. Though the foetus development is taking place in lower compartment and observation of speech parameter are recorded as seen in upper compartment.* But these two compartments are *interlinked* by a diaphragm which transforms these developmental signal of lower part i.e. foetus growth to the speech parameter in upper part.

Thus the developmental characteristics of foetus development can be easily monitored using speech signal. This will help for mass care of pregnant women even at Rural Health Centers.

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PROCESSING OF PREGNANT WOMEN SPEECH SIGNAL

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ABSTRACT

In the present paper firstly the analogy of throat performance is extended to the level of diaphragm oscillations. The mathematical analysis (Fant, 1970) is modified to accomodate changes due to pregnancy affecting the performance of diaphragm and the level of diaphragm configuration.

The actual phonetic parameters namely the formant amplitude, formant frequency, time-duration were traced out from the speech recording of pregnant lady by using computer programming and various instrumentation systems.

From these observations, the model parameters of pregnant lady are evaluated representing the model. The model analysis reflects that with the pregnancy the volume velocity at mouth end (U) and the internal impedance of throat which includes the lower part of body too (Zo) will undergo change. These changes are actually observed in speech signal of pregnant woman reflecting changes in formant frequency and amplitude.

Thus it is concluded that the assessment of pregnancy growth can be evaluated from the speech analysis of the pregnant woman.

THEORETICAL BACK GROUND

The phonetic studies and work of Zinkin (1968), H Mol (1970), Fry (1968), Fant (1970) have recorded that the throat can be represented by electrical network model having electrical parameters corresponding to analogous phonetic parameters. Further the output i e speech pattern can be found out from the analog of electrical current or voltage wave output. Thus the throat performance characteristics can be compared with actual speech characteristic (i.e. frequency or power density curve) and the cause of change or illment in the throat can be assessed.

In the production of speech (Clara,1964) the muscles of abdominal wall function as expiration muscles. The most important of them are rectus abdominis muscles and obliquus abdominis muscles. These when contracting, draw the abdominal wall inwards, there-by increasing the cavity pressure, forces diaphragm back, thus reducing the volume of lungs and visa-versa.

The speech sound is prduced due to passage of air through throat and it's modification through mouth cavity. The air is pumped through this passage by the lungs and the associated diaphragmal oscillations.

The vocal tract has been respresented by electrical analogue model with phonetic parameters. With necessary assumptions the same is represented for having a linear model [1].

The vocal tract as an acoustical device can be represented as in Fig. 1.

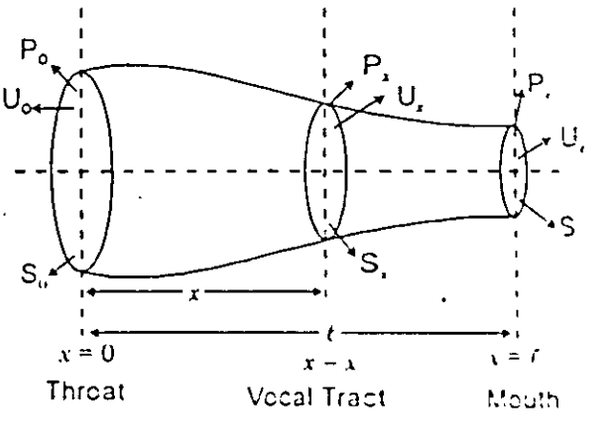

Fig. 1. The vocal tract as an acoustic device

where

P_o — Sound pressure at throat end.

U_o — Volume velocity at throat end.

S_o — Area of cross-section of vocal tract at throat end.

P_ℓ — Sound pressure at mouth end.

U_ℓ — Volume velocity at mouth end.

S_ℓ — Area of cross-section of vocal tract at mouth end.

x — Distance from throat end.

ℓ — Distance between throat end and mouth end.

P_x — Sound pressure at a distance x from throat end.

U_x — Volume velocity at a distance x from throat end.

S_x — Area of cross-section of vocal tract at a distance x from throat end.

Vocal tract can be seen in the same way with the electric four-terminal networks as shown in Fig. 2.

It is convenient to represent sound pressure volume velocity as analogous to electric voltage and electric current respectvely.

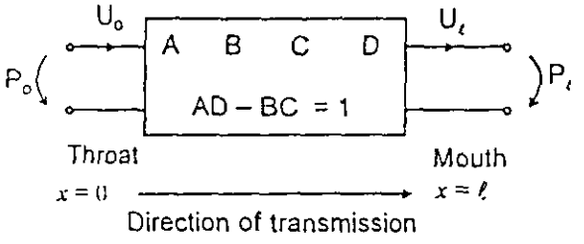

Fig. 2. Equivalent electric four terminal network of the vocal tract.

For sinusoidal oscillations at the input we have

$$P_o = AP_\ell + BU_\ell \quad ...(1)$$

$$V_o = CP_\ell + DU_\ell \quad ...(2)$$

Where A, B, C, D are the general circuit parameters of the network [11]. They depend on the configuration and values of of electric components of the network. As a rule they are functions of frequency (sinusoidal oscillations). For better analysis throat can be further represented as having twin tube resonator. The same twin tube resonator can be represented by electrical network having four terminal as shown in Fig 3

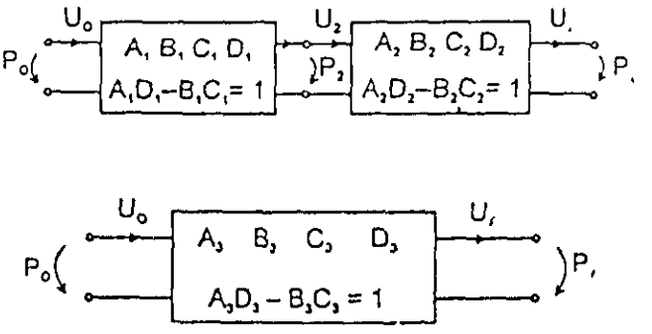

Fig. 3. Twin tube resonator seen as a single resultant network.

where

$$A_3 = A_1 A_2 + B_1 C_2$$

$$B_3 = A_1 B_2 + B_1 D_2$$

$$C_3 = A_2 C_1 + C_2 D_1$$

$$D_3 = D_1 D_2 + C_1 B_2$$

PREGNANT WOMAN VOCAL TRACT ELECTRICAL NETWORK

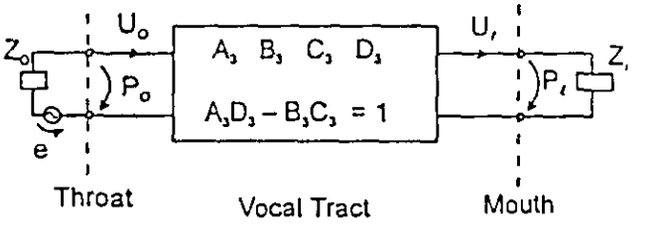

Fig. 4. The throat considered as a source of sinusoidal vibrations

With standard notations [1], we have

$$P_o = e - U_o Z_o \quad ...(3)$$

$$P_\ell = U_\ell Z_\ell \quad ...(4)$$

where

P_o and P_ℓ have usual meanings.

e — Source with internal impedance.

Z_o — Internal impedance of throat and lower part of body.

Z_ℓ — Load impedance at the mouth opening

Combining equations (1), (2), (3), (4) and solving for U_ℓ and U_o, we have

$$U_\ell = \frac{e}{B_3 + D_3 Z_0 + A_3 Z_\ell + C_3 Z_0 Z_\ell} \quad ...(5)$$

$$U_o = \frac{e}{Z_0 + \frac{A_3 Z_\ell + B_3}{C_3 Z_\ell + D_3}} \quad ...(6)$$

From equation (5) it is clear that U_ℓ varies with frequency (both in amplitude and phase). The graph depicting $|U_\ell|$, that is the amplitude of U_ℓ as a function of ω. It is known as the frequency response curve, which is shown in Fig. 5.

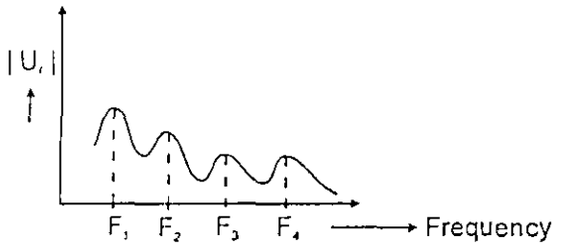

Fig. 5. Frequency response curve of phonetic segmental

The frequency locations of the peaks are called the resonance frequencies and may be defined as the formant frequencies [7].

U_ℓ is measured in terms of amplitude (in volts) of non-pregnant woman speech signal at mouth end. Its variations with frequency is tabulated in observation Table No. 1 and plotted in Graph No. 1.

It is well known that diaphragm [5] separates the upper part of body from its lower parts. As the pregnancy advances, the mass of foetus increases which in-turn increases the internal impedance Z_o [9]. So when lady is pregnant let the internal impedance Z_o changes to Z_o'. From equations (5) and (6), accordingly we have, U_ℓ', U_o' as new values of volume velocity at mouth end and throat end respectively. We have

$$U_\ell' = \frac{e}{B_3 + D_3 Z_o' + A_3 Z_\ell + C_3 Z_o' Z_\ell}$$

$$U_o' = \frac{e}{Z_o' + \frac{A_3 Z_\ell + B_3}{C_3 Z_\ell + D_3}}$$

This change in U_ℓ is due to pregnancy. It is measured in terms of amplitude (in volts) of pregnant woman speech signal at mouth end. It's variations with frequency is tabulated in observation Table No. 2 and plotted in Graph no. 2.

CHARATERISTICAL NATURE OF PREGNANT WOMAN SPEECH OBSERVATIONS

Table No. 1.

Observations of Formant Frequency and amplitude of non-pregnant lady for linguistic segmental (क)

Amplitude Volt	Formant frequency Hz
0 ·1	164
0 · 52	216
2 · 0	354
4 · 8	459
6 · 1	582
5 · 6	1432

Table No. 2.

Observations of Formant Frequency and amplitude of pregnant lady for linguistic segmental (क)

3rd month		5th month		8th month	
Amplit--ude Volts	Formant Freq. Hz	Ampli--tude Volts	Formant Freq. Hz	Ampli. -tude Volts	Forma-nt Freq. Hz
0·085	172	0·105	132	0·10	231
0·215	219	0·35	208	0·32	350
1·16	406	1·42	315	1·35	513
3·75	424	5·8	584	5·6	800
5·9	473	8·0	924	6·5	1230
5·6	1190	8·0	1288	6·5	1710

It is observed that due to presence of pregnancy, the amplitude and formant frequency of speech signal undergoes a change as compared to non-pregnant status. This shows a drastic change not only in amplitude but also in formant frequency and they depend on the internal development of foetus in the womb.

CONCLUSION

It is concluded that the assessment of pregnancy growth can be evaluated from the speech signal analysis of the pregnant woman using linguistic segmentals.

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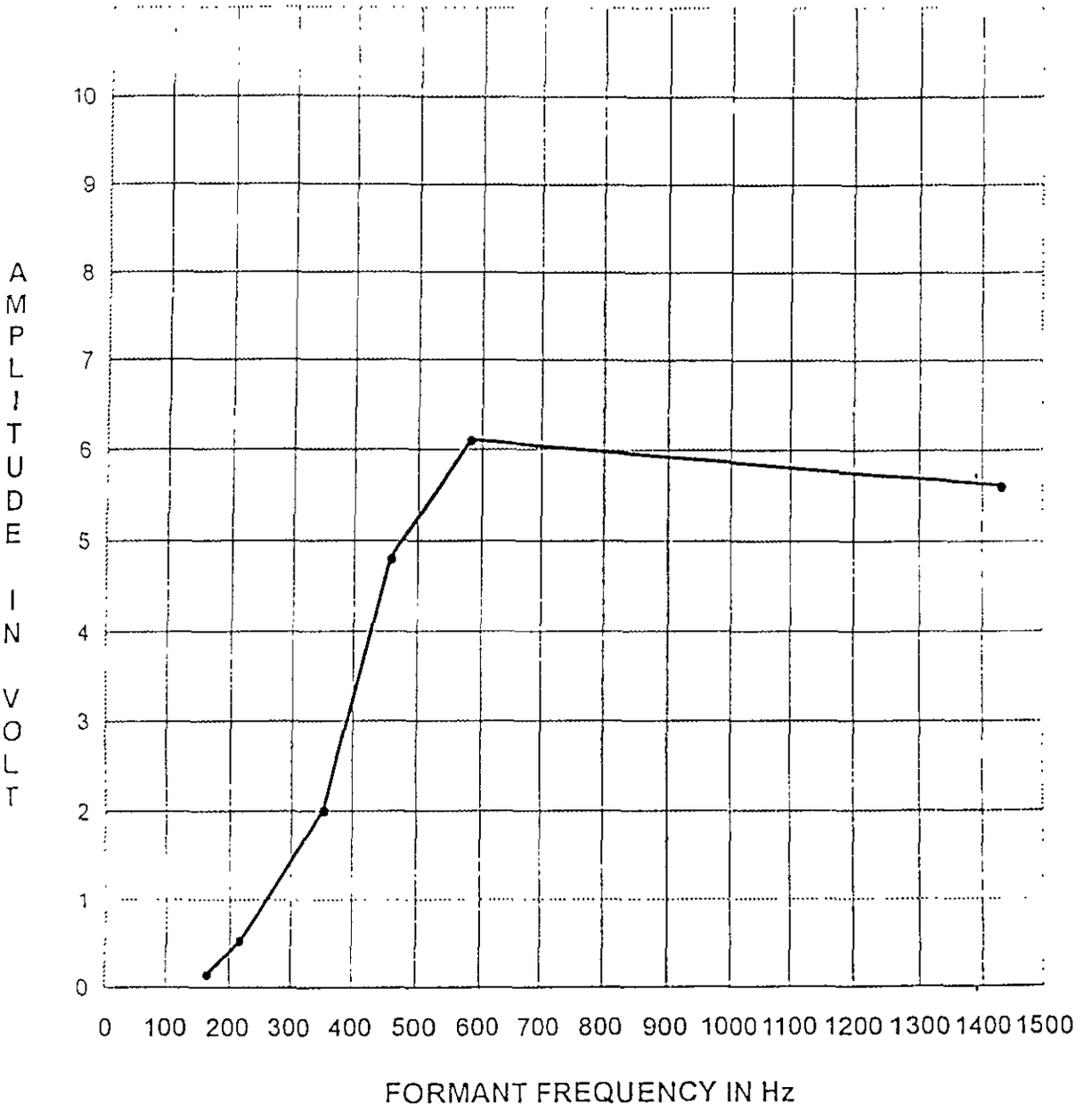
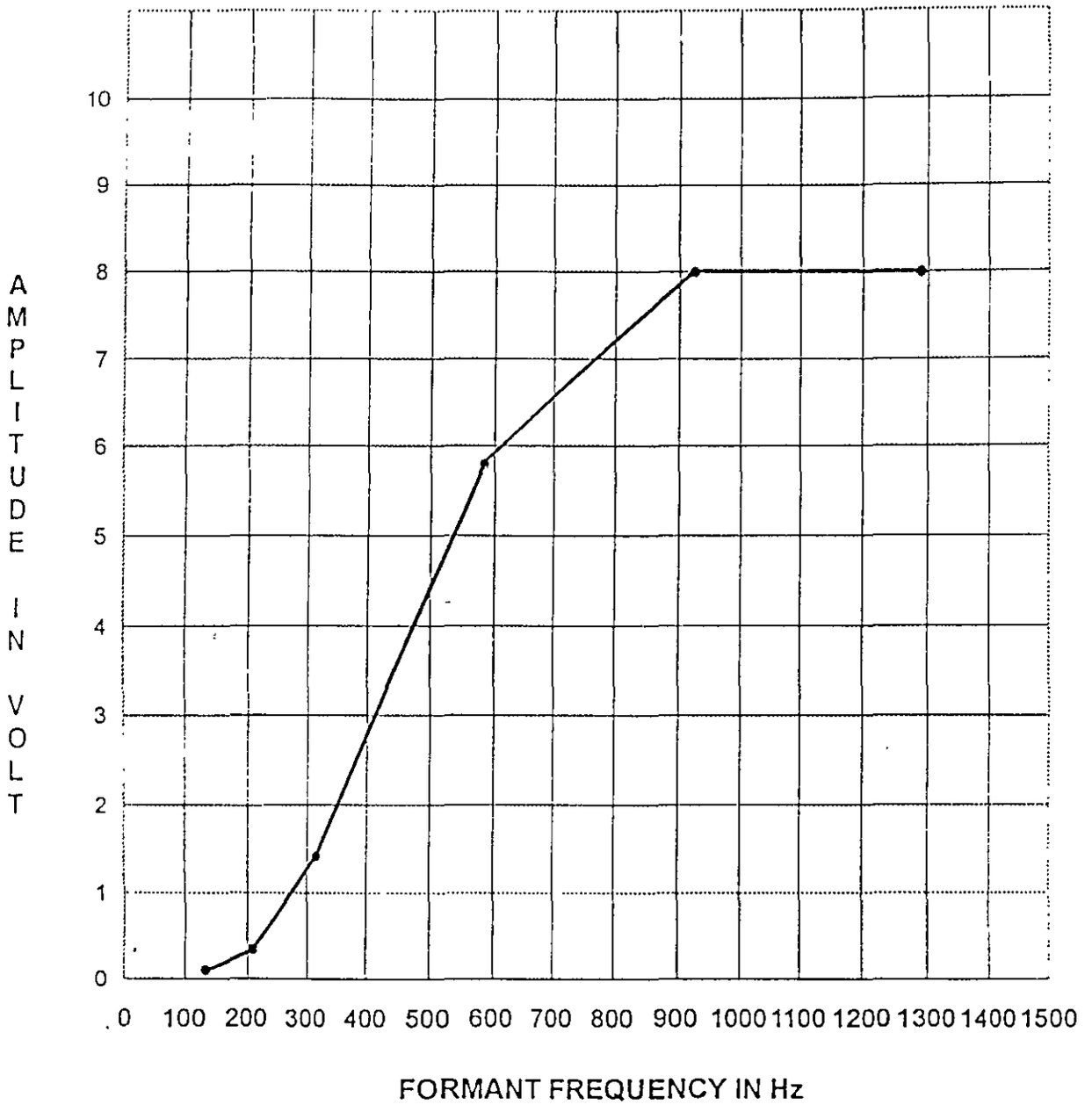


GRAPH NO. 1.

FREQUENCY RESPONSE OF NON PREGNANT WOMAN

FOR LINGUISTIC SEGMENTAL (क)



GRAPH NO. 2.

FREQUENCY RESPONSE OF PREGNANT WOMAN AT 5th MONTH OF PREGNANCY FOR LINGUISTIC SEGMENTAL (क)

NON-INVASIVE ASSESSMENT OF LEVEL OF PREGNANCY USING SPEECH PARAMETER

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Abstract

The mechanism of larynx and laryngeal vibrations have been explained on myoelastic theory by Ferrin (1971). It is a matter of genral observation that when a blow ot pressure is applied to stomatch, there is sudden increase of pitch during phonation. This is due to myoelastic impulses. In the production of speech the muscles of abdominal wall function as expiration-muscles. These muscles when contracting, draw the abdominal wall inwards, there by increasing the cavity pressure, forces diaphragm back, thus reducing the volume of lungs and via-versa. A change in the myoelastic pulse will be reflected in the change in the speech parameter namely the frequency.

Based on above facts authors have developed a non-invasive technique to asses the level of pregnancy of pregnant women.

The acoustical speech utterances of Hindi linguistic segmentals, that of the pregnant women are recorded on a good quality tape, in the experimental room free from external noise. The recording is made for number of pregnant ladies ranging from 8 weeks to 35 weeks of pregnancy (as certified by gynaecologist, the consultant doctor) irrespective of cast and creed.

From the observation it is concluded that level of pregnancy can be earily detected by using the technique developed by authors. Further it will be useful for Rural Based Medical Gynic Centre for checking of mass pregnancy level.

Body and Speech

In dealing with the voice (speech) of a man, we must not fall into habit of separating the body behaviour and calling it a sort of outward symbol of private thought [1]. In fact the air we breathe, the air we talk and here by is not merely an outside air.

The voice of man is one component in a whole body postural scheme [5] in this sense a man speaks with his breathing apparatus, his body muscles and head. The physical affords has its accompaniment in vocal efforts. Thus all with their own vocal and muscular obligates in harmony with characteristics in a speech.

The voice production have been a subject of research. The theory based on Neurochronaxies have been proposed by Hussion (1950) Ferrin (1971) have explained the characteristics behaviour of speech based on myoelastic theory. According to Hindu mythology (India) as well, speech sound have different body centers of generation and has the roots of charactoristics of their body behaviour as phonetic information. The change of pitch in speech with a blow on stomatch is matter of general observation and is due to

myoelastic impules.

The Stomatch and Speech

The chest is composed of 12 pairs of ribs, held in place by elastic connective tissues and muscles, which through their contractions raise or lower the ribs, thus increasing or decreasing the volume of chest cavity and lungs [4]. The diaphragm forms the horizontally set dome shaped floor of the chest cavity. At contraction the diaphragm is lowered where by the volume of chest cavity and lung is increased. At the same time the pressure in abdominal wall protrudes more or less. The muscles of abdominal wall function, when contracting draw abdominal wall inwards, there by increasing the cavity pressure.

The elestic connective tissue forms an important element of lungs and bronchial tree Thus in the phase of phonation, the muscles of abdominal wall also participates.

Foetus Development

At the earliest period of development, the fertilized ovum is dependent for it's nourishment on the remains of discus proligerus abhering to it, or on the fluid of the fallopain tube in which it is immersed. From the second month on wards, blood vessels traversing the chorionic villi come into close relation with the maternal blood, from which the whole growth of foetus is subsequently maintained by special development of these connection in the placenta. The placenta represents the foetal organ of respiration, nutrition and excretion [3].

In the fully formed foetus, blood passes from the foetus to placenta by ambilical vein. As the pregnancy advances, the foetus grows more rapidly due to maturation of placenta after 16-18 weeks of pregnancy.

Communication and Abdominal Elastic Behaviour

The elastic connective tissues of abdominal cavity regulates the flow of air stream while phonation, The abdominal cavity can be repressented [2] as a resonating cavity, with elastic muscular material which operates with a resonating vibrating frequency given by

$$f = \sqrt{\frac{E}{\rho}}$$

Where E = elasticity of constant

ρ = Density of muscular membrane

From the above mathematical representation, it is observed that it the muscular membrane have different dinsity (mass) more or less, accordingly the frequency of chest cavity or phonation will be changed.

The speech utterances of 90 pregnant ladies and ten samples for each month of pregnancy from 8 weeks to 35 weeks (as certified by Gynecologist) have been recorded on a good quality of sony tape, using philips tape recorder, in a noise free room.

The recorded sound was subjected to a bank of filters to find peak frequency [6] Vowel and consonant of each informant was analyzed and the analysis is reported, for an average pregnant women behaviour for phonetic segmental 'च'.

The average freuency of 10 pregnant ladies for each month of pregnancy, of linguistic segmental 'च', standard deviation and significance level (using standard test) [8] are tabulated in tabe no.

Table No. 1

Month of pregn-ancy	Average peak Freq. Hz	Standard deviation σ	Signifi-cance level test,T
2nd	424.50	67.4614	0.0234
3rd	364.71	29.1680	0.0644
4th	302.57	37.1759	0.0459
5th	350.30	30.5942	0.0341
6th	374.40	49.3339	0.0160
7th	406.0	42.5511	0.0490
8th	461.30	34.5399	0.0302
9th	502	33.3436	0.0948

Table : Table showing the standard deviation and significans level test for peak frequency of linguistic segmental 'घ'.

$$\sigma = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n}}$$

$$T = \left(\frac{\bar{x} - m}{\sigma/\sqrt{n}}\right)$$

Discussion of Result

Using Newton's forward interpolation formula [7], the level of pregnancy can be affirmed accordingly. For example, suppose, if the reading (369 Hz) being covered in 3rd and 6th month of pregnancy. The same can be differentiated by forming polynomial equation and we get roots as 3.36 and 42.52. Since higher roots are to be neglected, therefore the observation (i.e. freq. 369 Hz) lies in the third month of pregnancy. While it could have been in the sixth month of pregnancy than the one of the roots should be around 6 or so.

Thus the level of pregnancy can be pinpointed.

Conclusion

From the above observation it is concluded that the level of pregnancy can be detected easily by using the technique developed by authors.

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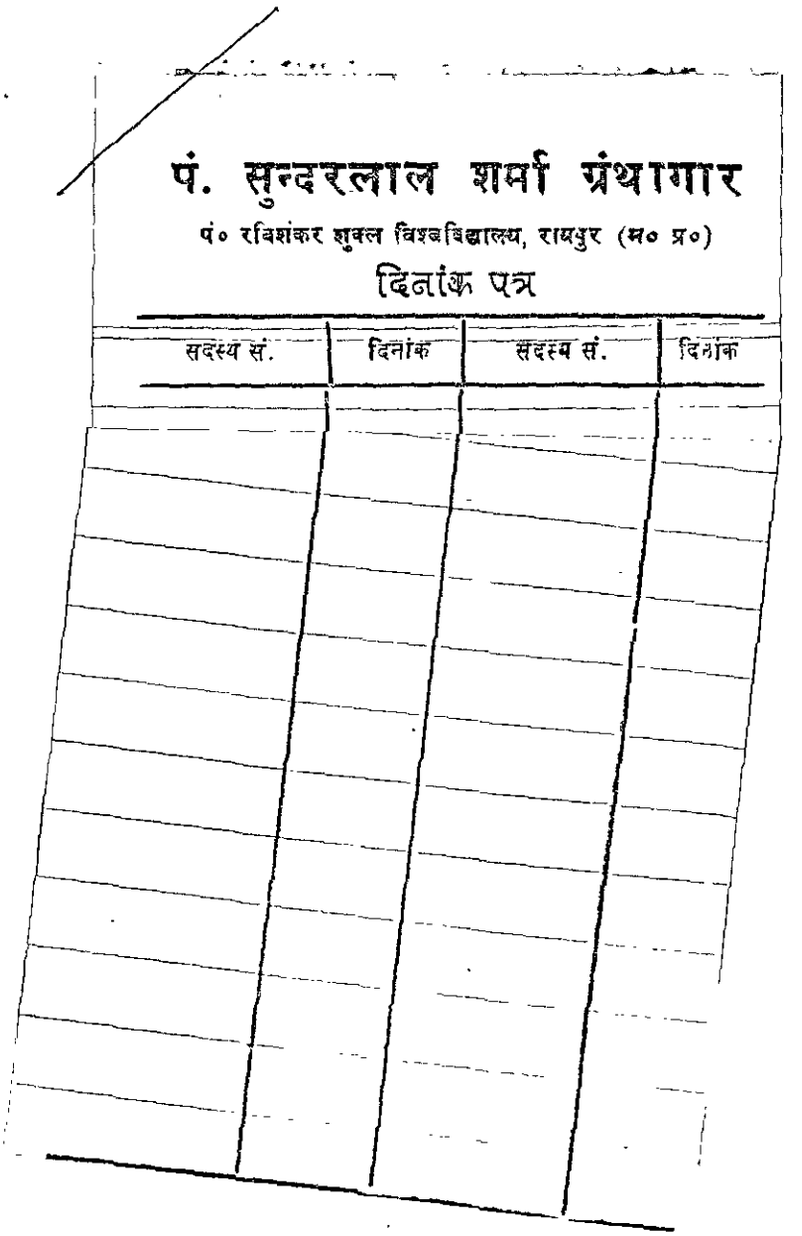

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दिनांक पत्र

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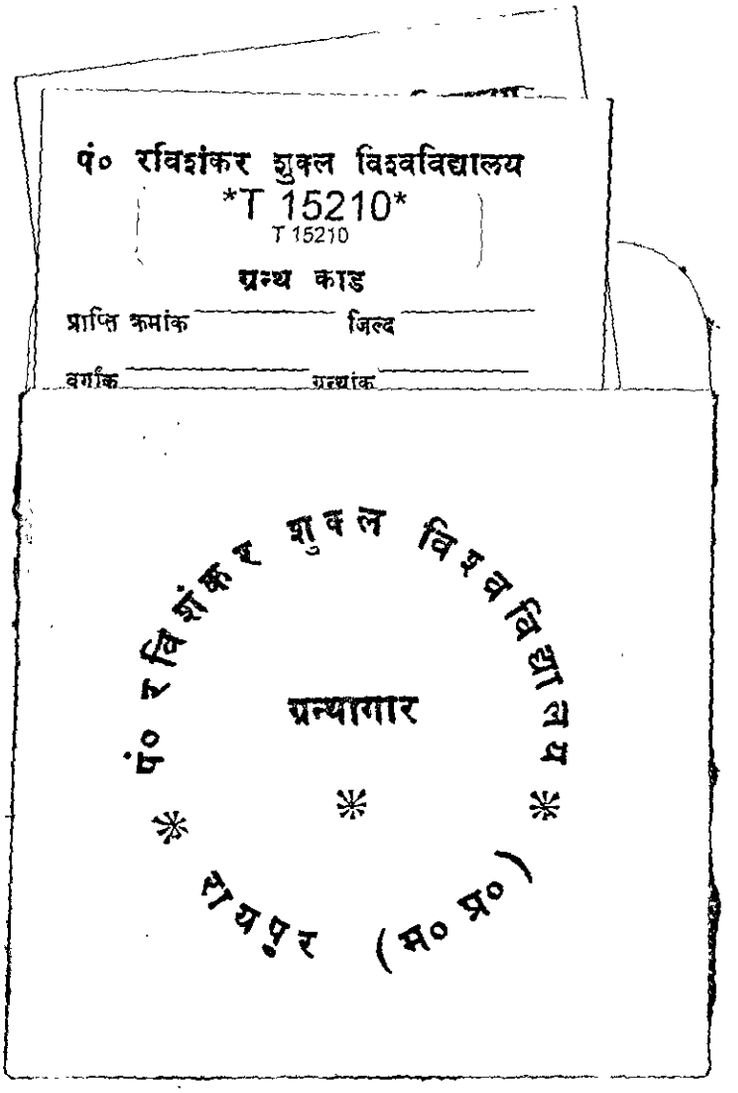
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