THE DEVELOPMENT AND STANDARDISATION OF A TEST OF HEARING FOR TELEPHONE OPERATORS

Raju Ananth

A DISSERTATION SUBMITTED IN PART FULFILMENT

FOR THE DEGREE OF MASTER OF SCIENCE (SPEECH & HEARING),

UNIVERSITY OF MYSORE

1975

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With Love

to my PARENTS, Brother, Sister,

Relatives, Teachers

&

Friends

CERTIFICATE

This is to certify that the dissertation entitled "The Development and Standardisation of the Test of Hearing for Telephone Operators" is the bona fide work in part fulfillment for M.Sc., in Speech and Hearing, carrying 100 marks, of the student with Register No.18.

Director
All India Institute of
Speech & Hearing, Mysore-6

CERTIFICATE

This is to certify that this dissertation has been prepared under my supervision and guidance.

Guide.

DECLARATION

This dissertation is the result of my own study undertaken under the guidance of Mr. M.N. Vyasa Murthy, Lecturer in the department of Audiology, All India Institute of Speech and Hearing, and has not been submitted earlier at any University for any other Diploma or Degree.

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TO WHOMSOEVER IT MAY CONCERN

Reference: 1. DG P&T ND O.U. No. 207/59/73-STB. I dt 31.5.1973.

2. Director, All India Institute of Speech & Hearing No. Trg. dt 25.9.74.

This is to certify that Mr. R. Ananth, Final Year M.Sc. student of the All India Institute of Speech & Hearing, Mysore conducted experiments at the Mysore Telephone Exchange, from 1st October 1974 to 30th April 1975, in connection with his thesis entitled "THE DEVELOPMENT AND STANDARDISATION OF A TEST OF HEARING FOR TELEPHONE OPERATORS".

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CONTENTS

LIST OF TABLES

LIST OF GRAPHS

LIST OF PHOTOGRAPHS

LIST OF BLOCK DIAGRAMS

Chapter I

INTRODUCTION

To our knowledge, in India, there is no hearing test that has been designed to test the hearing sensitivity of the Telephone Operators to speech through the telephone, either, before their appointment as Telephone Operators or as a periodic checkup during the course of their employment.

The demands on the duties of a Telephone Operator vary according to the establishment were he/she is employed, the equipment which he/she has to handle, the kind of population, he/she is catering the service and to the other additional duties he/she has to undertake like typing, or as a receptionist or as a private secretary.

Appointment as Telephone Operators are based usually upon the applications' age, sex, pleasant voice, some knowledge of the key boards, such together criteria and normal Hearing to conversational speech.

His/her efficiency to a large extent depends upon his/her Hearing acuity. In terms of efficiency, the ideal set up would be to assign the job placement, only if the candidate satisfies optimum criteria based on the demands of his job. Also, in order to maintain his/her efficiency and check if acquired hearing Pathologies to not intervene in his/her performance, it would be ideal to incorporate periodic in-service check-up. Adequate discrimination of speech in Hearing through a telephone therefore becomes important to determine his/her performance efficiency.

In our country, most commercial establishments do not insist on any specified Hearing requirement other than normal or good Hearing, which for practical purposes denotes hearing of speech in conversation and in telephone without difficulty.

In Indian Government establishments like the Post and Telegraphs specify, in a meeting of the Telephone Advisory Committee at Belgaum in 1973, that "…….recruitment of Telephone Operators in the P & T department is made by the circles Telephone Districts on the basis of metric. Before their selection, they are tested by the Divisional selection board with regard to the following essential qualifications:

1. Minimum height of 1.45 meters
2. Freedom from color blindness
3. Good physique

4. Good Hearing
5. Clear and good voice
6. Ability to converse fluently

A person who is hard of Hearing obviously cannot be very efficient as a Telephone Operator. It is therefore necessary that such persons are taken off operative duties or asked to use hearing aids. The method, however of fixing the power of Hearing that can be considered as adequate and of assessing this does not appear to be easy. The Ministry of Health is therefore requested to advice us regarding the fixing of standard of hearing and a method of its assessment." Ministry of Health D.G. P&T U.O. No. 207/59/73/-STBI, dated 31.5.73.

The Director General of Health Services in a communication to the Director, All India Institute of Speech and Hearing on 13.8.73 stated, "….. request you to kindly let us have your comments urgently". On the D.G. P&T U.O. 207/59/73 STBI, dated 31.5.73.

In a reply sent to the Director General of Health services, on 29.8.73, the Director of the All India Institute of Speech and Hearing stated, "We are glad to know that the P&T Board would like to make Hearing evaluation of Telephone

Operators before they are recruited for the jobs and that you intend to do monitoring audiometry (periodic testing) for telephone operators in order to improve the services for the public. This is a welcome proposal. In the interest of their services and in the interest of the prospective candidates to the P&T department, it is not desirable to fix a criterion arbitrarily without reference to the actual job requirements and the frequency characteristics of the telephone system.

We require sometime to study in detail these aspects for fixing the criteria. However, the list of places where the facilities for resting hearing are available is enclosed with this letter for your kind information.

We request for Director General of Health services to obtain permission for use to use the Telephone Exchanges in Mysore and in nearby towns to make on the spot studies of their requirements. Once this permission is granted, we may be able to suggest appropriate criteria."

So, the Government of India are urgently in need of specific criteria of establishing the levels of Hearing, which are adequate over the telephone to conduct Hearing tests, at the time of appointment and also periodical, for the telephone operators.

The Indian Army and Navy use the ‘Whisper test’ under ordinary environmental conditions to test ‘normal’ Hearing of Telephone Operators.

In order to know, whether candidates with a Hearing loss, acquired or otherwise, can perform adequately s Telephone Operators, with the help of a hearing aid, it becomes necessary to design a specific test for Hearing over the telephone.

The Telephone transmits acoustic frequencies between 300 c/s and 3400 c/s of the message. This clipping of the speech frequencies introduces a distortion along with the distortions produced by the noise elements of the channel and by the frequency and intensity characteristics of the Transmitter and Receiver of the sent end and the receive and telephones. The speech variability of the speaker as also his communicative language ability, and the single to noise ratio of the send end telephone are viral factors to be considered.

The recipient of the message has to decode this acoustic signal in his language and interact with the message, in the presence of inherent room noise and environmental conditions like competing messages reaching the opposite ear.

The quality of the output in the listener's ear being a distorted one, the discrimination of a normal Hearing subject with all the acoustic cues of speech sound identification and redundancy in his repertoire, is expected to be different from that of a subject with Hearing loss.

Speech audiometry tests in acoustically treated rooms for Hearing loss subjects may not reflect their performances over the telephone; since, no experimental evidence is available, it is essential to know whether a subject with Hearing loss with the assistance of a Hearing aid can fulfill the job specifications of a Telephone Operator.

The theory of signal analysis and how information hearing signals can be transformed without loss of information is important for telephony. The basic assumption of a definite and agreed ensemble is not true for many ordinary Telephone conversations, since a considerable part of the call is devoted to establishing some common basis for discussion and the participants are more bothered with the effort required in conversing and in any difficulty encountered than in any counting of errors committed in interpretation. The redundant structure of speech and the active role adopted by listeners in interpreting what reaches their ears, calls for multi-criterion methods of assessment, since, clues treated as redundant by one criterion may be essential elements according to another and therefore no successful assessment method has yet been based on scores in terms of bits/second.

The above existing conditions entail the development and standardization of a test of Hearing for Telephone Operators through the telephone.

Aims of the study:

In order to assess their suitability for Telephone Operators' jobs, this study aims to develop and standardize a test of Hearing for Telephone Operators, that

1) Will specify optimum Hearing conditions required for normals in terms of speech discrimination through the telephone.
2) Will specify optimum hearing conditions, with or without a Hearing aid required for Hearing loss subjects in terms of discrimination of speech through the telephone.

Statement of Hypotheses:

The performance of the normals, the Telephone Operators and the clinical group in the experiments A, B & C are to be compared with each other and also between them selves, for the PB lists of words and the sentences.

The following hypotheses were evolved for PB lists test material.

1. The performance of normals for PB lists over the telephone received in the Trunk Exchange room is poorer that their performance for the same PB lists in standard speech audiometry condition.

2. The performance of normals of PB lists over the telephone received in a subscriber set is poorer than their performance for the same PB lists in standard speech audiometry condition.

3. The performance of normal Hearing telephone operators for PB lists over the telephone received in the Trunk Exchange room is poorer than their performance for the same PB listsin standard speech audiometry condition.

4. The performance of normal Hearing Telephone Operators for PB lists over the telephone received in a subscriber telephone set is poorer than their performance for same PB lists in standard speech audiometry condition.

5. The performance of the Hearing loss subjects viz., (a) Bilateral Conductive loss. (b) High frequency loss. (c) Mixed loss – for PB listsover the phone received in the Trunk exchange room does not significantly differ

from their performances for the same PB lists in standard speech audiometry condition.

6. The performance of the Hearing loss subjects viz., (a) Bilateral Conductive loss. (b) High frequency loss (c) Mixed loss – over the phone for PB lists received in another subscriber telephone set does not significantly differ from their performance for the same PB lists in standard speech audiometry condition.

7. The performance of normal Hearing Telephone Operators for PB lists over the phone received in the Trunk Exchange room is better than the performance of normals in the same set up.

8. The performance of normal Hearing Telephone Operators for PB lists over the phone received in another subscriber telephone set is better than the performance of normals in the same set up.

9. There is no difference in the performance of normal males and normal females for PB lists over the phone received in the Trunk Exchange room.

10. There is no difference in the performance of normal males and normal females for PB lists over the phone

received in another subscriber telephone set.

11. There is no difference in the performance of normal males and normal females for PB lists in the standard speech audiometry condition.

12. There is no difference in the performance of the normal Hearing male telephone operators and female telephone operators for PB lists over the phone received in the Trunk Exchange room.

13. There is no difference in the performance of the normal Hearing male Telephone Operators, and female Telephone Operators for PB lists over the phone received in another subscriber telephone set.

14. There is no difference in the performance of the normal Hearing male telephone Operators and female Telephone Operators for PB lists received in the standard speech audiometry condition.

15. The performance of the normals for PB lists over the phone received in the Trunk Exchange room is poorer that their performance, when received in another subscriber Telephone set.

16. The performance of the normal Hearing Telephone Opeators for PB lists over the phone received in the Trunk Exchange room is poorer than their performance when received in another subscriber telephone set.

17. The performance of the normal Hearing Telephone Operators for lists over the phone received in the Trunk exchange room is better with pre-test exposure to the PB lists, than the performance of those with no pre-test exposure to the PB lists.

18. The performance of Bilateral Conductive Hearing loss subjects with Hearing aid for PB lists over the phone received in the Trunk Exchange room is better than the performance of normals for the same PB lists in the same set up.

19. The performance of Bilateral conductive Hearing loss subjects with Hearing aid for PB lists over the phone receive in the Trunk Exchange room is better than the performance of normal Hearing Telephone Operators for the same PB lists in the same set up.

20. The performance of the Bilateral Conductive Hearing loss subjects with Hearing aid for PB listeover the

phone received in another subscriber telephone set is better than the performance of the normals for the same lists in the same set up.

21. The performance of the Bilateral Conductive Hearing loss subjects with Hearing aid for PB lists over the phone received in another subscriber telephone set is better than the performance of the normal Hearing Telephone Operators for the same lists in the same set up.

22. The performance of the Unilateral Conductive Hearing loss subjects with Hearing aid (when the test ear is the Hearing less ear) is better than the normals for PB lists over the phone received in the Telephone Exchange room.

23. The performance of the Unilateral Conductive hearing loss subject with Hearing aid (when the test ear is the hearing loss ear) is better than the normal Hearing Telephone Operators for PB lists over the phone received in the Trunk Exchange room.

24. The performance of the Unilateral Conductive Hearing loss subjects with Hearing aid (When the test ear is the Hearing loss ear) is better than the normals for PB

lists over the phone received in another subscriber telephone set.

25. The performance of the Unilateral Conductive Hearing loss subjects with Hearing aid (when the test ear is the Hearing loss ear) is better than the normal Hearing Telephone Operators for PB lists over the phone received in another subscriber telephone set.

26. The performance of the Unilateral Conductive Hearing loss subjects without Hearing aid (When the test ear is the normal ear) is better than the normals for PB lists over the phone received in the Trunk Exchange room.

27. The performance of the Unilateral Conductive Hearing loss subjects without Hearing aid (when the test ear is the normal ear), is better than the performance of the normal Hearing telephone operators for PB lists over the phone received in the Trunk Exchange room.

28. The performance of the Unilateral Conductive Hearing loss subjects without Hearing aid (when the test ear is the normal ear) does not significant differ from the performance of the normals for PB lists over the phone received in another subscriber telephone set.

29. The performance of the Unilateral Conductive and Hearing loss subjects without Hearing aid (When the test ear is the normal ear) does not significantly differ from the performance of the normal Hearing Telephone Operators for PB lists over the phone received in another subscriber telephone set.

30. The performance of the Bilateral moderate mixed Hearing loss subjects (with good discrimination in standard speech audiometry) with Hearing aid does not significantly differ from the performance of normals for PB lists over the telephone received in the Trunk Exchange room.

31. The performance of the Bilateral moderate mixed Hearing loss subjects (with good discrimination in standard speech audiometry) either Hearing aid does not significantly differ from the performance of the normal Hearing Telephone operators for PB lists over the phone received in the Trunk Exchange room.

32. The performance of the Bilateral moderate mixed Hearing loss subjects (with good discrimination in standard speech audiometry) with Hearing aid, does not significantly differ from the performance of the normals for PB lists over

the phone received in another telephone set of subscriber.

33. The performance of the Bilateral moderate mixed Hearing loss subjects (with good discrimination in standard speech audiometry) with Hearing aid, does not significantly differ from the performance of the normal Hearing Telephone Operators for PB lists over the phone received in another telephone set.

34. The performance of the Bilateral Conductive Hearing loss subjects with Hearing aid, for PB lists over the phone received in the Trunk Exchange room does not significantly differ from their performance for the same lists received in another subscriber telephone set.

35. The performance of the Unilateral High frequency loss subjects without Hearing aid for the PB lists received over the phone in the Trunk Exchange room is poorer than their performance for the same lists received in another subscriber telephone set.

The following hypotheses were evolved for

Sentences test material:

36. The performance of the normal Hearing telephone operators is better than the performance of the normals for

sentences over the phone received in the Trunk Exchange room.

37. The performance of the normal Hearing Telephone Operators is better than the performance of the normals for sentences over the phone received in a subscriber telephone set.

38. There is no significant difference in the performance of the male and female normal subjects for sentences over the phone received in the Trunk Exchange room.

39. There is no significant difference in the performance of the male and female normal Hearing telephone operators for sentences over the phone received in the Trunk Exchange room.

40. There is no significant difference in the performance of the male and female normal Hearing telephone operators for sentences over the phone received in the Trunk Exchange room.

41. There is no significant difference in the performances of the male and female normal Hearing Telephone Operators for sentences over the phone received in a subscriber telephone set.

42. The performance of the normals for sentences over the phone received in the subscriber telephone set is better than their performance when received in the Trunk Exchange room.

43. The performance of the normal Hearing telephone Operators for sentences over the phone received in the subscriber telephone set is better than their performance when received in the Trunk Exchange room.

44. The performance of the Bilateral Conductive Hearing loss subjects with Hearing aid is better than the performance of the normals for sentences over the phone received in the Trunk Exchange room.

45. The performance of the Bilateral Conductive Hearing loss subjects with Hearing aid is better than the performance of the Hearing Telephone Operators for sentences over the phone received in the Trunk Exchange room.

46. The performance of the Bilateral Conductive Hearing loss subjects with Hearing aid is better than the performance of the normals for sentences over the phone received in a subscriber telephone set.

47. The performance of the Bilateral Conductive Hearing loss subjects with Hearing aid is better than the performance of the normal Hearing Telephone Operators for sentences for sentences over the phone received in a subscriber telephone set.

48. The performance of the Unilateral Conductive Hearing loss subjects with Hearing aid (when test ear is the Hearing loss ear) is better than the performance of normals for sentences, over the phone received in the trunk exchange room.

49. The performance of the unilateral Conductive Hearing loss subjects with Hearing aid (when test ear is the Hearing loss ear) is better than the performance of the normal Hearing Telephone Operators for sentences, over the phone, received in the Trunk Exchange room.

50. The performance of the Unilateral Conductive Hearing loss subjects with Hearing aid (when test ear is the Hearing loss ear) is better than the performance of the normals for sentences, over the phone, received in the subscriber telephone set.

51. The performance of the Unilateral Conductive Hearing loss subjects with Hearing aid (when test ear is the Hearing loss ear) is better than the performance of the normal Hearing Telephone Operators for sentences over the phone, received in the subscriber telephone set.

52. The performance of the Bilateral moderate mixed Hearing loss subjects with Hearing aid does not significantly differ from the performance of the normals, for sentences over the phone, received in the Telephone Exchange room.

53. The performance of the Bilateral moderate mixed Hearing loss subjects with Hearing aid does not significantly differ from the performance of the noramls Hearing Telephone Operators, for sentences over the phone received in the Trunk Exchange room.

54. The performance of the Bilateral moderate mixed Hearing loss subjects with Hearing aid does not significantly differ from the performance of the normals, for sentences over the phone, received in the subscriber telephone set.

55. The performance of the Bilateral moderate mixed Hearing loss subjects with Hearing aid does not

significantly differ from the performance of the normal Hearing Telephone Operators, for sentences, ever the phone received in the subscriber telephone set.

56. The performance of the Bilateral Conductive Hearing loss subjects with Hearing loss subjects with Hearing aid for sentences over the phone received in the subscriber telephone set is better than their performance in the Trunk Exchange room.

57. The performance of Bilateral moderate High frequency Hearing loss subjects without Hearing aid does not significantly differ from the performance of normals for sentences over the phone, received in the Trunk Exchange room.

58. The performance of Unilateral mild and moderate High frequency Hearing loss subjects without Hearing aid does not significantly differ from the performance of the normals for sentences over the phone, received in the Trunk Exchange room.

59. The performance of Bilateral moderate High frequency Hearing loss subjects without Hearing aid does not significantly differ from the performance of the normal Hearing Telephone Operators for sentences, over the phone,

received in the Trunk Exchange room.

60. The performance of the Unilateral mild and moderate High frequency Hearing loss subjects without Hearing aid does not significantly differ from the performance of the normal Hearing Telephone Operators, over the phone, received in the Trunk Exchange room.

61. The performance of Bilateral moderate High frequency Hearing loss subjects without Hearing aid does not significantly differ from the performance of normals, for sentences, over the phone received in the subscriber telephone set.

62. The performance of Unilateral mild and moderate High frequency Hearing loss subjects, without Hearing aid (when Hearing loss ear is test ear) does not significantly differ from the performance of normals, for sentences, over the phone, received on the subscriber telephone set.

63. The performance of the Bilateral moderate High frequency Hearing loss subjects without Hearing aid, does not significantly differ from the performance of normal Hearing Telephone Operators, for sentences,

over the phone, received in the subscriber telephone set.

64. The performance of the unilateral mild and moderate High frequency Hearing loss subjects without Hearing aid (When Hearing loss ear is test ear) does not significantly differ from the performance of the normal Hearing Telephone Operators for sentences, over the phone, received in the subscriber telephone set.

65. The performance of Telephone Operators for sentences over the phone received in the Trunk Exchange room is better than their performance in the subscriber telephone set.

Brief Plan of the Study:

Monosyllable phonetically balanced words standardized on Indian population were used as used test material. Sentences made from most frequently heard phrases and digits were also used as test-material.

Normal subjects, Telephone Operators and subjects having different types of hearing loss were tested. The Hearing loss subjects were provided with Hearing aids wherever it was warranted. Subjects were tested in three conditions of listening environment viz., in the Trunk Exchange room, in a subscriber telephone set and in the standard speech audiometric set up.

The PB lists were presented at different intensities through a subscriber telephone set. The PB lists were also presented in the standard speech audiometric setup. The number of correct responses by the subjects were analyzed. Articulation curves were plotted and the levels at which the maximum percent of monosyllables correctly discriminated were obtained. The sentences were presented at constant intensity through the telephone scoring was based on the key words correctly perceived. The results were analyzed using Non-parametric statistics. Reliability was obtained by re-testing the normal after a long lapse of time.

Limitations of the study:

1. The study was restricted to the Mysore State population.
2. English knowing adults only were included in the study.
3. The study was restricted to the equipment of Mysore City.
4. The number of Hearing loss cases was restricted to Mysore State population.
5. Objective measurements of one way channel upto the Telephone Operator's headgear set was done only in the laboratory.
6. Point of concern was the relationship of Hearing efficiency of Telephone Operators. So, the efficiency of Telephone Operators. So, the efficiency

7. There may have been variable free field noise in the receive end (i.e. in the trunk Exchange room) which could not be controlled for practical reasons. However, to attempt to keep the noise levels constant for all, testing was done at same tuning hours.

Definitions of the terms used:

Speech Audiometry:

A technique whereby standardized samples of language are presented through a calibrated system in order to measure some aspect of Hearing ability. The standardized material can be presented from a recording or a monitoring voice (Carhart 1951).

Speech Discrimination Test:

A test to measure the ear's ability to understand speech at a level above the threshold.

Discrimination Loss:

This is the difference between 100% and the percentage of words of the presented monosyllabic list that a listener repeats correctly, when the list is presented at an intensity which is so high that a further increase in intensity will not increase the articulation.

Performance Intensity Function:

This is the relation between the performance of the individual at different levels of the presentation of the stimulus.

Monosyllables:

This is a syllable CV or CVC combinations (Pike 1963).

Articulation Curve:

"The Articulation curve depicts the changes in intelligibility or the correct recognition of words as related to the intensity level of which the words are presented." (Oneill & Oyer, 1961).

Phonetically Balanced List (PB list):

"is a list of monosyllables words that contain a distribution of speech sounds that approximates the distribution of the same sounds as they occur in conversational American English." (Hirsh 1952).

Chapter II

REVIEW OF LITERATURE

History of telephone:

The telephone was invented by Alexander Graham Bell in 1876. The 1st set used bell receivers as microphones as well as earphones and therefore transmission performance was rather poor, about every all reference equivalent of 50 dB with an extremely narrow and peaky frequency response.

The carbon microphone was invented by Thomas Alva Edison in 1977. Then Edison Carbon microphones and induction coils with local batteries were used. The 1st conversation between London and Norwich (115 miles) used Edison Carbon microphones and Bell receiver. The first intervention trunk line in the U.K. was opened between Leeds and Brandford in 1882. In 1893, Glasgow was connected to Belfast via, a submarine cable.

A.R. Bennett 1891' on the telephoning of great cities' formulated four conditions – Speech must be loud and distinct and privacy of communication complete, and a subscriber's line and apparatus must be adapted equally well to speaking to another across the street or one 500 miles away. The other 3 conditions dealt with switching, tariff and ability to extend the net work.

History of Speech Test Materials.

"It is of interest to note that in 1874 Wolf had suggested that the human voice was the 'most perfect conceivable measure of hearing'. He constructed a table of intensity values for the various sounds of the German language. The intensity, rather than being express in decibels, was expressed in paces or distance from the speaking source. The major testing materials were consonants, syllables and words. Later in 1890, Wolf recorded words on an Edison Wax cylinder. He was able to present the words to the ear of the patient through adjustable tubing which permitted control of the intensity of the recorded materials." (O'Neil & Oyer, 1966 PP 76. 77).

The development of speech audiometry gained its impetus from the pioneering attempts made by Fletcher (1920) and his colleagues at the Bell Telephone Laboratory.

These attempts replaced the whispering tests developed by otologists for the screening purposes. Fletcher's work was based on Wolf's (1871) statement that "Human voice is the most conceivable measure of hearing and recorded consonants and words could be fed to the human ears".

The work at Bell Telephone Laboratory (1876) regarding vaccum tubes and sophisticated electronic equipment enabled the psycho physical findings concerning the physical parameters of speech perception and discrimination. From Flecther's (1920) work emerged the concept of articulation function which displayed accuracy of speech perception as a junction of the signal intensity.

Later, Cambell and Grandall (1920) developed the "articulation tests" which consisted of a series of unintelligible words made up of (1) consonant vowel consonant (CVC) (2) consonant vowel (CV) and (3) vowel consonant (VC) and the correct responses was scored as syllable articulation score. But this test was not administered on subjects owing to a lack of familiarity of the syllables.

Nonsense syllables

More than 60 years ago in 1910 the telephone industry became interested in the nature of the stimuli being transmitted over its systems. This led to the beginning of a quantification of speech materials as test items. However, these materials were not used to determine the threshold of speech, but were used instead as discrimination tests or measures of intelligibility of speakers using particulars communication system. The Bell telephone laboratories then began an analysis of the characteristics of isolated speech sounds (vowels and consonants).

The use of nonsens syllables in the study of intelligibility represents and analytic approach in which the interest is focused on the intelligibility or repeatability of specific phonemic elements. The advantage of using nonsense syllables is in fact that they are “devoid or meaning and hence their intelligibility is in no was dependent upon the vocabulary of the listerner. “ (Hirsh 1952).

Monosyllabic Words

Monosyllabic words are less analytic units of speech and more easily repeated than nonsense syllables. Therefore many researchers have preferred to use Monosyllabic words. There was always an attempt to balance the sounds in any one list according to their normal frequency of occurrence in normal conversational English. This has given these lists the name "Phonetically Balanced lists" or PB lists.

The shorter the word is, the more difficult it is to identify it out of context. Monosyllables are thus the best material for vocal audiometry, since they offer less scope for intelligent guess work than disyllabic words. (Lajon J.C., 1966 P. 86).

A word test was developed by Thea (1941) who used words based on the Yale chart of phonetic elements. 96 words were presented in lists of three. Each word list was attenuated from a 30 dB level to a – 3 dB level. Thresholds were determined using phonograph discs.

Macfarlane (1940) developed a test which used the first five hundred monosyllabic words from the Thorndike list and first fifty monosyllabic words from the Gates list. In order to find the particular frequency of the hearing loss for these words, Macfarlan developed a novel testing scheme. The words were recorded on discs, and these recordings were presented from the inaudible to audible level. At the time where the subjects was able to detect only one out of every five of the words the record was stopped.

Carhart (1965) emphasize the fact that “monosyllables are less redundant and do not baffle many subjects.”

A majority of the work concerning the construction of the test materials was carried out at psychoacoustic laboratory Harward (1939). The application of such discrimination tests in the assessment of auditory function has been elaborated by Walsh (1952), Davis and Silverman (1960) Glorig (1965), O’ Neil and Oyer (1966) and Newby (1964).

As early as in the 1940’s Hudgins at Psycho-acoustic Laboratory developed a number of recorded speech tests. He evaluated many tests to measure speech intelligibility. He considered familiarity, phonetic dis-similarity, normal sampling of English sounds and homogeneity with respect to audibility. This paved the way for the development of PAL tests lists.

Walsh and Silverman in 1946 proposed the concept of “Social adequacy Index”. This index was related to the articulation area i.e., the thresholds for speech discrimination at various levels. These were (a) faint speech or level of 55 dB, (b) conversational speech of a level of 70 dB, and (c) loud speech or a level of 85 dB. Social

Adequacy Index was the result of average speech discrimination scores. The cutting of point was 33. A score lower than this indicated a sever loss for hearing of speech.

Egan (1948) put forth the criteria for the construction of articulation testing methods. They were the following. (1) Monosyllabic structure, (2) equal phonetic composition. (3) Equal average difficulty, (4) representative of English speech, and (5) words of common usage. He stressed the quantitative estimation of speech as could be obtained by simply counting the number of individual speech elements correctly perceived by the listener during an articulation task.

Hirsh (1952) at the Central Institute for deaf developed the CIDW 22 monosyllabic word lists to assess discrimination ability and these have wide clinical applicability. These were modified from the original Hardward lists. The modifications were made because of deficiencies discovered in the first tests. The major deficiencies were differences between tests lists and extensiveness of the PB vocabulary which was dissatisfactory in terms of phonetic balance. The CIDW 22 list consisted of phonetically balanced familiar words with equal difficulty. The CID list show higher discrimination scope as compared to Harvard PB lists. This is especially true if the recordings of the early PB list (Rush Hughes recording) are used. Live-voice presentation of the spondees will probably yield thresholds which are quite similar to those obtained with recorded spondees. However because of differences between speakers, inherent speaker variability and the non-absolute aspects of the intelligibility of lists it is best to use the recorded versions of the PB lists (O' Neil and Oyer, 1966, PP 89-90).

Lehiste and Peterson (1959) observed that the individual's linguistic background will significantly influence his judgment regarding the speech he hears. They further emphasized that the particular phonetic manifestations that characterize a given speech element many vary as a function of the speech element which at precedes or follows. In this context they develop the concept of perceptual phonetics or phonemics and stated that it is difficult to find PB words. They developed lists that acted as PB and considered Harward PB 50 lists as imperfectly balanced.

Tillman et al (1963) and later Tillman and Carhart (1966) complied tests of 50 CVC words all of which formed more perfectly the phonemic balance advocated by Lehiste (1959). These were named the North Western University Auditory test No.4 and No.6

Jerger (1973) commenting on merits of these speech discrimination tests states that although no standard test has been advocated so for clinical testing, monosyllabic words of phonetically or phonemically balanced type have received the most widespread application. These materials have been accepted as a measure of the individual's efficiency in every day hearing, probably because of their face validity provided by the phonetic balancing. Nevertheless no one has conducted experiments to study its validity. But they are sused by the clinician for the diagnostic, prognostic and rehabilitated information which they yield.

Half-word lists

An important modification of these discrimination tests using monosyllabic words has been the use of half word lists. 50 word PB list were found to be cumbersome by several audiologist and thus some consideration has been given to the development of shorter lists to replace the 50 word lists. Several attempt (Bowling, 1959, Campanelli, 1962

Elperno 1961, Resnick, 1962 and Shultzs, 1968) to shorten the lists from 50 to 25 words have been made in the past. However, all of them with the exception of Shultz (1968) have used the same technique- spilt half or odd even divisions of a standard scrambling. The results showed high reliability and stability when the scores on a whole list were compared with scores for 25 words selected from the same presentation. Grubb (1963) questioned the statistical techniques employed in the construction of half word lists. Grubb contends that values obtained in part-whole correlation are usually high and should be interpreted cautiously.

Kenneth Berger (1971) found the evidence to be positive when the attempted to find whether the W-22 records can be just as accurate when suing half lists. Whether the W-22 lists are just as accurate when used as half listed with a monitored live-voice presentation is less clear.

Carhart (1963) observed that there is little to be gained clinically by using a 100 item test so as to enhance the representatives of the score. Some authors notably Elpern (1961) have contended that there is no point in using a fifty item test because precision can be maintained with 25 words.

Disyllabic words:

There are less analytic than the monosyllabic words and provide cues for intelligibility. In order to repeat a monosyllabic word correctly one must hear each of the phonetic elements. A disyllabic word can be distinguished from other two syllable words not only on the basis of phonetic elements but also on the basis of stress pattern.

With the advent of World War II, considerable research effort was directed towards the development of speech tests that could be employed in the evaluation of military communication equipment and systems. A major share of this work was done at Harvard University. This led to the construction of speech reception test based on the concept of a threshold of hearing speech. The first test developed was auditory test No.9 consisting of 42 disyllabic words.

Fairbank's work (1959) with this regard resulted in multiple choice type tests of closed message set, called Fairbanks rhyme test. This test utilized rhyming monosyllables and tests the phonemic differentiation of the initial consonant or consonant vowel transition in monosyllable words. Hence it fails to have face validity as is seen with PB lists.

Words:

Another approach to discrimination testing was the use of multiple choice words. In this procedure printed groups of phonetically similar words were shown to the listener but he hears and has to respond to only one word from each grouping. An advantage to this approach is that words of more than a single syllable may be used, so long as each grouping contains words of the same syllable length and stress pattern. These tests were a closed response set.

“Vocal communication lab. test” by Haagen (1946) was a multiple choice word intelligibility test. The other test was multiple choice word intelligibility test by Black J.W. (1963).

As opposed to this there are some who are against the use of monosyllables and spondee words as test material. They use single words and especially single syllable words; this imposes severe limitations on the capacity to manipulate a crucial parameter of ongoing speech, its changing pattern overtime. Better to have longer samples of speech than words.

The National Research Council Committee on Hearing and Bio-Acoustics (CHABA) found the monosyllabic words not to be representative of everyday speech. It specified the user of sentences as the sample item to represent everyday speech.

House et al (63-65) developed a modified version of Fairbanks rhyme test known as “Modified Rhyme test”; this consisted of sex equivalent lists of f50 words each. In developing these materials House and his associates took no strict account of either word familiarity or phonetic balance. This represented a truly closed response set.

This assesses consonantal discrimination in both initial and final positions of the monosyllabic stimulus words. This did not involve word familiarity and word difficulty as variables (Rose 1971).

Clarke (1965) has developed a test to test phonemes in medial position also ……..called ‘phonetically balance rhyme test'. He took into account factors like familiarity and orthographic constants of the orthographic constants of the test, and selected test items to obtain tests of 50 words each that preserved the representation of the phonemes and phoneme transitions that characterized the parent population of monosyllables used in constructing the test. Clark's PBRT consists of three tests; each measure phoneme differentiation in only one position, that is initial, medial or final. Each list of PBRT consists of equivalent forms of 50 items each. The subject selects the response from the sheet providing during testing. This test was developed to assess the efficiency of communication systems.

Schultz and Schubert (1969) reported a method for utilizing a test in a closed message set format, recognizing that CIDW - 22 tests often yield relatively high scores in some patients. These sets utilize the single word responses. They were meant for assessing the efficiency of the speech transmitting systems.

Sentences:

Sentences are considered to be more valid indicators of intelligibility. Sentences were used by the Bell Telephone laboratories (Fletcher and Steinberg, 1929) in their early work. Their lists consisted of interrogative sentences that were not to be repeated by the observer but were rather to be answered; their lists were not useful because the test demanded the observer not only to hear the words of the sentence but also to provide answers to some fairly difficult questions.

Hudgins et al (Auditory test No. 12) at PAL developed simpler tests. Their questions were relatively simple and can be answered by a single word. These were useful for group testing. If one subjects is to be tested be may be allowed to repeat the sentences in which there are five key words. A set of sentences had been prepared at CID to represent everyday American speech. The sentences were spoken by 10untrained speakers and were recorded. Much effort was devoted to obtain natural, spontaneous every inflection, tempo and emphasis, with a realistic range of individual variation. However, no test has been developed from this material. The disadvantages of sentence tests are that long lists are necessary because the same sentence can't be used twice with one listener, and his memory makes it much easier for him to recognize a sentence again even from a singly key word. But these test have high face validity as samples of English speech.

Jerger, Speaks, and Tramwell (1968) have described a new approach to speech audiometry using synthetic speech sentences, which are presented in a closed message set paradigm. Its limitation lies in the fact that it was meant for the literate population.

Continuous discourses:

The test developed utilizing continuous discourse has not me grater acceptance. “Although difficult to quantity with respect tot the response of the observer, the most valid sample of English speech is of course, a whole paragraph, or several paragraphs of continuous discourse”. (Hirsh, 1952). The available material is so uniformly monotonous and uninteresting that a speaker can repeat the material with remarkably little variability in intensity.

Falconer and Davis (1947) at CID attempted to develop a more rapid means of determining the threshold for speech. The method employed a sample of connected discourse to which the subject listenerd and adjusted the level of the recorded speech to appoint where he could just understand what was being said. The test was compared experimentally with auditory test No.9 and scores were found to be nearly identical.

Research findings

A. Studies pertaining to test materials

The studies reveal the usefulness and limitations of the speech discrimination test.

1. Familiarity and Intelligibility:

Black's study in 1957 revealed that multiple choice tests have the limitation in the form of rigidity of the answer form and the test items cannot be scrambled from one experimental session to another and presumably cannot be used with the same listening panels. Variables like environmental noise, signal level and distance in quiet affect the scores.

Elmer Owen's study (1961) on intelligibility of words varying in familiarity shows that lists characterized by greater familiarity even to a slight degree were significantly more intelligible.

Oyer and Doudha (1964) in their experiment, concluded that most highly familiar category make up the great majority of response choices to all misidentified stimuli, independent of stimulus familiarity.

Pertaining to the usage of familiar words, Owens (1964) states that "if the stimulus is a familiar word, it is likely to be prominent among those competing responses and is quite likely to be chosen. On the other hand, if the stimulus is of low familiarity, it is less, likely to be among the competing responses."

Owens (1964) undertook an analysis of the familiarity of W.22 and PB 50 words and demonstrated that W-22 had been successfully increased to a high familiarity status.

Bruce and Siegenthaler's study (1949) showed that hearing acuity of an individual plays a part in his perception of speech sounds. Intelligibility of speech is dependent upon the characteristics of the speech and of the speaker himself. In hearing aid selection and auditory education these tests results are useful. However certain factors like 1) voicing of the consonants, 2) pressure pattern of sounds, 3) influence of one sound upon the other, 4) intensity level, 5) speaker's vocal attributes (viz., rate, pitch and voice quality), and 6) syllabification of phonetic elements which effects intelligibility.

Further in 1963, Thomas Giolas and Aubrey Epstein attempted to compare the intelligibility of word tests and continuous discourses. They arrived at the fact that monosyllabic word test yield a clinically feasible quantified measure of the individual's ability to understand speech and hence they should be sued on the intelligibility testing.

Holies (1957) did a study on the relation between the intelligibility scores and frequency of occurrence of words. He revealed that repetition of the list will results in increased intelligibility scores.

H.J. Oyer and M. Doudna (1960) concluded in their study that discrimination losses decrease when the task is presented a second time.

2. Personnel:

Miller, Heise and Lichlenis (1951) stated that several factors affect discrimination scores. The class of variables involved are 1) personnel, 2) the test material 3) communication on equipment.

The work by Brandy (1966) shows that reutterance of a given list of words even by the same talker results in significant differences in listener performance.

3. Mode of presentation. (Live or recording).

William T. Brady (1966) showed that the recorded presentations are more reliable than live voice presentation, as greater variability is involved in the talker's presentation.

Portman and Portman (1961) favored live-voice techniques as it permits flexibility in the clinical procedure.

C. Nixon's study (1969) regarding the use of carrier phrase concludes that carrier phrase does not affect the speech discrimination scores. The carrier phrase is desirable for two reasons. 1) The listener is prepared for the presentation of the test item and variability in the articulation secures due to inattention or distraction is reduced. 2) This permits the announcer to module his voice so as to keep the level of his voice even from word to word (Egan 1948).

Shannon's experiments regarding the size of the test vocabulary reveals that the test list should be at the most of 32 words and a further addition will affect the information content of the test item.

B. Studies pertaining to speech discrimination in noise

The reduction of performance in a speech discrimination task with the introduction of noise was documented by J.C. Cooper and Betty; Palva (1955) reported less scores for sensorineural hearing loss cases at S/N ratio's of 10.

Olsen (1962) from his test results concluded that hearing impaired persons experience more difficulty in understanding speech under noisy situations.

Kruel (1968) attempted to use the modified Rhyme test with masking noise on normals at different S/N ratios. Further studies by Sppaks (1969), Owens (1970) Young and Herbert (1970) also indicate poor discrimination scores for Sensorineural loss cases in noise conditions.

Robert W. Keith and Hilary P. Talis (1970) mention that use of speech in noise aids in diagnostic audiometry.

Carhart's (1971) experiment shows no difference in the scores of normals under varied S/N rations.

These studies imply the necessity of measuring discrimination in quite and in noise to understand the problem faced by the individual patient and to assist in providing proper amplification.

C. Studies pertaining to the varied application of speech discrimination tests.

Carhart in 1965 studies the monaural and binaural discrimination against competing sentences and found monaural efficiency in quiet and binaural efficiency in noise at different S/N ratios.

Jerger and Susan Jerger (1971) have put forth the diagnostic significances of PB word functions. They state that PI function of each individual on a speech discrimination test yields a "Discrimination Index", which enables diagnosis as to his hearing impairments this would enable to distinguish between retrocochlear and cochlear cases too. Such a PI function is a must and any discrimination measure at a set level above the SRT is erroneous (Gary Thompson 1962). Several investigators (Schuknetch, Woellner and Grabbe, 1968) have noted that the maximum score for word discrimination is often disproportionately poor in relation to the sensitivity loss in patients with facial nerve disorder.

The results of the studies by W. Neff (1965), Gordan, L.Cheff (1969), M.C. Pollack (1969) and Jerry, L. Punch (1969)] reveal that speech discrimination test is an important tool in diagnosing sensorineural hypacusis.

Carhart's study concluded that speech discrimination measurement is useful in reaching the qualitative estimate of the outcome of surgery, of potential hearing aid use, of relative efficiency with different instruments and of phonemic perception in everyday life. He further adds that the existing tests of discrimination are imperfectly standardized and lack validation, yet have qualitative usefulness.

III. Indian Studies – A critical Note.

Abrol's study (1971) on the development of phonetically balanced word list in Hindi was a land mark in the research work with regard to speech audimotry in India. His study was based on the frequency analysis of the speech components and familiarity. It s drawbacks are 1) it did not include practice effect. 2) SRT level was not mentioned. 3) Articulation curves were not given.

Later, Kapur, Y.P. (1971) developed speech test material in Tamil, Telugu and Malayalam. Excepting for the nature of materials used in the construction of lists in Hindi and Tamil, the methods of their selection and methodology were similar.

Disyllabic words were used to test the discrimination and it yielded articulation curves with a max. score of 97% at 45 dB. This study faced the limitations like 1) SRT level was not specified 2) Practice effect was omitted and 3) disyllables were used in place of monosyllables.

Further attempts have been made be Swarnalath (1972) and Nagaraja (1973) in standardizing PB lists in English on Indian population and in developing a synthetic speech identification test in Kannada respectively. The drawback was that these tests were meant for literates.

In 1973 N.S. De developed a Hindi list and claimed that it could be used all over India. But this cannot be administered to non-Hindi speaking population due to unfamiliarity and language barrier. The validity of this test was not determined.

Dr. Shailaja Nikam's study on "adaptation of speech test material in English to Indian conditions" was done in 1968. The words form W-22 and the children's spondee list were combined avoiding repetitions. 80 words obtained and was administered to 72 undergraduates in Mysore for rating them as very familiar, familiar and not familiar. Cut of 800 words, 45 words were rated as very familiar by 70% of subjects. There words were intended to be used with more cases with a minimum of high school education.

Phonetic Balancing:

Phonetic balance was based on the relative frequency of appearance of various standards as they occur in English. Each word list is thus a sample of the language form which it is taken. Each list must then be given a phonetic composition corresponding to that of the language in question. Statistical studies show the relative frequency of utilization of the various phonemes and the percentages thus obtained can be used as guide, to the choice of the words for the lists, giving lists which are phonetically balanced with respect to normal speech. Relative frequency of occurrence of English speech sds. was studied by Whitney, W.D. (1874), Godfrey Dewey (1923), Funch, N.R. et al (1930), Travis, L.E. (1931), Voclkas, C.H. (1935), Fry, D.R. (1947), Hayden, R.C. (1950), Caroll, J.B. (1952), Froler, M, (1957), Fletches, (1955) and Lehiste and Peterson (1959). Some of these studies were based upon written material as their sources. (Dewey's (1923) relative frequency of English speech sds. served as an external criterion when he complied the original Harvard lists for those who modified these lists afterwards. It should be recognized that Dewey's work is poorly studied for this job of phonetic balancing because his source material was completely written though the analysis was phonetic. A better choice would be relative frequency lists obtained using day to day speech or telephone conversation etc. In the present day the data obtained by Fletcher using telephone conversations was used.

In studies done by Carhart (1965) general as long as the test items are meaningful monosyllables for the patient and their phonetic distribution is appropriately diversified one 50 words compilation is relatively equivalent to another. (Carhart 1965, P. 254).

Fletecher's table

Not all authorities agree upon the necessity of PB. Kennetch Berger (1971) argues well that any syllable sample for conversational vocabulary would be by definition, a phonetically balanced sample of spoken English

Relative Occurrence of Speech sounds in Telephone Conversation.

Fletcher (1965).

Vowels	**Frequency**	**Initial Consonants**	**Frequency**	**Final Consonants**	**Frequency**
P**i**n	10.27	W	9.36	t	14.30
P**i**ne	7.58	T	7.86	r	13.05
P**a**n	6.89	th (then)	6.72	n	12.52
P**e**n	6.60	Y	6.48	l	8.40
P**u**l	6.44	D	6.21	z	6.01
P**oo**l	6.26	M	5.89	m	5.48
P**o**t	5.21	H	5.75	d-	4.44
P**a**ne	4.78	K	5.55	v	4.23
P**a**le	4.74	S	5.46	ng	3.57
P**a**wn	4.15	N	4.99	s	3.13
P**u**n	4.14	E	4.64	K	2.85
P**u**ll	2.96	G (Gun)	4.33	F	1.37
P**o**ut	1.69	L	4.31	th (with)	1.25
P**a**r	1.31	F	3.96	P	1.24
P**a**ir	1.09	R	2.78	Ch	.53
P**u**rr	.80	P	2.54	b	.42
P**e**w	.26	th (thin)	2.02	g	.38
P**oi**se	.19	SH	1.74	Sh	.32

Unaccented vowels

		V	1.25	J	.14
Poss**i**ble	5.52	J	.83	th (myth)	.04
About	5.33	CH	.55	zh (azure)	.01
Diff**e**r	4.56	z	.34	h	-
R**e**ceive	3.78	zH	.02	h	-
Moti**o**n	2.65				
Want**e**d	1.83				
P**e**ople	.97				

Review on Telephones

The new types of telephones that are to be marketed in our country are the following.

1. Answering Phone:

1. Answers in incoming call in the absence of the user by playing back a pre-recorded message. 2. Records the message left by the caller for 30 seconds. 3. gets ready to answer the next call. 4. simple controls like a cassette recorder. 5. enables to check back recorded text. 6. takes dictation. 7. useful for business organizations and VIPs.

2. Auto Dialer:

1. Automatically dials out a pre-programmed No. by pressing a button. Programming by fitting the encoded magazines in appropriate positions. 2. Capacity 30 addresses (16 digits maximum) 3. enables hands free calling and has cancel facility. 4. Loud speaking facility and monitor tones and speech. 5. Access pause after 1^{st} 2^{nd} or 3^{rd} digit as desired by user. 6. variable impulse speed 10/20 i.p.s.

3. Field Telephone set 5A NK 1

1. Can be used on magneto, CB CBS exchanges.

2. As the auto telephone with dial attachment. 3. As an end terminal of a radio set. 4. Uses dynamic noise cancelling microphone. 5. casing is moulded out of unbreakable nylon/ABS. 6. Reduced battery drain. 7. Reduced weight compared to other conventional field telephones.

New dial

88 parts to 61 parts totally with new simplified straight springs, single molded lobe case, efficient drive bar governor, efficient molded gear wheel, base simplified by reduced No. of operations, main spring 3 tier, No. dial modified for better appearance. Finger wheel for aesthetic appearance.

4. 672. Type.

5. 681 Type.

6. 601 Type. – Priyadarshini – Receiver Capsule Balanced Armature construction.

7. SW Telephone 671 MK V extension – normal extension but has facility to avoid artificial traffic when the extension calls main telephone.

8. Telephone with Electronic ringing generators.

i) uses solid state devices. 2) generates 17 to 25 c/s ringing voltage. 3) easy operation by a single push button. 4) less maintenance due to elimination of mechanical part in generator. 5. Has more reliability and increased life.

9. Switching Telephone facilities - 751 Type Extension.

Main	**Extension**
a. Can call extension by pressing ring 2 button.	a. Can call main by pressing ring
b. Can converse with extension by pressing Extension button	b. Can converse with main by pressing main button.
c. Can call exchange by pressing exchange button.	c. Can call exchange by pressing exchange.
d. Can hold and exchange call by pressing extension	d. Can hold exchange and call back main.
e. Visual indication to show busy conditions of extension on an exchange call.	e. Visual indication to show the busy condition of main on an exchange call.

10. Push button telephone (671 TYPE)

1) Push button key pad replease the convention Rotary dial. 2) Easy and quick dialing 3) better impulsing performance 4) Works with stronger/crossbar exchange 5) Less maintenance and more reliable.

11. New Desk Tel. 752

1) Employs new dial with dry bar type. 2) Employs new equalized carbon transmitter. 3) Uses

printed circuits for easy assembly and maintenance. 4) uses greater reliable gravity, switch mechanisms with operator springs. 5) Reduces No. of components compared to its predecessors.

12. Telephone 751.

Users high quality carbon microphones and receivers 2. Employs new dial. 3. Uses printed card 4. Gravity switch mechanism uses molded parts and comb operated springs. 5. Improved molded dial mounting. With simplified cradle, miniature induction coil, reduced condenser size, assembly simplified by printed cards on base, reduced No. of parts from 285 to 211.

Equalized Transmitter:

1. has uniform frequency response. 2. Low distortion. 3. Less noise. 4. Faithfull reproduction of acoustic equalization.

New back cover, silk washer for equalization of frequency response, dome shaped electrode for improved function, washer and spring prevents granules from leakage. washer keeps electrode in a position, case modify for better acoustic function, an alloy with dome electrode for improved function – diaphragm, ring clamps diaphragm, cover for protector and acoustic function, transmitter No. of parts reduced from 21 to 16.

A Telephone net work

1. Primary Switching centre
2. Local Exchange
3. Secondary Switching center or Zone centre.
4. Tertiary and Quaternary switching centres
5. In dense Primary area some pairs of local exchange will be interconnected through a 3rd (called) Tandem exchange.

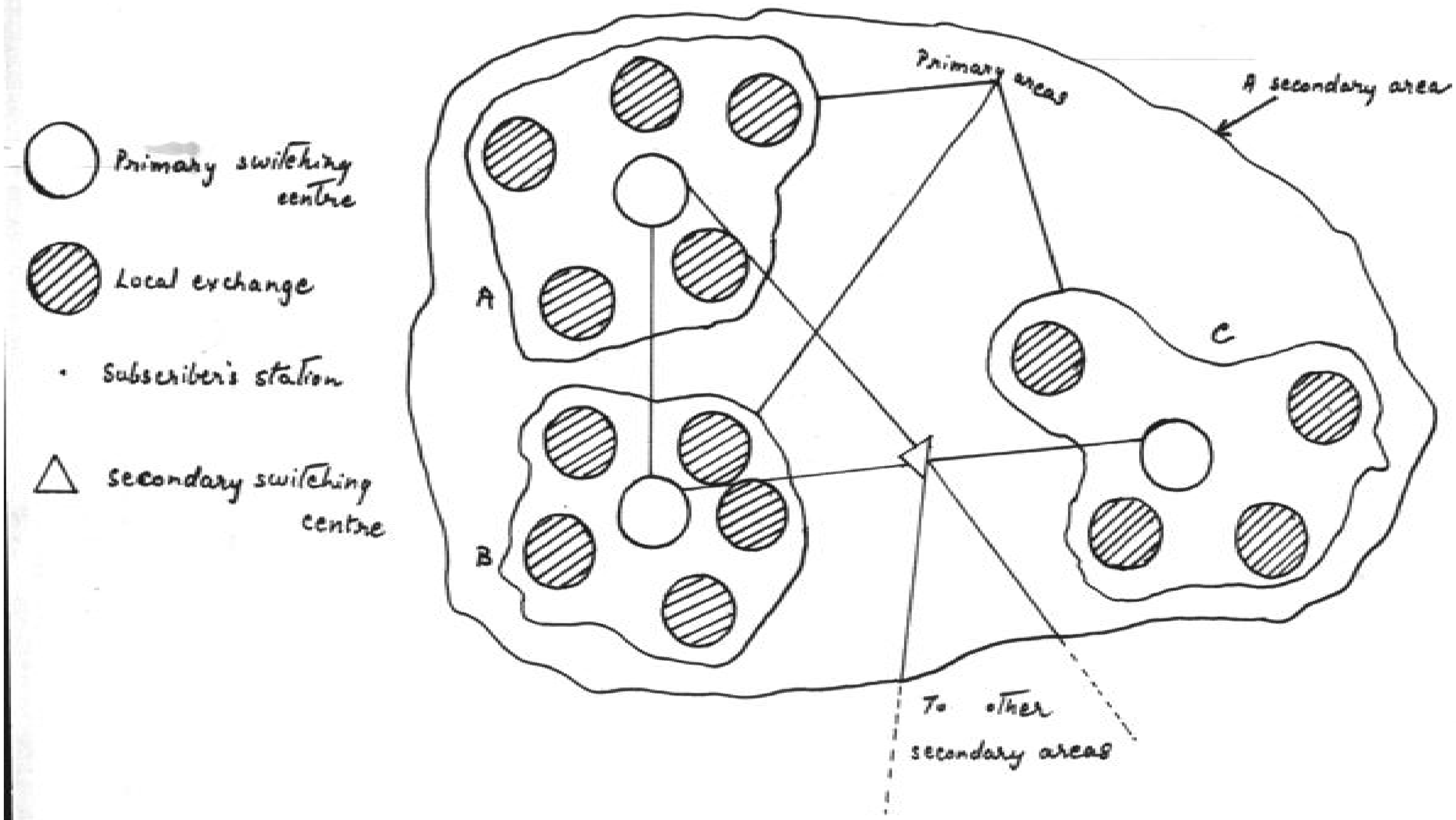
Transmission of Information:

When some action by a sender enables a receiver to select one particular item out of a set of possible alternatives previously agrees upon by sender and receiver on the alphabet to be used ….. transmission of information occurs. Model of communication: -

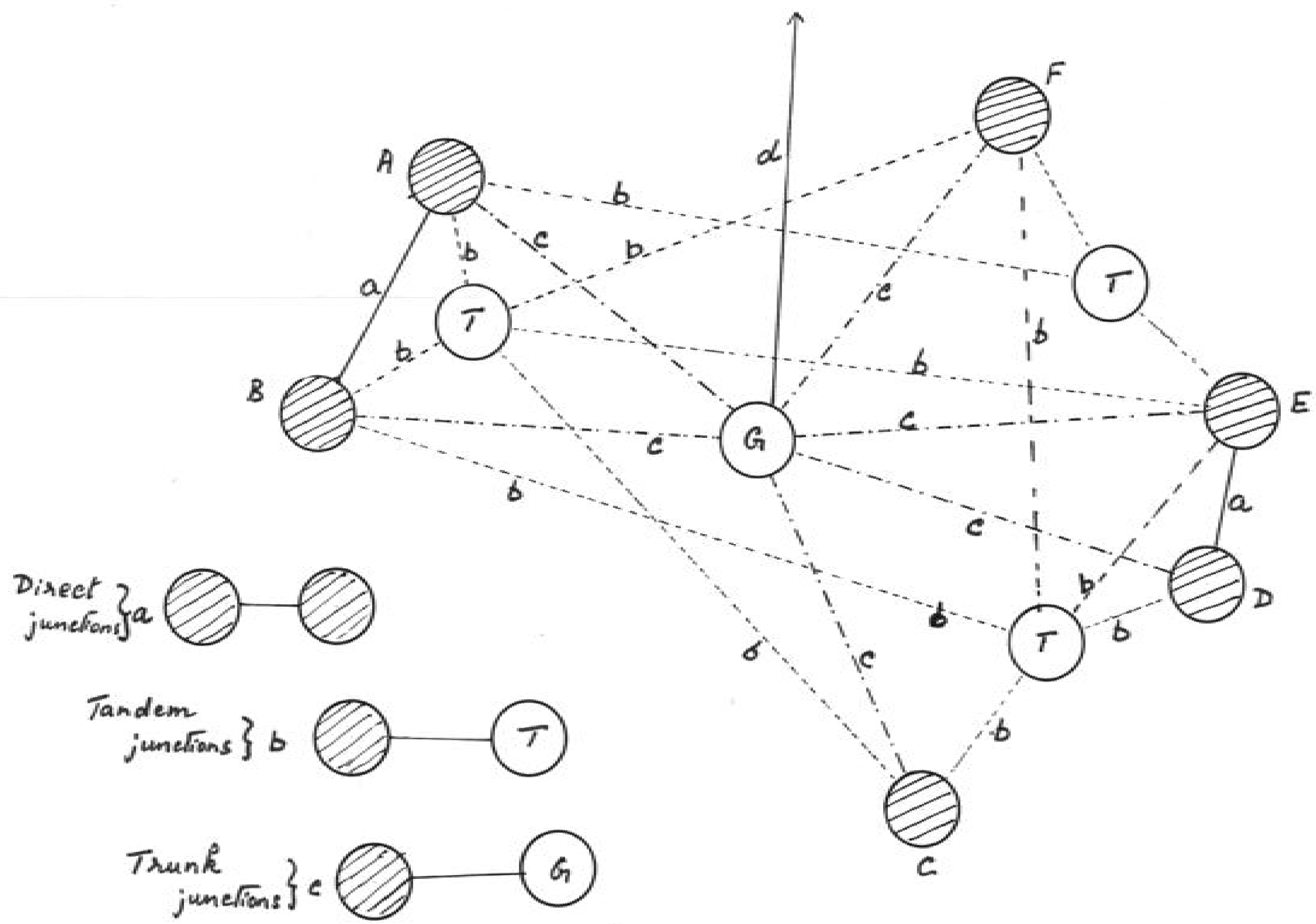
Source ------sender ----- Transmission channel ----- Receiver apparatus

Information destination apparatus

Source Coding Noise Decoding Destination



1. A TELEPHONE NETWORK.



Trunk circuit to zone centre = d.

[2] Fig. Showing a primary area using tandem exchanges.

Shannon Weaver's model of speech communication: - Information source operates a process in which items are selected from a defined ensemble of symbols, each representing a message element. They are coded in the sending apparatus as signal elements suitable for transmission over the channel. The receiving apparatus decodes the signal elements, thereby restoring them to the same form as in the original ensemble of symbols representing message elements. Thus the amount of information emitted by the source is governed by the statistics of the ensemble of potential message elements and the rage at which the selection takes place. This theory of communication defines certain necessary properties of the transmission channel, if it is to convey signals sufficient to permit selections to be made by the receiver at a given rate. The articulation method attempts to measure the capability of the system to reproduce sounds from a defined population emitted by a speaker (sender) and recognized as specific members of that population by a listener (receiver). Two distinct quantities have to be considered 1) The rate at which the sender emits symbols of which each has a certain selection potential The English language has 40 different sounds, which serve to distinguish the meaning of one word from another. Any spoken sentence can be transcribed by writing a sequence of signs drawn from a set of 40 different signs and this written material could be read aloud by another person to produce the same meaning to a listener as he would have received by hearing the original talker. The rate at which the signs are written down along with the statistical description of their probabilities governs the information rate of the talker as the source. Therefore Log_2 40 = 5.3 bits / sec. for signs which are equiprobable and independent; but speech sounds are not so, and therefore we take account of the zero order probabilities and the diagram transitions to get a maximum information rate of speech at about 43 bits / sec. By accounting for redundancy between sound within words, the rate comes down to about 35 bits /sec. and redundancy between words in a sentence further bring the rate of emitting information to an estimated valued of 12 bits /sec. If the precise topic of conversation has been defined and is known to both participants, it has been estimated that the information rate is not grater than about 0.2 bits/sec.

2. The channel capacity relates to the hearing mechanism of the listener. Listeners can make very fine distinctions between sounds of a set and so the total number of distinguishably different sounds is perhaps equivalent to 25000. Application of a sound for about 50 to 200 m.secs. is required for a discrimination to be made - - by taking an average of 100 m.secs. it may be stated that the ear can receive upto 50,000 bits /sec., assuming that the transmission capacity of this amount is necessary to ensure that the listener will never be above to distinguish the difference

between the sounds entering a transmission system and those arriving at the other end. No human activity, whatever the senses or combination of senses, can be continued at information rates exceeding about 4.3 bits/sec. and it has been shown that the limitation is in the internal processing in the brain. In communication systems interposed between talker and listener, an information capacity of less than 50 bits/sec. would suffice not only to transmit all the information but also to satisfy the rate at which the listener can operate. But in telephone speech path, as in a poor telephone connection, having bandwidth of 3000 Hz. and ratio of speech S/N might be about 30 dB, by Shannon's formula, $C = W \log_2 (1+ S/N) = 30{,}000$ bits /sec. The ratio of nearly 1000/1 implies that the efficiency with which the channel is used by talker and listener is only 0.1 % and even with sophisticated methods, the efficiency is improved to only about 1% . the ratio of the rate of information transmission to the information rate of the source is an obvious measure for assessing the transmission performance of the system.

The basic assumption of a definite and agreed ensemble is not true for many ordinary telephone conversations, since a considerable part of the call is devoted to establishing some common basis for discussion and the participants are more bothered with the effort required in conversing and in any difficulty encountered than it any counting of errors committed in interpretation. The theory of signal analysis and how information bearing signals can be transformed without loss of information is important for telephony. We know that theoretical information content of speech is very small compared with the transmission capacity of channels usually considered necessary in telephony. This disparity is not wholly wasteful. Messages an be transmitted without error at rates upto the information capacity of the channel and if full channel capacity is exploited, elaborated coding is necessary to match the signals to the characteristics of the medium, involving long sequences of message symbols; this requires time for organization and therefore delay results. Therefore if practically, instantaneous transmission is required, a margin must remain between channel capacity and theoretical information content of the messages. Surplus channel capacity is also used to avoid error, when only temporarily, the channel capacity is reduced. Speech sounds having many different wave forms will be accepted even by a discriminating listener as the same phoneme having many aliases any one of which is acceptable. In speech sound recognisation only a few clues are used to distinguish from other sounds. Failure occurs only when all the clues are obliterated due to channel degradation. Redundancy is the property of message symbols to contain theoretically unnecessary elements; its presence results in the assessment problem becoming often of measuring the effort needed to take advantage of the redundancy to avoid error rather than counting the occurrence of error which are very few even in a bad telephone channel. Redundant structure of speech and the active roll adopted by listeners in interpreting what reaches the ears calls for multicriterion methods for assessment of very wide rang of transmission quality because clues treated as redundant according to one criterion may be essential elements according to another. Therefore no successful assessment method has yet been based on principles leading to scores in terms of bits /sec.

Mean one ways propagation time:

As propagation time increases subscriber's difficulties increase and the rate of increase of difficulty rises. Relevant evidence is givne in the bibliography. CCITT recommends following propagation times when echo sources exist and appropriate echo suppressors are used. a) 0 to 150 ms – acceptable (b) 150-440 ms acceptable (c) 400 ms. unacceptable.

Information on the organization of a national telephone network.

a) Genera organization and nomenclature
b) Choice of method for specifying transmission performance.

Different methods are used in different companies. The simple procedure is to set reference equivalent limits for national calls since in any case this must be done for international calls. Once the sending and receiving reference equivalents for every type of subscriber set used in the country are known. The reference equivalent of any connection (an part of connection) can be calculated.

Improvement of performance in existing net works.

Within existing telephone net work it is important to improve that transmission quality for unfavorably situated telephone sets which can handle considerable traffic and specially international traffic. Several methods can be used -1) Repeaters may be used on subscriber lines, junction circuits in the networks of large towns and toll circuits. The repeaters may be either 2 wire of standard type of negative impedance repeaters (2 or 4 wire). In each case, the stability of transmission should remain adequate.

2. Transmitting the receiving insets may be graded in several qualities and the better insets may be fitted in a telephone sets served by lines having the greatest attenuation and vice versa.

3. Telephone sets especially designed for particularly long subscriber lines may be used. They may include amplification at the sending end.

Subscriber Telephone sets containing either loudspeaking receiver or microphone associated with amplification – CCITT expedites studies on it.

Provisional recommendation: - In order to avoid overload of carrier system the mean long term power of speech currents should not exceed the mean absolute power level assumed for system design. The value for absolute power level corresponding to a zero relative level point, is – 15 dB (mean power = 31.6 micro walts). Also to avoid excessive cross talk from high level speech current and for inadequate volume from low level speech currents care should be taken to ensure the variation of speech currents that it is not substantially greater than that from modern telephone instruments. Also precautions that the listener may be able to break the sending circuit if oscillations occur or devise methods so that a device controlled by voice may prevent oscillation.

There are three systems in existence to determine reference equivalents:

1) N.O.S.F.E.R. – new fundamental system for the determination of reference equivalents ---- White book.
2) Primary system for determination of reference equivalents – CCIF Green book.
3) Working standard systems.

Determination of Transmission quality by objective measurements

First essential method for measuring quality of a telephone circuit is that it should give results which correspond to the experience of any user employing the telephone for purposes of daily life and it should be simple and practical.

a.(1) Loudness comparison for speech – not satisfactory.

a.(2) A.E.N. method – not sensitive for modern sets.

a.(3) Opinion sets method – CCITT Red Book ref.

a. (4) Observation by 3rd parties by interrogation criteria repeats, difficulties reported etc.

Theory of Objective Reference equivalents: Relationship between objective and subjective measurements.

b.(1) Based on information follow several theories for calculation of articulation logatoms and sounds.

b.(2) To evaluate information transmitted in word components. Ref. COM XII – No. 87 in 64-68.

b.(3) Absolute method of calculate information transmitted from objective measurements applies to a one way transmission channel – yields results that correlate with opinion test for a type of set.

The British administration developed an objective test for line and electrical assembly of a set which for a type of microphone and receive yields results that correlate with AEN measurements and opinion test data.

b.(4) It is difficult to devise an objective measurement method based on principle used in opinion sets, which rely on 2 way conversation and take account of mutual reactions of 2 individuals conducting the conversation.

Methods for evaluation of service from speech transmission quality stand point: It should be representative of actual use condition viz., (a) direct actual calls reported by customer (b) indirect use of measurement transmission parameters.

According to White book IV Plenary session, the necessary an desirable properties for measurements are as follows:-

(1) Reliability – must give similar or same results on repeated measurements under same conditions ---- ‘robustness’.

(2) Validity - It must reflect changes in transmission quality and correlate with other good measures of transmission quality. Example A.T. & T Co.

(A) General questions concerning transmission used when the exact nature of transmission parameters is unknown is of secondary importance.

B) Specific questions concerning transmission features have been classified when the types of difficulty can be specified and a classification of the users responses into these categories is desired.

C) Overall rating by user has to be used on almost all forms i.e., for example ----- ‘which of these 4 words comes closest to describing the quality of that connection ‘excellent’, ‘good’, ‘fair’, ‘poor’, ‘bad’, - minimum of 50 to 100 calls is essential.

Subjective Voice Ear measurements.

1. Speech volume – ref. Vol V White Book.

a) Measurement of reference equivalent – N.O.S.F.E.R. – called ‘Telephometric measurement – ref. White Book Vol. V

b) S.E.T.A.B. and S.E.T.E.D. ref. CCITT – Vol. IV of Yellow Book.

Comparison of sending system with a standard sending system, and comparison of receiving system with a standard receiving system.

Precautions while using the telephone hand set for speaking during measurements: (1) To maintain Volume With Volume indicator – S.F.K.R.T. Volume indicator is standard. (2) Packing effect. (3) Contact resistance.

(4) Position of lips with respect to microphone - use of guard ring – reference white Book Vol. V.

Measurement of Sidetone Reference equivalent:

a. Speech Side tone b. Room noise sidetone. For a refer CCITT – Vol. V of White book. The Room noise sidetone is still under study by CCITT.

Method of subjective determination of transmission quality:

The transmission qualities under test may be circuit noise, distortion, Induce noise, operator noise, cross talk noise, phase distortion and attenuation distortion The methods are a) repetition observation test: 50,000 to 100,00 sec. minimum. The curve is drawn of repetition rate /100 secs. as a function level of artificial circuit noise. b) Immediate Appreciation tests – refer Vol. V Red book. c) Other methods – refer Vol. V White book.

Heasurement of absolute sensitivity of a sending/receiving system.

One of the following methods are used.

a) Thermo Phone method – refer Vol. IV Green Book.
b) Rayleigh Disk method – refer Vol. V White Book.
c) Compensation method and electrostatic actuator

method – Ballantine S. 1932.

d) Reciprocity method for calibration of condenser microphones. refer Vol. V Red Book.

Measurements of subscriber's Telephone equipment

a) Measurements of Attenuation distortion of a telephone set is done by frequency characteristics and this does not supply full information on the manner in which this equipment reproduces voice or music – refer White Book Vol. V.

b) Measurement of the Non-linear distortion of a telephone set and microphone noise; while non linear distortion of receivers is in general negligible, microphones especially earbon type show considerable non-linearity. 1) There is a threshold of excitation 2) as a consequence of mechanical inertia of carbon granuers, the various states of agitation of the carbon under the influence of acoustic waves are not same for all frequencies – refer Part II of Vol. V of Red Book.

Manual Trunk Exchanges: CCITT recommendations

1) Operators sets should be provided with an arrangements allowing the microphone to be disconnected,

the device being a change over key.

2) Operators set should not cause, in silent listening position, an insertion loss of 0.43 dB, at any frequency below 300 and 3.4 KHz, by introducing suitable impedance.

It is necessary that speech signals of operators do not overload the amplification or modulators of carrier systems. The operators set and associated equipment should be so designed, that under service conditions, the operators do not provide a speech volume greater than that of a subscriber situated very close to the trunk exchange considered.

Subscriber's lines and sets. CCITT recommendations

1) Formic the use of microphones giving grater power output than that given by normal microphones and also the use of special receivers.

2) To reserve the right to verify by means of volume meter, that the volume transmitters over rented telephone circuits does not reach an excessive level.

3) Where authorized to use receiving amplifiers it is desirable that the gain be limited so that it is not

possible for the user to over hear by means of cross talk conversation on neighboring circuits.

Definition of the articulation reference equivalent (A.E.N).

If articulation tests are made under specified conditions alternately on a telephone system to be tested and through reference system for the determination of A.E.N. (S.R.A.E.N) with the different values of line attenuation, upto the point where values of articulation on both systems are substantially reduced then the results on these tests may be recorded in the form of curves showing the variation of sound articulation against attenuation. The value A1 of the attenuation of the system under test and the value A2 of the attenuation of the S.R.A.E.N at fixed valued of 80% sound articulation, can then be determined (A2 – A1) and this by definition equal to A.E.N.

Calculation

The nominal A.E.N. of a national sending or receiving system is –

1) Nominal A.E.N. (average value in service) of the local system.

2) Nominal A.E.N. of the connection between the local exchange and the international exchange (average value

in service) which is equal to some of the following numbers – the equivalent of the trunk circuits between the last trunk exchange and the international exchange, measured at 800 Hz., increased by the transmission impairment due to a bandwidth limitation when these circuits have an attenuation / frequency distortion grater than that which is allowed in the recommendation of the CCITT.

Nominal A.E.N values for national sending system should not exceed 24 dB.

Nominal A.E.N. values for national receiving system should not exceed 18 dB.

The A.E.N. method does not make allowance for the effect of sidetone on subscriber's speech power.

Transmission impairments and noise:

a. Due to bandwidth limitation effectively transmitted through trunk circuit – observations by CCITT of repetition in conversations and articulation measurements.

b. Due to room noise: method of method of measuring A.E.N. takes into account of 60 dB of room noise (Hoth Spectrum) at the receiving end, informs the method of evaluation through impairment due to room noise.

METHODS OF MEASURING THE COMMUNICATION EFFICIENCY OF A SPEECH LINK

1. Loudness rating
2. Articulation
3. Listening methods using sentence material
4. Talking methods
5. Examination of conversations
6. Examination of participants during of after conversation
7. Methods based on instrumental measurements

Articulation

Articulation measurement provide a method of determine the information capacity of a path when it is transmitting information in the form of speech signals. The effects of the following features important in telephony are specifically excluded in an articulation test.

1. Variation between talkers.
2. Variation between listeners.
3. Any influence the characteristics of the path

being measured may have on the behavior of talker or listener.

4. Any influence on the behavior of talker or listener of any other characteristic of the speech link of which the part being measure to forms part.

The results of an articulation measurement apply to one direction of transmission in isolation, so that conversational factors are totally excluded. Articulation can deal only with listening factors.

Articulation can claim to deal with the effects of circuit noise and room nose; distortions are taken into account in a more sophisticated manner.

The principle consists of determining the percentage of information bearing elements by the talker, that the recognized correctly by the listener.

Methods

Articulation tests are usually conducted with a trained testing team. The talking condition are carefully controlled by providing the talker with means of monitoring the level of his utterances, for example a speech voltmeter connected to a high quality microphone located at a controlled distance from his lips.

The listening conditions are also controlled including provision of suitable listening cabins and furnishing them with definite levels of room noise. It is convenient to use a team of five persons of which, at any time, 4 listen simultaneously on parallel connected receiving ends, while the fifth does the talking. The members are rotated systematically with each change in the test condition according to a property designed and administered experimentation design.

Articulation tests can be scored in different ways even which a given type of logatom or word material is used. Strictly, the score ought to be made in terms of the number of complete logatoms or words recognized completely correctly; this is termed the logatom, syllable or word articulation score. However, scoring is often done in terms of the fractions of the complete logatom, that is, a score of three is given for a complete consonant-vowel-consonant combination recognized correctly with partially correct combinations allocated scores of two or one if one or two errors are present in the combination written down by the listener. Scoring in this way, out of a total equal three times the number of logatoms emitted by the talker, yields the sound articulation score.

The scores obtained from an articulation test have very little absolute significance and can very widely when a different crew is used or changes made in the procedure. For this reason the scores are used to obtain ratings, relative to a defined reference system, by the ‘indirect balancing’ method. The CCITT has defined a reference system for this purpose derived from the ARAEN which was described and termed SRAEN. Ratings in terms of equivalent settings of SRAEN are called ‘AEN values’ and these are determined at a value of articulation, scored in sound, of 80%.

The SRAEN is set up by introducing into the junction of the AREAN a defined 300-3400 Hz handpass filter and arranging to inject a certain level of circuit noise, having a defined frequency spectrum, into the receive end. The SRAEN is used without any noise at the listening location but the receive ends of all commercial local telephone circuits under test are used with a room noise of 60 dBA (Hoth spectrum) at the listening location.

An alternative reference system was developed for conducting AEN determination and this is termed SETED; this system is arranged with its microphone somewhat closer to the talker’s mount than the case with SRAEN.

When determining the AEN values of local telephone circuits, the loss setting corresponding to 80% sound articulation is determine by transforming the scores for four listeners, according to the logistic transformation function and fitting linear lines to the response metameter. Analysis in terms of such transformed units also permits confidence intervals to be estimated and tests of significance to be made to check that the results do not exhibit any unusual features. Details in Red Book, Volume V 1962.

Other methods are in use for articulation testing; for example, the procedure can be simplified so that relatively untrained and inexperienced persons can be used, example volunteer students. Closed response sets can be constructed which require the listener merely to select one of a small number of responses offered on his score sheet. Words that are difficult to distinguish from other common words, example by their initial consonant only (rhyming words), have the merit that they can readily be administered to persons without any appreciable special training. Other special sets of word have been complied for diagnostic testing, especially when studying the problem surrounding development of channel economy transmission systems.

Use

It is limited to links of rather poor performance. Although noise and distortions do reduce articulation scores, it has been established that telephone speech paths having different impairments but producing the same AEN values can be far from equally acceptable so far as their use for ordinary telephone conversations are concerned. Further reference available in CCITT Red Book, Volume V 1962.

The U.K. Post Office uses specialized articulation techniques, the results of which can be presented as a set of confusion matrices. It must be noted that analysis of speech into phonemic elements (such as are used to construct lists of logatoms) is related only in a very complicated manner to phonetic and acoustical analysis and these relationships are not completely understood. Measurement of articulation scores can therefore be expected to provide only a very limited assessment of speech communication efficiency; it is not suitable for dealing with circumstances where long ‘runs’ of speech material are being interpreted, example in ordinary conversation.

Relationships between articulation scores and certain physical particulars of speech paths.

The first theoretical model was that proposed by Collard in 1928 and, although this had been later elaborated by others to extend its range of application, most of the essential fundamental principles remain unaltered. The later adaptations are reported by French and Steinberg, Fletcher and Galt, Beranek, and Kryter. As reported elsewhere (Richards and Archbold (1956)), the Collard principle can be used to reproduce articulation scores according to the AEN method of measurement. It has also been employed as a basic for prediction the best frequency responses of hearing aids and telephone microphones.

Listening methods using sentence material.

Aims and Principles.

Sentence material can be used to determine an "information capacity" for a path of a speech link. Scoring in terms of amount of material received correctly is, however, rather difficult; writing down what the listener hears is excessively laborious and so scoring by verbal repeat or in terms of 'key' words is often resorted to.

To retain the idea of scoring in terms of amount of material 'satisfactorily' received, it is possible to use the 'immediate appreciation' method – Grinsted in 1937. A fixed, one way speech path is used with talking and listening conditions held constant and the scoring is done by the listener noting whether or not he understood the meaning of each sentence without mental effort. The method is, however, rather too insensitive for assessing ordinary telephone speech paths; a score of about 95% is given for a speech path of 33 dB nominal overall reference equivalent without appreciable circuit noise. Such a path represents approximately the greatest transmission loss permitted in a modern telephone network.

The principle of scoring having no semantic connections is very attractive for telephony and valuable results can be obtained by use of a multigrade rating scale. This can be used to determine thresholds of detectability or objectionableness.

The general aim is one of obtaining assessment scores that will enable predictions to be made by subjects conversing over symmetrical speech links of which the principal paths are identical to the path in question. For such purposes it is necessary to confirm that the listening assessment method used does indeed properly rate at least the effects of loss, noise and distortion. This is ensured when the listener has sufficient opportunity to appreciate the nature of the degradation. The specific aim is one of rating correctly the relative effects of different varieties of one type of degradation.

Methods

When making recordings ten groups are usually recorded by one talker and the next ten by another so that a variety of voice I used. No sentence may be repeated, even by a different talker, so that each sentence is unknown to the listener.

Recordings of this can be used for immediate appreciation tests, listening opinion test or for pair comparisons.

Because the effects of talking factors (like side tone an echo) and conversational factors are specifically excluded, it is possible to record the sentence lists using the type of microphone appropriate to the various speech paths to be included in the experiment.

Immediate appreciation tests consist of the transmission of a list of 25 or 50 sentences and asking the listener to indicate, for each sentence, whether or not be has understood the meaning immediately, without mental effort. The results obtained can then be plotted as a function of the amount of added loss.

Listening opinion tests are conducted by arranging for the listener to hear groups of sentences, each group being reproduced over a different setting of a speech path. After each group, the listener expresses his opinion on an appropriate scale. Response may be excepted verbally. When the results are to be used for prediction conversational performance, it is to be ensured that the listeners are given sufficient opportunity to appreciate the nature of the degradation to which they are being exposed. It should also be ensured that standardized performances for the extreme conditions within each sequence are obtained.

The following opinion scale - - - D.L. Richards 1973 – has been found useful in telephony.

Listening effort scale

A. Complete relaxation possible; no effort required
B. Attention necessary; no appreciable effort requri3d
C. Moderate effort required
D. Considerable effort required
E. No meaning understood with any feasible effort.

The categories A to E with any of these scales are scored 4, 3, 2, 1 and 0 respectively. The setting of loss that yields a score of 2.5 with the above scale can be said to mark the threshold of listening effort. Direct comparison is possible by making use of recordings prepared and replayed into an arrangement that permits the listener to select one path or another and to listen alternately to decide which enables him for example, to understand the meanings of the sentences with less mental effort. This method is termed as pair comparisons. Other methods of performing pair comparisons are possible.

Use

Has very extensive use for applications in the study of circuit noise and attenuation /frequency distortion and for applications to non-liner distortion. Other uses are for determining thresholds of audibility, detectability, objectionableness and disturbance under listening conditions.

Relationships between listening opinion scores and certain physical particulars

of speech paths.

The Collard model is attempted to predict the scores given by ordinary, untrained, persons taking part in listening opinion tests has proved difficult. The fundamental particulars of the listening opinion situation are –

1. Speech reaches the listener's ear with a particular mean spectrum density:

2. Noise (room and circuit) enters the listener's ear with a particular mean spectrum density and if audible, will produce a certain masked threshold of audibility.

This information is expected to be sufficient to form a basis for calculation purposes. The theoretical must distinguish between faintness of the speech and the sensation level.

Talking Methods.

Aims and Principles

Factors causing loss of communication efficiency consisted of those that causes difficulty in talking. The aim is to study the effects of varying the characteristics of these paths and this done by observing the level of speech emitted by the talker, by noting any changing in his manner of talking or by interrogating him.

Methods

Two types i) talking only tests and ii) "full conversation" tests.

The paths concerned are "sidetone" and "talker echo" . In principle, information is needed not only for a wide range of loudness of the speech heard but also for certain practical variations in loss of these paths as functions of frequency. Speech sidetone and talker echo paths each contain in element associated with a return loss at some point (or points) in the connection where reflections occur and return losses are notoriously variable in frequency response. With sidetone, the reflection takes place mainly at the interface between telephone set and subscriber's line and so the speech returned to the talker is not noticeably delayed; with echo, however, the refection is at the remote end of the connection and suffers twice the mean one way propagation time of the connection fro the talker to the point of reflection.

The limitations of the talking only method and certain differences in behavior when the full conversational environment is reproduced should be noticed. Conversation tests, using definite tasks for the participants to complete show somewhat different results for the effect of sidetone on speech level.

Although the speech level output from a handset microphone under conversational conditions is affected by the level of room noise, the relationship between speech voltage output and sidetone loess is unaffected by the level of the room noise, at least over the range 40 to 60 dBA. Furthermore, the speech voltage output versus sidetone loss relationship does not interact with the values of transmission loss in either direction, talker to listener or listener to talker.

Information on the effect of sidetone on the opinions of subjects while conversing is rather scanty; a telephone connection having STRE equal to – 5 dB has a serve effect on conversational opinions but, when the STRE exceeds about + 3 dB, conversational opinions seem to be unaffected in spite of the substantial effect that this amount of sidetone has on the speech voltage output from the microphones and on the opinions obtained from talking only tests.

Echo paths that affect the participants while they are talking differ in form from sidetone paths only by the presence of appreciable delay in the round trip route taken by the speech signals. In fact, echo can only be distinguished subjectively from sidetone when the round trip delay exceeds about 30 ms.

The relationship between reference equivalent values and losses relative to the one meter airpath is different for echo from that used for side tone; A one meter airpath sidetone path is equivalent to about 28 dB STRE but a one meter echo path is equivalent to about 32 dB nominal overall reference equivalent.

Use.

the above methods can be used to derive allowances in terms of changes in speech volume produced on lines when, for example, the side tone reference equivalent is changed.

In some circumstances requiring study, changes in talker behavior are not governed only by the characteristics of one or more direct mouth to ear paths terminated at the talker but also by interaction and the participant at the other end of connection. The talking only methods are unsuitable and a complete conversation type method must be used.

Examination of conversations

Aim and Principle:

When some difficulty is encountered, it will in most cases, be surmounted by the participants making some slight adjustment in their behavior, such as talking louder or closer to the mouthpiece, listening more carefully and holding the earphone more firmly to the ear; they may also respond by requesting some material not understood to be repeated or otherwise indicating trouble by saying, for example, 'I can't hear you'; 'This connection is poor', etc. Such changes in behavior and other response can, in principle, be observed and their frequencies of occurrence used as an indication of failure to provide completely adequate performance.

The aim of conversational methods of assessing speech links and telephone connections is therefore; (1) to reproduce situations that results in pairs of subjects conversing with each other over the connections to be assessed; and (2) to observe relevant features of their behavior so that abnormalities attributable to deficiencies in the connections can be identified.

The observations possible can be cassed as (a) those made upon the conversations themselves and (b) those involving examination of the participants, either during or after their conversations.

Methods

Use of actual conversations over working telephone connections seems attractive because the environment is undisturbed; not only is this not permissible on grounds of infringing privacy but it also proves extremely difficult to make reliable observations of conversational events, even under good laboratory conditions. The following precautions are important.

1. The various paths of the telephone connection being simulated must be arranged to present the speech link to the participants as they would experience an actual telephone connection. Not only must the sidetone, room noise, attenuation/frequency distortion, circuit noise and other physical features be realistic but also the equipment used by the participants must be like a telephone.

2. Each conversation should be initiated as would a real telephone call, that is one participant should dial a number which causes the other’s bell to ring and, on answering, the connection must be found by the participants to have been established so that the conversation will commence with the usual introductions.

3. The topic of the conversation should form a definite task which has a lcear objective which, when achieved, allows the call to be terminated in a normal manner by replacing the handset

4. The participants in the experiment should be untrained and as representative as possible of normal members

of the public. They should take part in such tests not more frequently than, say, once in six months and, on each occasion, the number of conversations should be limited so that the tasks do not become too familiar to them.

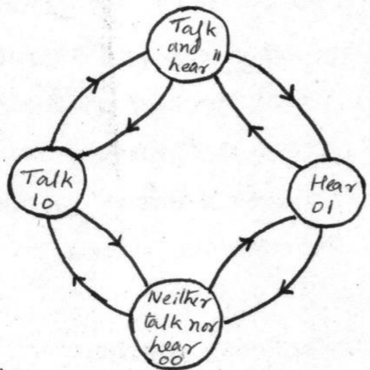
5. The range of test conditions included in any experiment should be wide enough to ensure that the participants experience conditions likely to be considered 'excellent' down to those likely to be considered 'poor' by average subjects.

Clearly one of the participants must originate the call and he is termed the caller; the scene must be set to provide him with a reason for making the call and many of the task used have required the caller to find some information he is lacking and which is in the hands of the other person, called the respondent. An early type of task is that using the map-like diagrams; the caller's sheet is identical to that of the respondent except that certain areas shown shaded lack names which appear without shading in the respondent's sheet. The caller is required to find out the missing names. This task proved excessively difficult for the purpose and the maps were simplified these were used similarly, proved somewhat easier as a task but suffered from the disadvantage that few of the subjects were familiar with maps and found the whole exercise strange. The next state is the pictorial material which is much more diversified and of about the required order of difficulty; titles are provided for both participants so that little spelling is necessary.

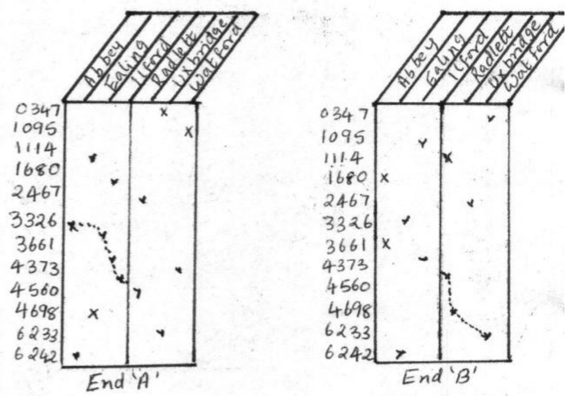
It is wroth nothing that the differing difficulty experienced in solving the puzzles was reflected in the changes in the level of speech sent to line by the precipitins.

A different, but equivalent, pictorial set was necessary for each call made by an participant. Later requirements were for a very large supply of different pictorial material so that a smaller number of subject pairs could be used in any experiment and make several calls without being vien the same picture set again. A polar coordinate graticule is used having 8 radii and 5 concentric circles. From a source of random decimal digits, a sequence of eight is selected, for example, 58235185. Starting from the 12 o'clock radius, the first random digit locates a point on the circle marked 5/6 and, being an odd digit is marked with a cross. The second digit defined a point on the 7/8 circle and, being even, is marked with a dot. All eight radii are treated in the same manner so that a sequence of crosses and dots is built up. A line is then drawn through the points passing smoothly through the dots and with discontinuities at the crosses; the dots and crosses are erased before use. Random shapes produced in this way are assembled into callers' and respondents' sheet with word titles selected from the first word in a newspaper column, excluding proper names, participles, pronouns, prepositions and other unsuitable words. In theory 10^8 different shapes can be generated but the number of separately distinguishable shaped may be rather fewer. About 25% of the shapes generated were stated to represent something but only about 6% were consistently recognized as being like the same thing by two or more persons. These 6% were therefore not used.

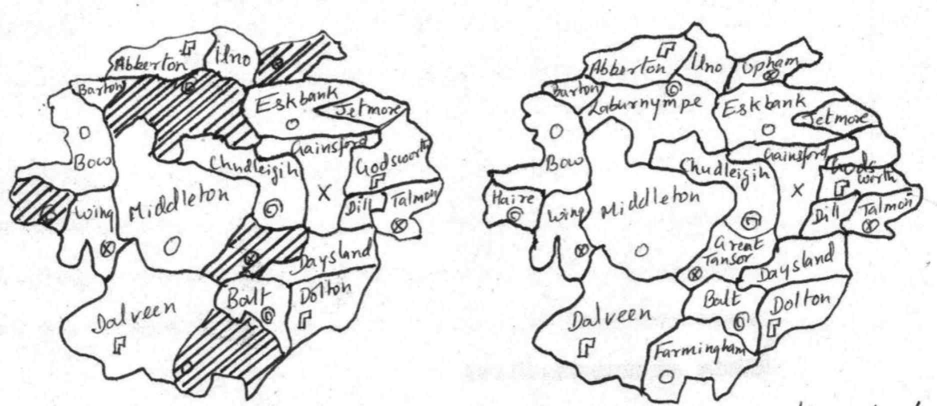
The next stage in development was reached when studies were to be made on telephone connections containing long propagation times. The performance was expected to be affected by the structure of the conversations, and especially by the frequency of occurrence of alternations in talking and listening roles. The preceding types of task result in conversation that is markedly one sided; the caller does most of the talking and the respondent only occasionally interrupts or replies. A more symmetrical task was therefore required. Conversation would be more equally distributed between the participants and therefore a design of puzzle was used. It is supposed that the diagram represents a river,



3 States and events in conversation as perceived by one participant



4 Stepping Stones Puzzle



(a) Caller's Sheet (b) Respondent's sheet

5 Pictorial material for conversation tests. Simplified map type sets.

running up or down and separating the two participants; A is supposed to be on the left bank and B on the right. The river is dotted with stepping stone located as shown by the crosses; half the number of stepping stone are visible to A and the other half to B. The task of the participants is to cooperate to find a route using adjacent stepping stones to the centre where they are supposed to shake hands. One solution is indicated by the broken line. Telephone exchange names and four-digit numbers are used to identify the locations of the stepping stones.

The U.K. Signals Research and Development Establishment (SRDE) has used pairs of photographs which are almost identical but were taken with a slight separation in time of scenes containing some movement; typical subjects are street scenes, groups of persons walking along a railway platform. One participant is given the earlier photograph and the other the later; they are not told which was taken first but their conversational task consists of finding this out by discussions.

Examination of conversations can be facilitated by recording the spoken material in a suitable manner to preserve the time relationship between what a participant hears and what he says. This can be used for the following kinds of examination:

1. Speech voltages at some definitely located points in the connection.

2. Durations of the conversation, i.e., time to complete the task.

3. Monitoring by independent observers to report significant events and, possibly, to obtain the opinions of the observations on the quality of the conversation.

Speech voltages can be measured on conversational speech by many different instruments but the present method used by the United Kingdom Post Office is the speech voltmeter type 5B; this yields the long term r.m.s. voltage of speech while the talker is active.

The ratio of time required to complete a given task over a good connection of time required to complete a given task over a good connection to that required over the given connection is termed ‘message rate efficiency’.

Study of this method was done by Peacock, 1948 - - - it showed that the mean incidence increased exponentially with the amount of transmission loss inserted in a connection.

This method cannot be used in the field work because privacy of telephone conversations over the public network would be infringed.

Use

Used in providing examples of conversational material which can be recorded and examined in detail. However they do not provide information directly. The participants themselves, can be examined in various ways.

Examination of Participants during or after conversation.

Aim and Principle:

To perform observations upon the participants, rather than the physical signals passing between them which constitute the ‘conversation’.

In principle, direct physiological measurements such as skin resistance, blood pressure, analysis of E.E.G.’s Less direct observations of a ‘secondary task’ like psychophysical measurements of subjects’ performance of a task, separate from his main conversational one, is determined to discover how much ‘spare capacity’ remains to him after devoting the required effort to the main task. Though tried in telephony, there has not been an appreciable success.

The subjective method of interrogating subjects with the use of questionnaire forms, administered verbally, in writing, on a form or by indicating by keys or push buttons. So, the participants are examined after they have been conversing by requiring them to perform certain definite talker/listener tasks, like articulation and follow almost immediately after the conversation so that the mental contact formed during the conversation is maintained.

Methods:

Independent interrogation in terms of opinion scales e.g. U.K. Post Office used opinion scales like 4 – G Good circuit; no appreciable effort required. 3 – F Fair circuit, some effort requrid on conversing. 1 – P Poor circuit; conversation possible but much difficulty on unfamiliar words. O - B Bad circuit; usable only with extreme difficulty.

Such quantifications provided the opinion Index.

Uses

It now forms the fundamental basis on which telephone network planning data are assembled in countries like U.K.

Methods based on Instrumental Measurements

4 categories can be identified –

1. Examination and description of the Speech link itself.
2. Measurement of the information capacity of the paths of the speech link.
3. Examination of conversation that take place over the speech link.
4. Examination of the participants in such examinations.

In category 1 physical descriptions in terms of measured quantities such as loss, level of noise reaching the participant's ear, propagation time, distortion etc. Methods like calculation of loudness ratings, articulation scores and listening opinion scores have been used.

In category 2 diagram shows speech efficiency meter in terms of communication based on comparison between input and output signals after identical processing of each. Further references available from CCITT White Book Vol. V, Gleiss, N. '68. They used testing devises based on the above principles. In these test signal is a set of sinusoidal tones, a number of frequencies present simultaneously or single tone swept in across the band. Another method uses actual speech and performance a cross correlation between the patterns of zero crossings at the two ends of the path under test. Use of Gaussian singles of suitably chosen spectra, perhaps represents a selection of speech formants, are other possibilities.

In category 3, speech levels emitted from telephone microphones tend to increase as the speech link becomes more degraded and certain patterns I the alternation of talking and listening roles in conversation can be associated with increase of the propagation time.

In category 4, examination of participants by physical measurements has not yet been followed in the telephone assessment field.

So, loudness ratings only fulfills a practical need in telephonometry.

The principle is based on the theory of calculations.

$\overline{L_{ME}}$= - 1/m 10 log 10 $_0{}^{00}$ G ($10^{(1|10)\quad(-mL_{ME})}$) df.

$\overline{L_{ME}}$ expressed in terms of the ratio of sound pressure at the mouth reference point and the ear reference point.

L_{ME} = 10 log 10$\frac{P^2 in}{P^2 out}$

substituting

$\overline{L_{ME}}$ = - $^1/_m$ 10 log 10_0 ^{00} G $\left(\frac{P^2 out}{P^2 in}\right)^m$ df

Suppose that an artificial mouth, closely representing the impedance characteristics of real mouth is fed with a test signal consisting of a sinusoid varying in frequency smoothly and periodically with time at a definite rate so that df/dt can be arranged on a special manner. Let the r.m.s. sound pressure, p_{in}, from the artificial mouth remain constant as the frequency changes. Applying this as an input to a liner speech path, for which the value of $\overline{L_{ME}}$ is to be determined will produce in an artificial ear, properly representative of the acoustical impedance characteristics of real ears, a sound pressure p_{out} which is varying with frequency in the same manner. Because the test signal varies smoothly in frequency with time, the variable in equation above can be changed from frequency to time.

$\overline{L_{ME}}$ = - 1/m 1/P^2 in 10 log10 $_0 T$ $(P_{out})^{2m}$ F(t) dt.

where F(t) = G (df/dt) and T is the period of variation in frequency of the test signal. P_{in} has been removed from the integral because it has been made independent of f & t.

By choosing df/dt to be proportional to 1/G, the term F(t) becomes constant and can also be removed from the integral. $\overline{L_{ME}}$ = - $^{1}/_{m}$ G $\frac{(df/dt)}{P^{2}in}$ 10 log10 $_{0}$ $T(P_{out})^{2m}$ dt. The integral is simply the mean value averaged over time, of the 2 m power of the sound pressure of the artificial ear.

Instrumentation based on this principle has been designed by Braun and is commercially available as OREM (objective Reference Equivalent Meter). There are 2 limitations in its use. The present artificial mouths and artificial ear do not perfectly represent their real counterparts under the conditions present in subjective tests or in real use of telephone sets. Secondly, the purpose of this instrument is strictly limited to loudness ratings of speech paths and if is not intended to provide a complete measure of the communication efficiency of a speech link or complete telephone connection.

Effects of Specific Factors

Factors such as loss, distortation, circuit noise are directly attributable to the functioning of several items of the telephone plant.

The physical environment such as in which telephone conversations are conducted (level and character of room noise and other disturbances) cannot be controlled, although such factors have profound effects on the efficiency of the telephone conversations. Also, physiological and psychological factors of the telephone users cannot be controlled.

Hypothetical Reference Connections (HRCs) is to be used to represent relevant classes of real connections likely to be affected by the performance of the item under consideration Representative Limiting Connections (RLCs) represent the worst telephone connections permitted as per network transmission plan. An RLC contain a pair of identical local telephone circuits jointed together trough an attemator of 600 10^0 in age impedance to represent the maximum value of the sum of all losses in junctions and trunks in a maximally adversely routed connection. The identical telephone circuits represent the worst transmission permitted in the local telephone network.

Choice of assessment criteria

The telephone connections provided by a public network range widely in performance and a battery of criteria are needed. The total range of performance is conveniently divided into a ‘Conversation Effort Scale’ -

A – Complete relaxation possible; no effort required.

B – Attention necessary; no appreciable effort reqd.

C – Moderate effort required.

D – Considerable effort required.

E – Extreme effort required; prolonged conversation impossible. Changes in the performance will occur if the room noise is different.

For telephone planning purposes, the most useful general assessment methods are the interrogation of the participants obtaining their opinion on rating scales.

Listening Factors

These are those factors whose direct effect consists of modifying the speech signals after leaving the mouth of one participant and before reaching the ear of the other. In telephone connections, they are loss, circuit and room noise and attenuation /frequency distortion and group delay / frequency distortion which are linear effects and nonlinear distortions.

Room noise spectrum level – CCITT recommendations Hoth – 50 d BA specification. Calculation of spectrum density of circuit noise at a given0 pshophometric level

- CCITT specification = - 65 dB mp.

Psophometer: the level of circuit noise attributable to a particular circuit in a connection is expressed in terms of the reading on a circuit noise meter called psophemeter.

When the room noise is 50 dBA, a circuit noise level of -52 dB mp at the input to odB RRE receive and will be regarded as disturbing to 50% of subjects when they near it in the absence of any speech.

Listening Assessment Scores:-

In order to permit comparison of the effects of factors like loss, noise and distortion, which are liable to cause difficulty in listening with those liable to cause difficulty in listening with those liable to cause difficulty in talking or specifically when conversing and the talking and listening roles are alternating rapidly, it is necessary to express all results in terms of conversation assessment scores. Ideally, all assessment tests ought to be of the conversation type, but this would impracticably laborious for the very wide range of test conditions to be covered when studying the effects of various combinations of loss, noise and attenuation/frequency distortion; listening only tests must therefore be pressed into service and the results suitably converted to those that would have been obtained from a proper conversation test. Some cross checking is needed to confirm that the conversion method used is correct for the type of test conditions under consideration.

Non-Linear distortion

2 types. (1) Instantaneous involving no storage and represented by single transfer characteristics – may be discourteous, step like, sections such as is the case with amplitude quantization.

(2) Those that involve storage which can be represented by a device of which the gain changes, relatively slowly compared with the Nyquist rate, in accordance with recent past history of input amplitudes. Speech has quasistationary properties and so it is possible to introduce with certain advantage under appropriate conditions, nonlinearity of this type without producing any appreciable non-linear distortion of the 1st type defined above. Compandors of the syllabic type and constant volume devices exploit these harmless features of non-linearity making use of suitable storage and averaging arrangements. Carbon microphones have this property – a deliberate introduction of non-linearity with storage can serve to improve the transmission performance of

a speech link suffering from noise arising in a main transmission element between terminal equipment e.g. cable. By Amplitude compression or ‘limiting’, advantage is taken of the characteristics of speech and hearing perception to deceive the ear brain mechanism into believing that the connection is quite, because noise is being reduced or suppressed, when speech is absent or low level segments are being transmitted. When loud speech segments are being transmitted, the accompanying noise is much grater but this is not notice, because it is masked by the speech.

Group Delay/Frequency Distortion

When extensive changes in transmission loss as a function of frequency are present in a transmission element, it is likely that this will be accompanied by changes in phase at frequencies adjacent to the loss discontinuity such group delay are found in loaded cable lines and in channel filters of multiplex systems. CCITT recommended that distortion should not in a complete 4 wire chain of circuits, exceed 60 ms at 300 Hz and 30 ms at 3400 Hz.

Group delay if severe, may cause transmitted speech appear to be accompanied by an echo with effect like ‘ringing’ at high frequency range ‘blurred’ at low frequency range and ‘near singing’ manifested by rolls in attenuation/frequency characteristic and by ‘listener echo’.

Combination of Effect of Difference Listening Factors

Only transmission loss is expected to cause a substantial proportion of telephone subscribers to hve difficulty and so a great deal of simplification of the treatment is possible.

Recent Studies

Ira Hirsh (1971) on Masking of Speech and Auditory Localization states: 1) Normals and Hearing aid users will understand better speech that is presented against a background of noise or other speech when (a) Speech and noise come from spatially separated sources (b) the listener can localized the sounds. 2) Listener’s ability to localize is greater when a) he can use two ears or 2 aids with microphones separated and/or b) the ear, ears, aid or aids are located on his moving head.

It is likely that auditory localization of separate acoustic sources is only one of several means for making a signal more easily discriminable from the noise or other background in which it is immersed , i.e. it appears to be a special case of enhancing the figure against a ground, therefore Binaural hearing and possibility of localization will not be great advantage for signals in quiet (Hedgecock & Sheets 1958), but rather will aid those situations where attention to a particular signal is enhanced by any means whatever (Broadbent 1958).

Jefferes (1974) on “Detection and Localization of binaural signals” states: two central mechanisms are functioning 1) The time mechanism operates on the time differences in the firing of phase located neural fibers. It is almost unaffected by interaural differences of level. 2) The intensity mechanism – it is affected by the difference of time of stimulation of the 2 ears of impulsive stimuli, that is by the difference of latency resulting from an interaural difference of level. It is probably affected by difference of total neural activity on the two audiometry nerves. It operates over the entire frequency range, whereas time mechanism is limited to frequency.

G.M. Siegel and T.M Longhurt (1973) on “Effects of Communication failure on Speaker and Listener behaviour” state: that speakers used three main strategies to cope with the distortion. 1) they gave longer descriptions 2) They talked slower and 3) they used more redundant speech.

Miller ’51 and Osgood ’63 – formulated the communication process in terms of a speaker who has some “intent” (a message to communicate) and listener who is disposed to receive that message. Communication is accomplished when the listener is affected by the speaker’s verbal behavior. “Speakers intent” and “Communication effectiveness” have been reduced to analyzable elements – Rosenberg ’70, Krauss and Winheimer ’64, ’67, Maclay and Newman ’60, paseual Zeone and Smith ’69, Rosenberg and Cohen ’66, Rosenberg and Gordon ’68, Triandis ’60, Werner and Kaplan ’67.

John Black ’55 on ‘A Relationship between Speaking and Listening’ states: favorable scores in both speaking and listening might be expected to accompany high motivation on the part of the participant and in turn to be closely related to skills related to language. However, no reliable relationship between speaker intelligibility and listeners reception of words is indicated. Apart variable noise, as the headset loses, rigidity noise leaks more freely under the earphone. This would tend to decrease the word reception score at a station but would probably elicit a voice signal of grater SPL to maintain a good S/N ratio in the side tone. This is turn would improve the speaker score of the station contribute to a negative correlation between speaking and listening. Similarly a specially sensitive or weak earphone might be expected to contribute a negative rather than a positive correlation.

R.W. Peters ‘55 on ‘The Relative Intelligbility of Single Voice and Multiple Voice messages under various conditions of noise’ states: that single voice transmissions were consistently more intelligible than were multiple voice transmissions and the later became relatively less intelligible under increasing levels of noise.

Williams Evans ’55, using multiple choice intelligibility tests filtered various portions of the test into five different frequencies. The selected filtering conditions were comparable to other types of speech tests, differentially affecting the magnitude of information loss usually found when message is relayed. There was no evidence found for a decrement in total No. of words transmitted per unit time due to selective filtering and transmission.

Hodgsum and Sung '72 on 'Sentence intelligibility with Microphone Vs. Induction coil' of speech routed through two hearing aids state that frequency response appeared to determine the performance difference in the hearing aids either with microphone or telephone coil input. The better low frequency response below 1 KHz of the telephone coil appeared to increase sentence intelligibility.

K.J. Fleming '71 on 'Guidelines for Choosing appropriate phonetic context for speech sound recognition an production practice' stated eight factors which can influence discrimination and production performances. Seven factors influence production performance. Some of the factors are –

1. No. of features the other sound in the context have in common with the problem sound.
2. Position of the problem sound in context.
3. The stress and duration with which the problem sound is articulated in the context.
4. Knowledge of occurrence and location of the problems in the context.
5. The phonemic value of the problem sound in the context.

H.Gardner '71 on 'Application of high frequency consonant discrimination word lists in hearing aid evaluation' devised a word list containing high frequency consonant exclusively.

Vergo, Taylor, Tannahil and Plummer '70 on 'The Intelligibility of speech by Hearing aid on Inductance loop and microphones modes of signal reception' state that intelligibility for speech for the conventional hearing aid for both inductance coil and microphone inputs was significant. Also the loop of hearing aid was significantly loss intelligible on its inductance coil setting than on the microphone reception.

Ritterman S.I. on 'The Role of practice and the observation of practice is speech sound discrimination hearing' states that Retroactive facilitation effects were observed in the observation group.

Speaks, Jerger, and Trammell '70 on 'Comparison of sentence identification and conventional speech discrimination scores' state that as the slope of audiometric pattern increased, the discrepancy between the scores for words and sentences also increased. In quite PB performance is 80% of performance for sentences with competing messages. If there is good hearing below the region of 1 KHz there will be little difficulty with sentences but mounting difficulty with PB words as high frequency diminishes.

Tillman, Carhart and Olsen on ‘Hearing aid efficiency in competiting speech situation’ state 1) Hearing impaired require more of an increase in SPL re: performance in a sound filed to achieve spondee threshold via the hearing aid then can be accounted for the difference in methodology. 2) The intelligibility of monosyllabic words in quiet was somewhat poorer during aided listening, than during unaided listening even though sensational level was constant. 3) Subjects with presbycusis and other Sensorineural losses were less resistant to masking by competing messages during unaided listening than were subjects with normal hearing or with conductive loss. 4) All groups exhibited reduced intelligibility for a constant sensation level. Especially for patients with sensorineural losses.

Speaks and Trammel ’70 on ‘Distracting properties of competing speech’ state that the performance was increased by 20% when the semantic content was eliminated by reversing the tape of the competing speech. The curves were also flatter than those obtained when the competing signal was noise, and this could be duet to the random temporal masking pattern and the semantic content of the competing speech.

If a listener is distracted by what is said, presumably such an effect would/ diminish with repeated exposure to the same message. Thus it was found that the semantic content had ceased to have a significant effect upon the performance. Therefore Features exist in a competing message that might cause a distracting influence on listeners. The distractibility of the competing message depends upon the presence of potentially distracting features residing in the signal and the degree to which the listener yields to the potential distractors.

Dirks and Bower – 'The masking effect found in the sentence identification task when a single competing voice message is employed is apparently not altered by the distributive features of the semantic content or meaning of the competing message.

Grover and Martin '74 on the 'Practical gain limit for post-aural Hearing aids' states that investigation into acoustic sealing properties of acrylic ear moulds has indicated that considerable amplification is obtainable from a post-aural hearing aid without the occurrence of acoustic feedback oscillations, when a well fitting mould is used. i.e. permitting air to air gains of more than 50 dB across 0.5 to 4.0 KHz.

Huggins ’72 on ‘Perceptions of temporal phenomena in speech’ states that perception of timing in natural speech is based on events at the syllabic level rather than at the segmental level and that it is important to maintain rhythm of the sentence, as defined by the onset of vowels (especially stressed vowels, if the sentence is to sound temporally fluent.

Recently Gerald Soloway et al at the Bell Telephone Labs in Holmdel, New Jersey brought out an experimental voice control device which gives command performances that is it can dial a telephone No. When given a spoken command. Voice control is obtained in a simple form of integrated circuit that converts sound waves into electrical pulses to open and close the electromechanical switches necessary for obtaining a dial tone, executing dialing and terminating a call. A similar voice control device may one day provide ‘hands-free’ telephone service for motion handicapped persons ……… Mel Awipi, C. Hoffman, G. Soloway. A small circular display of 10 lamps labeled with the numerals 0 through 9 used along with voice control device. The lamps lights in numerical sequence. Any voice utterance spoken I coincidence with a lighted No. will activate that No. and people should find it more convenient to speak a number when using the new device than simply to utter a sound as the desired numeral is illuminated in the display.

Speaking the Nos. 1, 3, 5 as corresponding numerals light up in this order will enable the device to store in its memory all of the digit in a typical telephone no. As the numbers are spoken, the corresponding lamp remains lighted in the display for a slightly longer interval to indicate registration in the devices memory. The memory in the voice control device will transmit stored digits as a weries of electrical pulses to telephone dialing circuitry when a special command is given.

A telephone number remains in the memory even after it is dialed and can be re-used any time the dialing command is given. Storing a new number will automatically erase the old one from the memory.

Report from AT & T (Bell Labs) reads: EARS

400 GENERAL

Adequate bilateral hearing acuity is essential for positions requiring the constant use of a headset (operators, service assistants, service representatives and central office plant craftsman). If applicant does not meet auditory standards, a consultation with the Medical Director should be obtained.

401 HEARING

Whenever possible, audiometry should be done. The examiner should pay close attention to the history and findings of the present or past ear troubles. If on the basis of history, physical examination or apparent hearing difficulty, otological consultation is indicated, referral should be made to the medical director.

402 AUDIOMETRY

If the audiogram shows an average hearing loss of no more than 25 dB ANSI* in each ear in the speech frequency range (.5, 1, 2, Kilocycles), hearing is adequate for all jobs.

The following table summarizes recommended placement based on the degree of hearing loss. Individuals with significant progressive hearing loss should be referred to the Medical Director.

All references are to ANSI 1969. See appendix 3 for ASA & ISO conversion tables. AVERAGE HERAING LOSS (at speech frequencies 500, 1000, 2000 cycles).

Line No.	Better ear	Poorer ear	Restrictions
1.	25 dB or less	25 dB or less	None
2.	25 dB or less	25-40 dB or less	None
3.	25 dB or less	40 or more	Should not be assigned to a position with potential prolonged high noise level.
4.	25-40 dB	25-40 dB	Should not be assigned to a position with potential prolonged high noise level; not suitable for the use or regular headset fitted with an amplifier maybe suitable.
5.	25-40 dB Greater	40 dB or more Greater	* Same as in line 4.
6.	than 40 dB	than 40 dB	Individualized placement will be necessary.

Nelson '70 on 'Experiments on the use of the Touch Tone Telephone as a Communication aid for the deaf' states that it serves as a communication aid for the deaf; 2 methods were explored for presenting visual outputs of dial manipulations. Both arrangement depend upon the calling party spelling the message to the deaf receiver in a previously agreed code. One method presents lighted digits on a representation of a touch tone dial. The 2nd method displays alphanumeric characters for coding schemes. Speech and accuracy determinations were made. Typical speeds were 4 and 8 words per minute for the 1st and 2nd methods respectively – both methods yield comparable error % of less than 1% after brief learning periods are completed. These performances are achieved without special training or skills.

Bell Telephone Labs., Murray Hills, have recently introduced a portable adapter for use with hearing aids with a telephone pick up that depends on a magnetic leakage. This was a temporary solution to a problem encountered by hearing aid wearers with telephone switches in the use of some new telephones which were incompatible with present hearing aid telephone switches. The new tel. units had much less electromagnetic leakage than the older units and therefore the hearing aid telephone pick up feature, which depends on electromagnetic leakage for good sound level, does not work well with the new telephones. A similar problem had also arisen in Britain as reported in the Spring 1974 Newsletter of The British Society of Audiology.

Chapter III

METHODOLOGY

Aim of Pilot experiments:

A series of pilot experiments were conducted to arrive at a stable methodology.

The initial deign for the study incorporated the following.

1. (a) Word lists:

One English phonetically Balanced Adult list of 25 words, standardized on the Indian Population by Swarnalatha (1972) was used. This list was then randomized and distributed by Latin Square method to obtain eight lists of 25 words each. The aim was to try different techniques of recording and presentation.

(b) Sentences:

The sentences were prepared by the investigator by noting down the most commonly received words, phrases and digits as reported by Telephone Operators; these were incorporated to form meaningful sentence material. Five sentences were thus prepared.

2. Recordings:

The am of recording the test material was to serve the need of presenting the material at the same constant levels to all subjects.

The 8 lists of PB words were recorded on to an Ampex Tape Recorder in the sound treated room of the A.I.I.S.H. The intensity of the recording was monitored by a VU meter of the Ampex tape recorder to maintain a constant level of input. The volume control knob of the ampex was opened up to near full position. The first 4 lists of words were termed as Lists A; and the second 4 lists of words are termed as Lists B.

An attempt was made to get a tape recording to simulate the speech test material sent through the telephone and a Hearing aid. This was done in the following way. The taped lists B were fed through the loudspeaker of a 15 CX Beltone audiometer to the telephone transmitter of subscriber telephone set No. 22502 in a free filed environment. The presentation of the 4 lists were done at 80 dBHL, 90 dBHL, 100 dBHL and 110 dBHL of the audiometric intensity dial; the distance between the loudspeaker and the telephone transmitter was 1 meter. The signals fed into subscriber telephone set 22502 were received in telephone subscriber set No. 20715. An Oticon extra super Hearing aid in ‘T’ position (induction coil position) was placed on the receiver of the receive end subscriber telephone No. 20751. The volume control of the Hearing aid was kept at maximum amplification position. The receiver of the Hearing aid was coupled to a 2 cc coupler which was connected to a condenser microphone and an Audio Frequency analyser from where the signal was fed to a Philips Tape recorder. This was known as Hearing aid processed telephone speech. The aim was to present this test material in the sound treated audiometric setup to the subjects.

3. Pilot Experimental trails:

Taped test material A lists were presented through the audiometer in free field condition. The speaker of the audiometer was kept at 1 metre distance from the transmitter of the send-end telephone No. 22502, in a free field setup, in the records room of the A.I.I.S.H. The intensity of the test material presentation (raised in 10 dBSPL steps to find the PI function) was monitored by an SPL meter (B & K equipment), the SPL meter condensor microphone was placed adjacent to the mouthpiece of telephone No. 22502, so its distance from the speaker was also 1 meter. This experiment was tried between the subscriber telephone sets 22502 and 20715 respectively. A lot of distortion of the signal was reported by the subjects listening at the receive-end telephone No. 20715. This method was not found feasible.

Block diagram 7 shows the set up of instruments for testing purposes.

ii. In this experiment, it was decided to eliminate the audiometer from the setup. The signal was fed straight away from the Ampex Tape recorder and its speaker distance from the send-end telephone No. 22502 was kept at 1 meter. The volume control of the tape recorder was manipulated to increase or decrease the signal to maintain a constant input into the mouthpiece of the send-end telephone No. 22502. This was monitored by the SPL meter, placed adjacent to the telephone No. 22502. All other conditions were kept similar to pilot experiment No. i. The PI functions of eight normal subjects was tried with signal presentation at four levels viz., 70 dBSPL, 80 dBSPL, 90 dBSPL and 100 dBSPL as read in the SPL meter in ‘C’ scale. The noise level in the room was low, ranging from 50 to 55 dBSPL as read in the SPL meter.

PB max. and the intensity levels of maximum performance were noted. The mean PB max ranged from 52% to 84% and the level of mean maximum performance ranged from 70 dBSPL to 100 dBSPL. All the subjects complained of a lot of distortion of the signal. The reverberations of the signal was found to distort the signal appreciably and cause a lot of inconsistencies in the performances of the subjects. If was imperative that room reverberation be controlled. Block diagram 8 shows the setup of instruments for testing purposes.

iii. In this Pilot experiment, the signal (4 PB lists) was presented live voice through the audiometer monitored by the VU meter of the audiometer. The headphone TDH 39 of the audiometer was placed over the mouth piece of the send-end telephone. All other conditions were same as in experiment ii. The same procedure of finding the PI functions was attempted. Again, the subjects reported inability to discriminate the signal with poor PB max scores among them. It was found that there was distortion of the signal and the placement of the headphone THD 39 on the mouth-piece was inappropriate. Therefore, an attempt had to be made to obviate this gross distortion of the signal, while at the same time, to have a device that will monitor the input of the signal, so that PB max. may be found. Block diagram 7 shows the setup of instruments for testing purposes.

iv. In this pilot experiment, the signal presentation at the send end telephone No. 22502 was through live voice; the distance between the lips of the speaker and the telephone transmitter was maintained constant and kept in normal conversation position. The intensity of the signal was monitored by the SPL meter; its condenser microphone was placed adjacent to the telephone transmitter so that its distance from the lips of the speaker was same as that of the telephone transmitter and the lips of the speaker. It was desired to test the subjects in normal free field conditions. 12 normal subjects were tested; they received the 4 PB test lists on the receive and telephone No. 20715 and the intelligibility of the lists was tested. The noise level in the room where the receive end telephone No. 20715 was placed, ranged from 55 to 60 dBSPL as read in the SPL meter. Their mean performance at 80 dBSPL level of signal was 92%. Their mean performance at 90 dBSPL level of signal was 92%. Their mean performance at 100 dBSPL level of signal was 90%. Block diagram V shows the experimental set up used for Pilot experiment No.4.

The aim of the recorded Hearing aid processed telephone speech was to facilitate in presenting the test material to Hearing loss subjects in audiometric set up. However, this would have eliminated other factors like competing messages, telephone exchange noise environment etc., which may play a significant role on the performance of the subjects. The results due to the distortion of the signal in pilot experiments (1) and (2), discouraged the investigation from attempting further experiments in free field set up with the recorded Hearing aid processed telephone speech. It was therefore decide to test the hearing loss subjects in the same procedure as in pilot experiment No. 4. Block diagram No. 10 shows the instrumental set up for recording Hearing aid processed telephone speech.

Based on these pilot experiments, the final methodology was arrived at.

I. The Criteria adopted for selection of subjects

a) Normals:

i) Audiogram configuration of air conduction threshold within 20 dB (ISO standard).

ii) Age range: - Between 18 years and 26 years, which is the age requirement by the Indian Government to apply for the job of a telephone operator.

iii) SSC qualification:- which is the minimum qualification to apply for the job of a telephone operator required by the Indian Government.

iv) With good communicative ability (sufficient proficiency in English).

v) No Otological complaints.

vi) Both males and females were tested.

b) Telephone Operators:

i) Audiogram configurations of air conduction threshold within 20 dB (ISO standard)

ii) Both males and females were tested.

c) Clinical groups:

i) Conductive Hearing losses of mild and moderate degree with no prevalent ear discharges. Both unilateral and bilateral case was tested.

ii) High frequency losses of mild and moderate degree; both unilateral and bilateral cases tested.

iii) Mixed Hearing losses of mild and moderate degree; both unilateral and bilateral cases were tested.

iv) Sensory Neural losses of mild and moderate degree, both unilateral and bilateral cases.

In the clinical groups of Sensory Neural losses and mixed losses, it was essential that they scored a minimum of 80% in the speech discrimination testes in standard speech audiometry.

II. Instruments

The following were the instruments used in this study:

1. A 15 CX Beltone audiometer with talk back system for routine audiometry and plotting PI functions in audiometric set up.

2. Two subscriber telephone sets. Telephone set No. 22502 used as the send end telephone and telephone set No. 20715 used as the receive end telephone. Both sets were type 332 ITI (Bangalore) manufactured.

3. One telephone operator’s head gear set with microphone manufactured by ITI Bangalore.

4. An SPL metre No. 2203 with octave filter set and condenser microphone No.4145.

5. A Madam Audiometer for audiometry testing purposes.

6. An artificial mouth and artificial voice for objective tests at ITI – B & K equipment.

Calibration:

The 15 CK Beltone audiometer and the Madsen No. were calibrated for air conduction and bone conduction. The 15 CX Beltone was also calibrated for speech intensity dial, and noise levels using artificial ear No. and Audio Frequency Analyses (all B & K type) of the Electronics Laboratory, A.I.I.S.H.

Subjective calibration was done everyday. Instrumentation calibration was done once every month till the data collection was accomplished.

Block diagram 6 indicates the arrangement of instruments for calibration.

The final methodology used in the study may be categorized into: -

1. Test construction

2. Method of Presentation

3. Method of Scoring.

1. Test Construction

i) Procedure for test development:

The common speech discrimination material in

English adopted from the Adult Speech Discrimination list I, Standardized to the Indian Population by Swarnalatha (72). The list was phonetically balanced. From this list, 4 lists were prepared, using the same words by arranging them randomly using the Latin Swuare design.

The sentences were prepared by noting down the most commonly received words, phrases and digits by the telephone operators of the Mysore telephone exchange and incorporating them to form meaningful material.

The intelligibility of the PB word lists and the sentence lists were tested by presenting them to 12 normal subjects, as mentioned in Pilot experiment No. 4.

2. Method of presentation:

a) The presentation was through live voice; the speaker was a male; his mother – tongue was Malayalam. However, he was proficient in other languages viz., English Tamil, Hindi, Marathi, Gujerati and was acquinted with Konkani, Kannada, Punjabi, Telugu and Urdu.

Each monosyllable was presented using the carrier phrase, “write the word”.

The sentences were presented using the carrier phrase, "sentence number" in its chronology.

The PB lists and the sentence were presented in the free field condition through live voice, into the telephone transmitter of subscriber set 22502, while holding the handset in normal talking position. The intensity of the speech input was monitored by the SPL meter with its condensor microphone to read in 'C' scale. The SPL was so placed, that its condensor microphone and the telephone transmitter of 22502 set were equidistant from the lips of the speaker in normal telephone conversation position. The telephone set No. 22502 was constantly used as the send-end telephone for presentation of the test materials. The send end telephone was situated in the records room of the A.I.I.S.H. The noise levels measured in the SPL meter, during the testing sessions are given in table No. 13. Same testing hours were maintained throughout the study in attempt to keep the variable noise levels in the free field setup constant for all subjects.

b) Carrier phrase:

The purpose of the carrier phrase was two fold: (i) To make the subject vigilant (ii) To monitor the voice while presenting.

It was not meant to give any meaning to the subject.

c) Testing environment

The testing of the subjects were done in three situations –

(i) Audiometric set up – Experiment (A)
(ii) In the Telephone Exchange setup – Experiment (B)
(iii) Two telephones setup – Experiment (C).

In experiment A, the audiometric testing of the subjects was done in a sound treated room at the Audiology department of A.I.I.S.H. Air conduction and bone conduction testing was done in a one room situation. Speech discrimination tested was done in a 2 room situation. The noise levels in the test room measured using an SPL meter (B & K type 2203) with an octave filter set (B & K type 1613) were found to be within the specifications. Table 13 gives the noise levels in the audiometric room.

In experiment B, the subjects received the test material in the telephone exchange set up; the table 13 gives the noise levels measured with same SPL meter present in the exchange during the testing sessions.

In experiment C, the subjects received the test material in the subscriber telephone set 20715 situated far from the send end telephone 22502, within the campus of A.I.I.S.H. The table 13 gives the noise levels measured with same SPL meter in the room of the receive end telephone 20715.

d) Procedure for test standardization

i) Testing Procedure:

Instructions:

Before the rest began the subject was instructed as follows:

"You will now be presented with 4 list of monosyllable words; each list consist of 25 words; each word will be presented with a carrier phrase 'Write the word" for example, 'write the word ran'. You have to write only the word 'ran' and not the phrase; each list will be present at different intensities; so, you will have to pay attention to listen to the words, identify them and then write them down; a gap of 5 seconds time will be given after the presentation of each word, to enable you to write down. After the word lists are over, you will be presented with 5 sentences. You need not write them down. You only have to repeat the sentences. A time gap of 10 seconds will be given to you after the presentation of each sentence to enable you to repeat the sentences. No repetitions of the words or sentences would be given. Are you read? Here, we start with list No. one.

Method of testing and level of presentation

The testing was done by the experiment with normal Hearing and studying in the final year MSc. in Speech and Hearing. The level of presentation was kept constant for each PB list and the sentences at definite sensation levels above the individual's pure-tone average threshold.

The test procedure was first standardized by presenting the test material to male-female normals. The test material was also presented to make and female telephone operators, who are already working at the Mysore telephone exchange. Then the test material was presented to the clinical population with amplification provided with an Oticon extra super Hearing aid with custom made and stock ear moulds, wherever required.

Experiment A – The audiometric set up.

Normals:

32 normals with different mother tongues were screened for pure tones to test their Hearing at 20 dBHL for frequencies at 250 c/s, 500 c/s. 1 Kcs, 2Kcs, 4 Kcs, 6 Kcs and 8 Kcs. Their PI function was done with the 4 PB lists by presenting them at 10 dB, 20 dB, 30 dB and 40 dB above their Speech Reception Threshold (SRT).

Table 4 gives the data about these subjects.

Telephone Operators:

17 Telephone Operators with different mother tongues were screened for their Hearing with pure tones at 20 dBHL as in the case of the normals and their PI function were done in the same way as in the normals. Table VI gives the data about these subjects.

Clinical Population:

The puretone audiograms, SRT discrimination scores were done for everyday; special tests were done wherever necessary as per clinical findings. Their PI functions for the 4 PB lists were also found by presenting the lists at 10 dB, 20 dB, 30 dB and 40 dB above their SRT's.

Table 9 gives the data on the clinical population tested.

Experiment B – In the Telephone Exchange setup

In order to test the performance of subjects in actual conditions, same as those of telephone operators in the trunk exchange room it was decided to test the subjects in the trunk exchange room of the Mysore Telephones. The telephone operators, who work in the trunk exchange room wear headgear sets which are monaural. They work on boards seated beside each other with hardly a distance of 1 1/2 feet gap between them. There are about 20 operators working at one time and each of them is either talking into the phone or listening and immediately responding by speech. Their task is such that it needs vigilance to listen and immediately respond. The room noise is therefore high and more than 60 dB. Since, the head gear set is monaural, the other ear is exposed to competing messages spoken by the other operators in the room. So, an operator has to devote a lot of attention in terms of vigilance to decode the speech signal reaching his head gear set ear, in the presence of competing messages and inherent room noises reaching the exposed ear, apart from the side tone noise, channel and trunk board noises, and the distortions produced by the send end telephone and also by the characteristics of the receiver of his head gear set.

The subjects were seated in the telephone operator's chair and the test material was received through the trunk exchange boards from the head gear set worn by the operators.

At one time, only one subject was tested. The other conditions were not altered.

Normals: 32 normal subjects were tested. The 4 PB lists were presented at 85 dBSPL, 90 dBSPL, 100 dBSPL, 105 dBSPL. The sentences were fed at 95 dBSPL.

Table 6 gives the data on these subjects.

Telephone Operators: 25 subjects were tested in the same way as the normals. 5 of subjects were allowed to read the 4 lists before the testing.

Table 3 gives the data on these subjects.

Clinical Group: The Clinical groups were tested in the same was as the normals. The Clinical groups were provided with Oticon extra super Hearing aids wherever the test ear was the ear having Hearing loss. Custom made moulds were provided to most of them using Hearing aids. However, in some cases, it was not feasible to make the customs ear moulds, due to some practical problems of the patient. Stock ear moulds were trained and the one that fitted best was used. The Hearing aid was kept in 'T' position (Induction Coil Position); its volume control was adjusted by each subject to his comfortable listening volume, as he heard some telephone speech before testing; the volume control of Hearing aid was not altered and left in that position. Most of the subjects had no practice using the hearing aid. Hence, they were allowed to listen to running speech through the telephone for some time. The High frequency Hearing loss subjects were no provided with amplification. In unilateral Hearing loss cases, when the test ear was the normal ear, the Hearing aid was not provided for the Hearing loss ear. The head gear set receiver was placed over the microphone of the Hearing aid.

Table x shows the data on the Clinical group, and their puretone thresholds, are given in appendix.

Experiment C – Between two subscriber telephones set up.

The subjects received the test materials in the subscriber telephone set No. 20715. They were instructed to hold the receiver in the same ear, which was used in experiment B set up.

Normals:

20 normals were tested of which 11 of them were tested in the Experiment B set up also.

Table 5 gives data on these subjects.

Telephone Operators:

15 Telephone Operators were tested; they had also undergone testing in the Experiment B set up.

Table 2 gives data on these subjects.

Clinical subjects:

All the subjects were tested. Here again, the telephone receiver was placed over the microphone of the Hearing aid in 'T' position. Conditions of providing amplification were same as in Experiment B set up.

Table 10 gives data on these subjects.

All the subjects in Experiments B and in Experiment C had undergone testing in Experiment A set up.

3. Method of Scoring

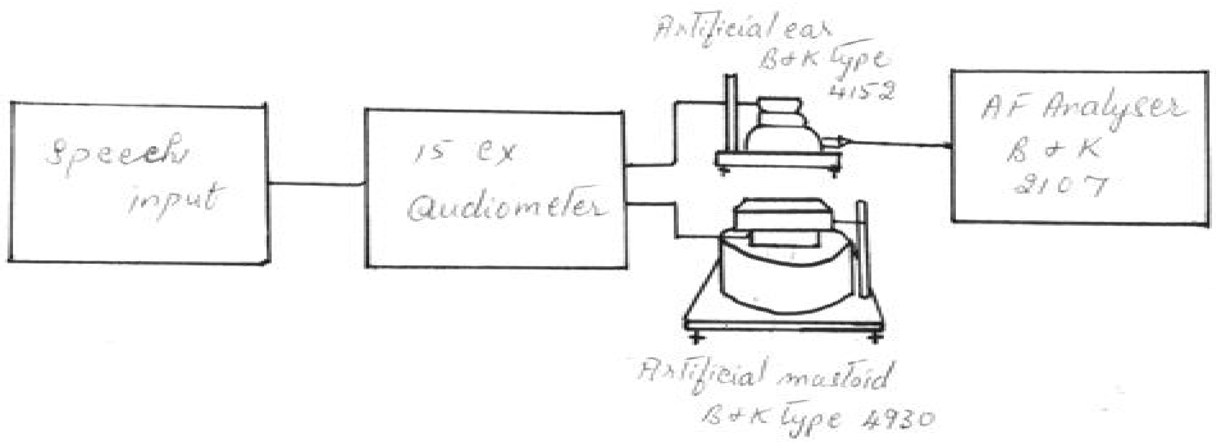
For each of the 4 lists, the PB max. was found out. The maximum scores thus obtained was taken for analysis. The sentences were scored using the principle of key words, defined in terms of the subjects understanding the essentials in the sentence.

Appendix gives the key words underlined for the sentences. So, if the subject, missed one key word or even the digits or its correct sequence in one sentence, he got zero points. If he repeated all the key words correctly in a sentence, he was given one point.

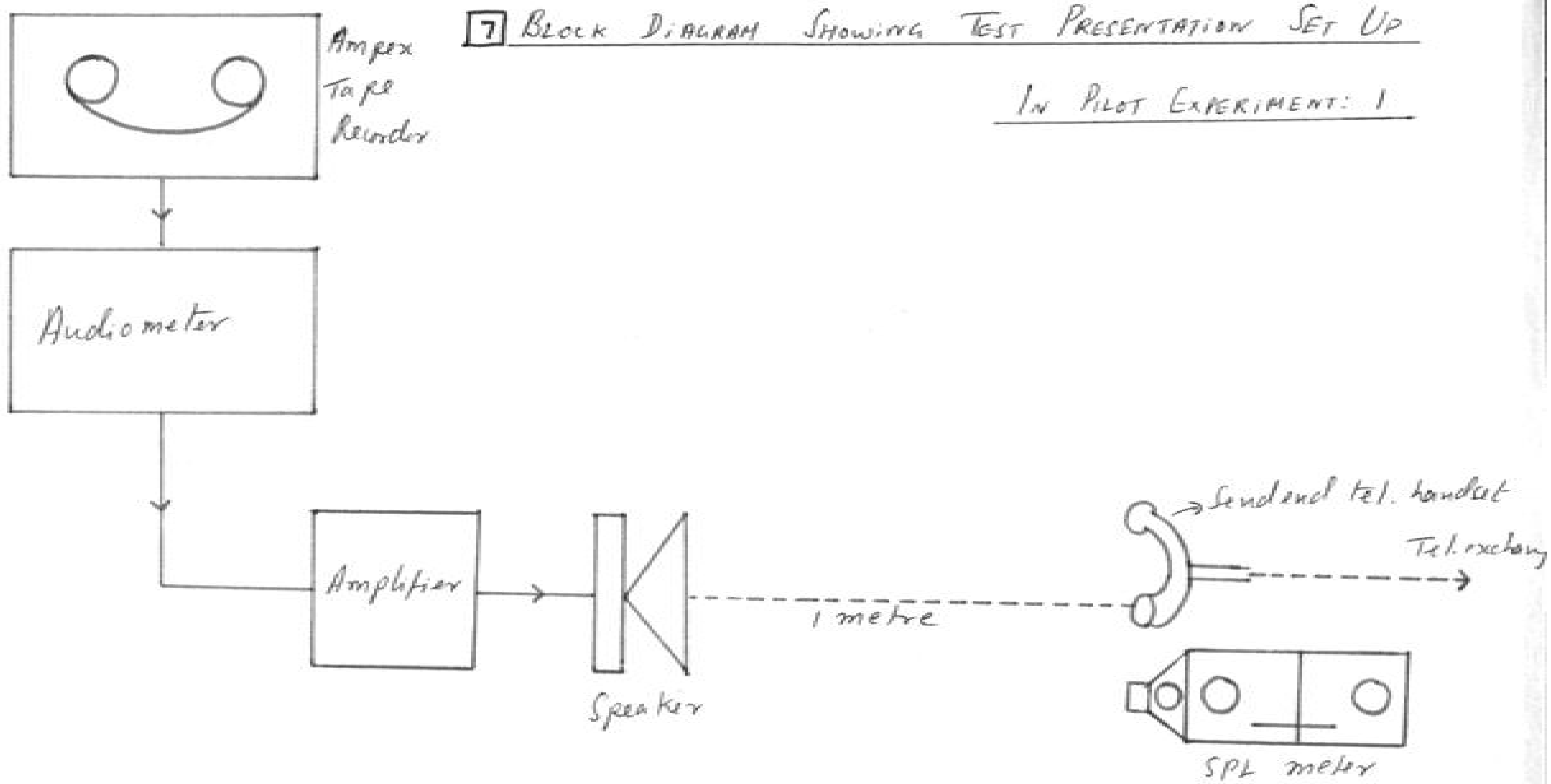
Reliability

Reliability of the tests were done by taking 5 subject and then testing them again in the Experiments A, B and C., after a long time.

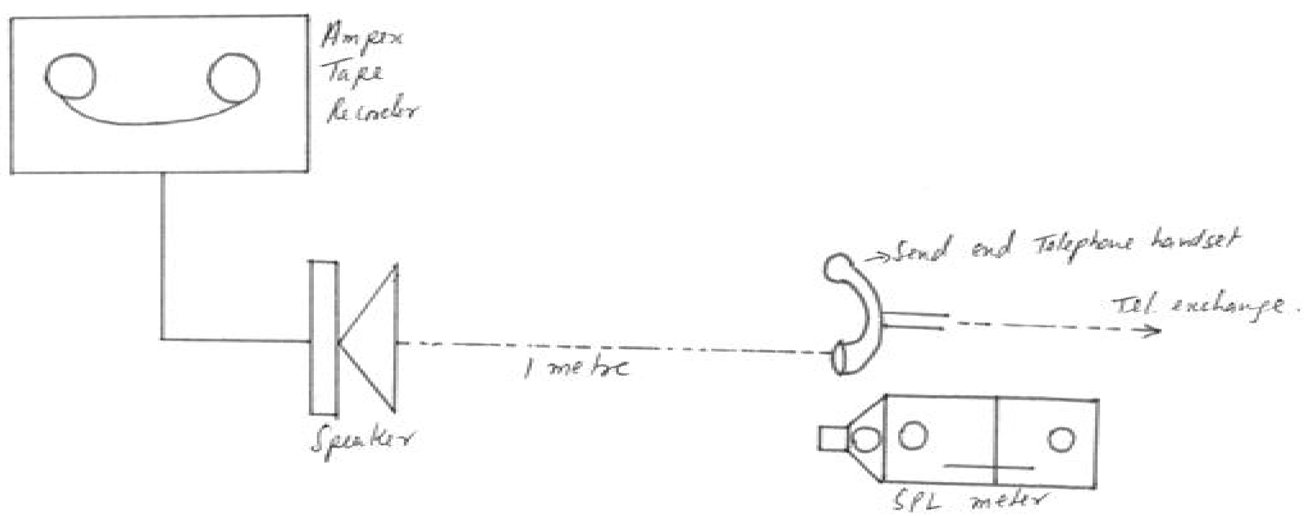
[6] Block diagram showing arrangement of instruments for calibration of audiometer.



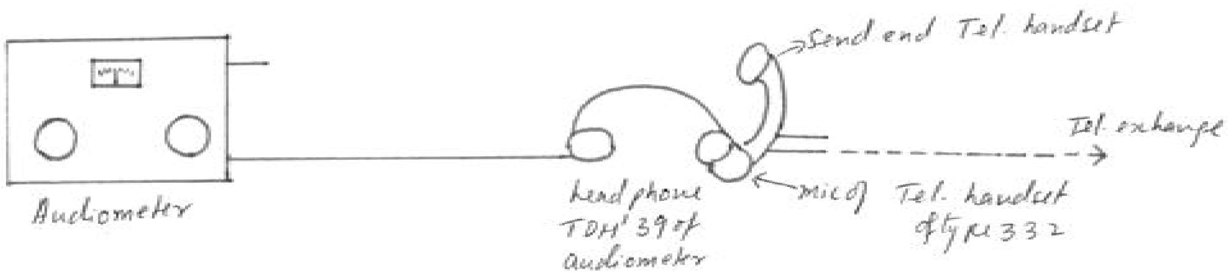
7 BLOCK DIAGRAM SHOWING TEST PRESENTATION SET UP IN PILOT EXPERIMENT: 1



[8] BLOCK DIAGRAM SHOWING TEST PRESENTATION SET UP IN PILOT EXPERIMENT: 2



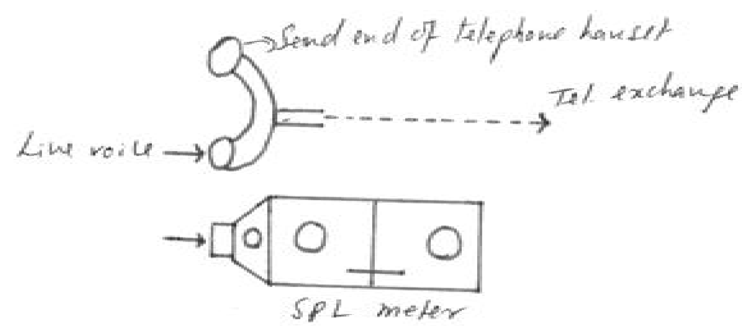
9 BLOCK DIAGRAM SHOWING TEST PRESENTATION SET UP IN PILOT EXPERIMENT : 3



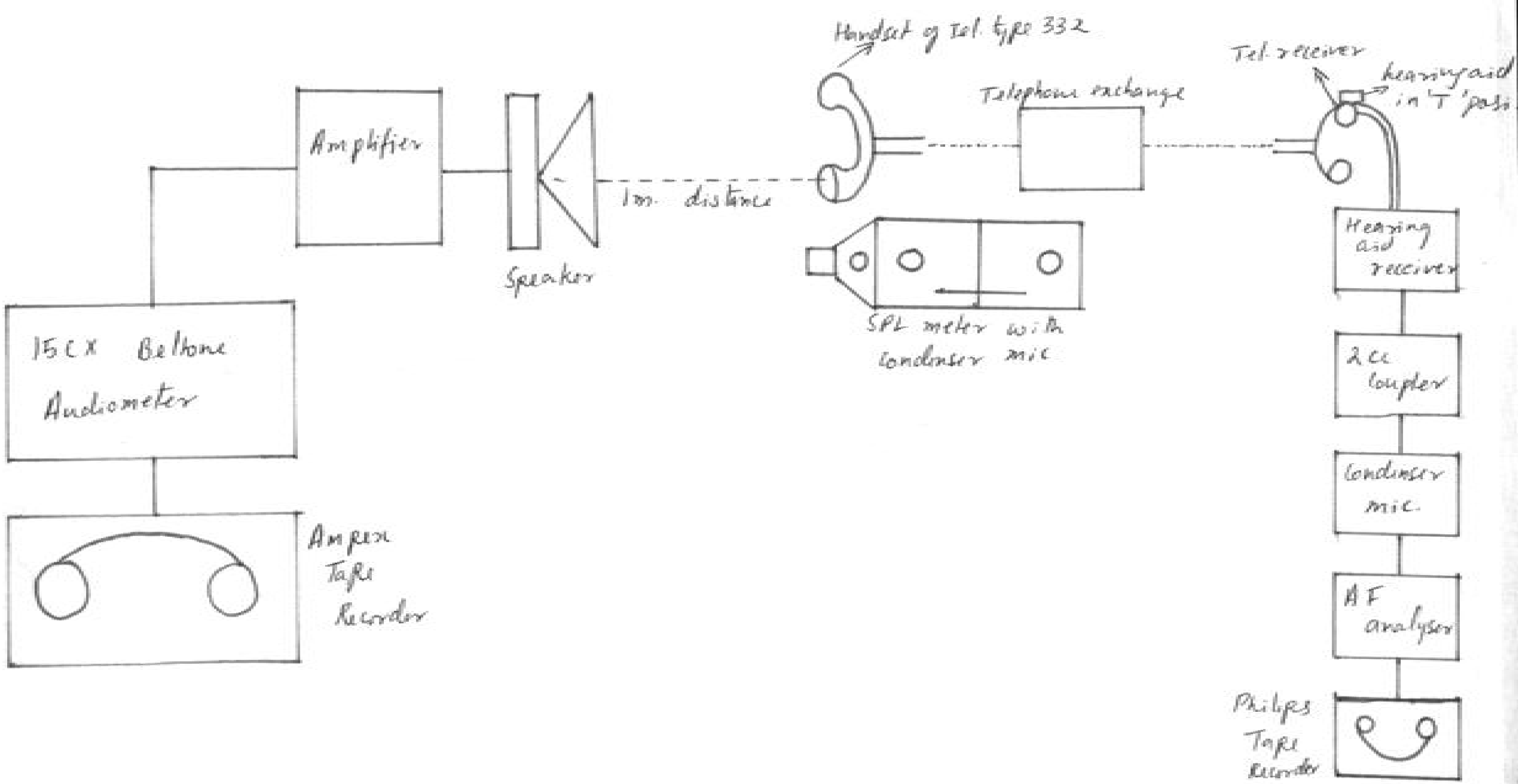
10 BLOCK DIAGRAM SHOWING TEST PRESENTATION

IN PILOT EXPERIMENT: 4 AND

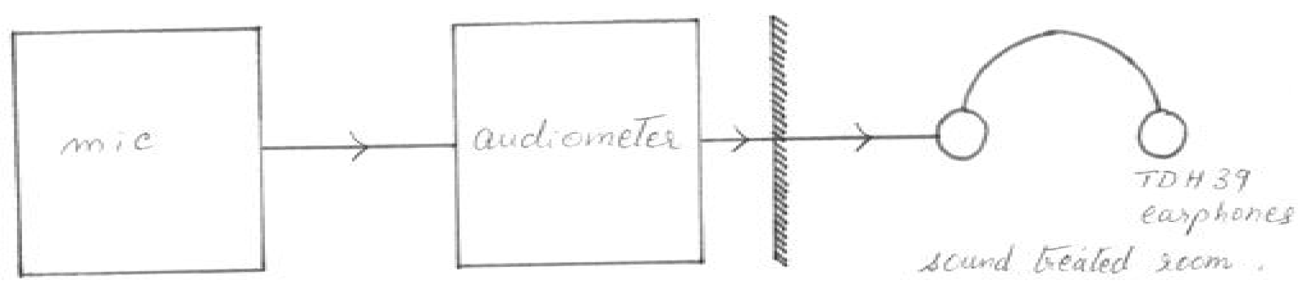
FINAL PROCEDURE



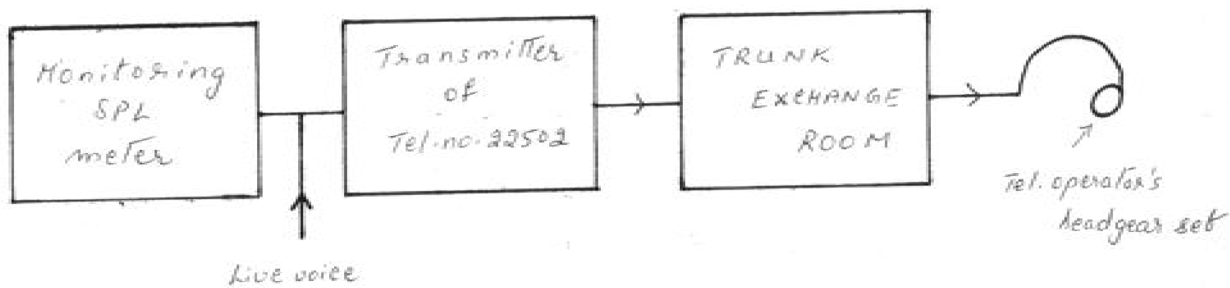
III Block Diagram Showing Set Up To Record Hearing Aid Processed Telephone Speech



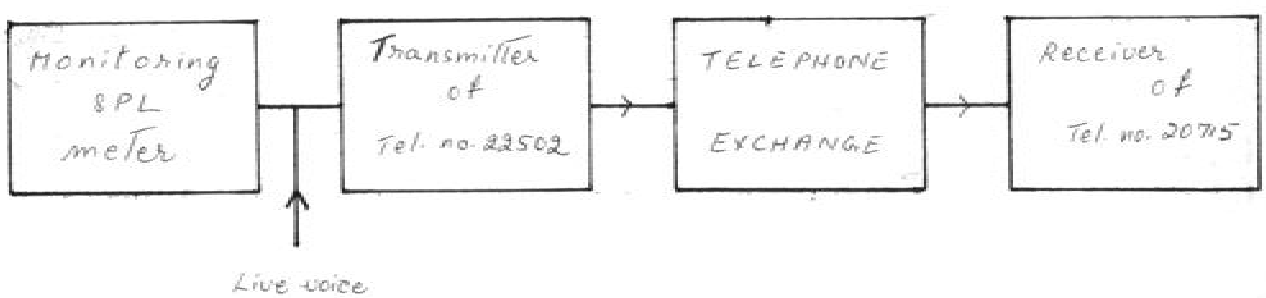
12 Block diagram showing Test presentation in Standard Speech Audiometry set up.



13 Block diagram showing test presentation in Trunk Exchange room set up.



14 Block diagram showing Test presentation in Subscriber Tel. set up.



Chapter IV

RESULTS AND DISCUSSION

The data obtained on the normals, the telephone operators and the clinical groups, for the PB lists and the sentences, was subjected to statistical analysis for the purposes of standardization.

Non-parametric statistics was applied since:

1. In the groups, the 'N' was different.
2. Percentage scores were dealt with
3. The groups were not matched
4. The scores obtained did not fall under normal distribution.

For dependant samples, the Eilcoxon signed Rank Test was used.

For independent samples, the Mann Whitney test was used.

'Practical Non-parametric statistics' by W.J. Conover was referred.

Analysis, Testing of the Hypothesis and Results (For PB lists)

1. Normals: X: Audiometric setup

Y: Exchange setup

H_0: E(x) ≤ E (y)

H_1: E(x) > E (y)

n=2 32; T=0; $W_\propto$ = 176.03

Since T < $W_\propto$ therefore Reject H_0 in favour of H_1

i.e. E (x) > E (y)

i.e. the performance of normals for PB lists in standard speech audiometry is better than in the telephone exchange setup. The hypothesis (1) is accepted.

2. Normals: x: Audiometric setup

y: Exchange set up

H_0: E(x) ≤ E (y)

H_1: E(x) > E (y)

n = 17 T = 0 $W_\propto$ = 4

Since T < $W_\propto$ therefore reject H_o in favour of H_1

i.e E (x) > E (y) i.e hypothesis (2) is accepted.

There is a performance of normals in Standard speech audiometry for PD lists is better than their performance for the same PB lists over the telephone received in another telephone set.

3. Telephone Operators :

x: Audiometric setup

y: Exchange set up

H_0: E(x) ≤ E (y)

H_1: E(x) > E (y)

n = 7 T = 2 $W_\propto$ = 31

Since T < $W_\propto$ therefore reject H_0 in favour of H_1

i.e. $E(x) > E(y)$ i.e. Hypothesis (3) is accepted.

i.e. the performance of telephone operators in standard speech audiometry for PB lists is better than their performance for the same PB listsover the telephone received in the trunk exchange.

4. Telephone Operators :

x: audiometric setup

y: exchange 2 telephones

H_0: $E(x) \leq E(y)$

H_1: $E(x) > E(y)$

$n = 9$ $T = 1$ $W_{\propto} = 9$

Since $T < W_{\propto}$ therefore reject H0 in favour of H1

i.e. $E(x) > E(y)$ i.e. Hypothesis (4) is accepted.

i.e. the performance of telephone operators in standard speech audiometry for PB lists is better than their performance for the same PB lists over the telephone received in another telephone set.

5. A. Bilateral moderate conductive hearing loss.

x: audiometric setup

y: trunk exchange room setup

H_0: $E(x) = E(y)$

H_1: $E(x) \neq E(y)$

$n = 5$ $T = 12$ $W_{\propto/2} = 0$ $W_{1-\propto/2} = 12$

Accept H_0 since $W_{\propto/2} < T < W_{1-\propto/2}$

i.e. E(x) : = E(y) i.e. Hypothesis (5)A is accepted.

i.e. the performance of Bilateral moderate conductive hearing loss subjects with hearing aid for PB lists over telephone received in the trunk exchange room does not significantly differ from their performance for the same PB lists in standard speech audiometry.

5.B. Bilateral moderate High frequency hearing loss subjects.

x: Audiometric setup y: trunk exchange room

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

n =5 $W_{\propto/2} = 0$ $W_{1-\propto/2} = 15$ T = 12

Accept H_0 since $W_{\propto/2} < T < W_{1-\propto/2}$

i.e. E(x) = E(y)

i.e. The performance of the Bilateral moderate high frequency hearing loss subjects without hearing aid for PB lists over the phone received in the trunk exchange room does not significantly differ from their performances for the same PB lists in standard speech audiometry.

5. C. Bilateral moderate mixed hearing loss subjects.

x: Audiometric setup y: trunk exchange room

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

n =4 $W_{\propto/2} = 0$ $W_{1-\propto/2} = 10$ T = 0

since $W_{\propto/2} = T$ therefore accept H_0

i.e. E (x) = E (y)

i.e the performance of the Bilateral Moderate mixed hearing loss subjects with hearing aid for PB lists over the phone received in the trunk exchange room does not significantly differ from their performance for the same PB lists in standard speech audiometric condition.

6 A. Bilateral moderate conductive hearing loss subjects with hearing aid.

x: Audiometric setup y: Subscriber telephone setup.

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

n =6 $W_{\propto/2} = 1$ $W_{1-\propto/2} = 20$ T = 14.5

Accept H_0 since $W_{\propto/2} < T < W_{1-\propto/2}$ i.e. E(x) = E (y)

i.e. hypothesis 6A. is accepted.

i.e. the performance of the bilateral moderate conductive hearing loss subjects with hearing aid for PB lists over the phone received in a subscriber telephone set does not significantly differ from their performance for the same PB lists in standard speech audiometric condition.

6 B. Bilateral moderate high frequency loss subjects

x: Audiometric setup y: Subscriber telephone setup.

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

n =4 $W_{\propto/2} = 0$ $W_{1-\propto/2} = 10$ T = 0

accept H_0 since T = $W_{\propto/2}$ i.e. E(x) = E (y)

i.e. Hypothesis 6B is accepted.

i.e. the performance of Bilateral moderate High frequency hearing loss subjects without hearing aid for PB lists over the phone received in a subscriber telephone set does not significantly differ from their performance for the same PB lists in the standard speech audiometric setup.

6C. Bilateral moderated mixed hearing loss subjects with hearing aid.

x: Audiometric setup y: Subscriber telephone setup.

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

n =4 $W_{\propto/2} = 0$ $W_{1-\propto/2} = 10$ T = 0

accept H_0 since $W_{\propto/2} < T < W_{1-\propto/2}$

i.e. E(x) = E (y) i.e. Hypothesis 6C. is accepted.

i.e. the Performance of Bilateral moderate mixed hearing loss subjects with hearing aid for PB lists over the phone received in a subscriber telephone set does not significantly differ from their performance for the same PB lists in the standard speech audiometric setup.

7. Trunk Exchange set up.

x: Telephone operators y: Normals.

H_0: E(x) $\leq$ E (y)

H_1: E(x) > E (y)

n =17 T = 459 T' = 85 $W_\propto$ = 269.39

Since T'< $W_\propto$ reject H_0 favour of H_1

i.e. E(x) > E (y) i.e. Hypothesis (7) is accepted.

i.e. performance of telephone operators for PB lists over the phone received in the trunk exchange room is better than the performance of the normal in the same set up.

8. Subscriber Telephone set.

x: Telephone Operators y: Normals.

H_0: E(x) $\leq$ E (y)

H_1: E(x) > E (y)

n =15 T = 155 T' = 145 $W_\propto$= 101

Since T' > $W_\propto$ therefore accept H_0 i.e. E(x) ≤ E (y)

i.e. Hypothesis (8) is rejected.

Further testing:

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

$W_{\propto/2}$= 91 $W_{1-\propto/2}$= 209 T = 155.

Since $W_{\propto/2} < T < W_{1-\propto/2}$ therefore accept H_0.

i.e. E(x) = E (y)

i.e. the performance of normal hearing telephone operators does not significantly differ from the performance of the normals for PB listsover the phone received in a subscriber telephone set.

9. Trunk Exchange Room.

x: females y: males

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

n= 14 m= 18 T= 60 $W_{\propto/2}$= 75

Since T< $W_{\propto/2}$ reject H_0 in favor of H_1

i.e. E(x) $\neq$ E (y)

i.e. there is difference in the males and females normals performance.

Further testing:

H_0: E(x) $\leq$ E (y)

H_1: E(x) > E (y)

$W_{\propto}$= 101 T = 60

Since T < $W_{\propto}$ therefore H_0 in favor of H_1 i.e. E(x) < E (y)

i.e. Males performs better than females for PB words over a phone when received in the Trunk Exchange room.

10. Subscriber Telephone set.

x = females y= males

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

n = 8, m = 12 T =50 $W_{\propto/2}$= 23 $W_{1-\propto/2}$= 73

Since $W_{\propto/2}$ < T < $W_{1-\propto/2}$ accept $H_{0.}$

i.e. E(x) = E (y) i.e. Hypothesis (10) is accepted.

i.e. There exists no difference in the performance in males and females for PB words over the phone when received in a subscriber telephone set up.

11. Audiometric set up

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

x = females y= males

n = 14, m = 18 T = 132 $W_{\propto/2} = 75$ $W_{1-\propto/2} = 177$

Since $W_{\propto/2} < T < W_{1-\propto/2}$ therefore accept H_0

i.e. E(x) = E (y)

i.e. Hypothesis (11) is accepted.

i.e. there is no significant difference in the performance of males and females normals for PB lists in the audiometric set up.

12. Trunk Exchange set up

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

x = females y= males n = 6 m=11

T =20.5 $W_{\propto/2} = 14$ $W_{1-\propto/2} = 52$

Since $W_{\propto/2} < T < W_{1-\propto/2}$ therefore accept H_0.

i.e. E(x) = E (y) i.e. Hypothesis (12) is accepted.

i.e. there is no significant difference in the performance of sales and females telephone operators for PB lists over the phone when received in the trunk exchange room.

13. Subscriber Telephone setup

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

x = females y= males

n = 6 m=9 T =23 $W_{\propto/2}$ = 11 $W_{1-\propto/2}$ = 45

Since $W_{\propto/2} < T < W_{1-\propto/2}$ therefore accept H_0.

i.e. E(x) = E (y) i.e. Hypothesis (13) is accepted.

i.e. there is no difference in the performance of males and females telephone operators for PB lists over the phone when received in a subscriber set.

14. Audiometric setup

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

x = females y= males

n = 6 m=9 T =11 $W_{\propto}$ = 11

Since T = $W_{\propto}$ therefore accept H_0 i.e. E (x) = E (y)

i.e Hypothesis (14) is accepted.

i.e. there exists no significant difference in the performance of males and females telephone operators for PB lists in the audiometric setup.

15. Trunk Exchange performance.

H_0: E(x) $\leq$ E (y)

H_1: E(x) > E (y)

x: Subscriber set y: Trunk exchange

$n = 11$ $m = 11$ $T = 0$ $W_{\propto} = 14$

Since $T < W_{\propto}$ therefore reject H_o in favour of H_1

therefore $E(x) > E(y)$ i.e. Hypothesis (15) is accepted.

i.e. the performance of normals for PB lists received over the phone in the subscriber telephone set is better than their performance for the same, when received in the trunk exchange room.

16. Trunk Exchange set up, Subscriber telephone set up

$H_0: E(x) \leq E(y)$

$H_1: E(x) > E(y)$

x = Subscriber telephone set y= Trunk Exchange room

$n = 15$ $m=15$ $T = 9.5$ $W_{\propto} = 26$

Since $T < W_{\propto}$ therefore Reject H_0

i.e. $E(x) > E(y)$ i.e. Hypothesis (16) is accepted i.e. the performance of telephone operators for PB lists over the phone when received in the subscriber set is better than their performance for the same when received in the Trunk exchange room.

17. Trunk exchange room.

x = telephone operators who had read PB lists once before the test

y = telephone operators who had not read the PB lists before the test

H_0: E(x) = E(y)

H_1: E(x) > E(y)

As per Sidney Siegal's 'Non-parametric Statistics' Mann Whitney 'U' test.

n =5 m=12 u=12.5 k table value = 17

Since u< K table value therefore accept H_o

i.e. E(x) = E(y) i.e. Hypothesis (17) is rejected.

i.e. there is no significant difference between the performance of these telephone operators, who are exposed to the PB list before the testing and those telephone operators, who are not exposed the PB listsbefore testing, for PB lists over the phone, when received in the Trunk Exchange room.

18. Trunk Exchange setup.

H_0: E(x) ≤ E(y)

H_1: E(x) > E(y)

x = Bilateral moderate conductive hearing loss with hearing aid.

y = normals.

n = 11 m=32 T= 333.5 T' = 18.5 $W_\propto$ = 158. 94

Since T' < $W_\propto$ therefore reject H_0 in favour of H_1

i.e. E (x) > E(y) i.e. Hypothesis (18) is accepted.

i.e. Bilateral moderate conductive hearing loss subjects with hearing aid perform better that normals for PB lists over the phone, when received in the trunk exchange room.

19. Trunk Exchange setup

H_0: E(x) ≤ E(y)

H_1: E(x) > E(y)

x = Bilateral moderate conductive hearing loss with hearing aid.

y = Telephone operators.

n = 11 m=17 T= 134.5 $W_{\propto}$ = 58 $W_{1-\propto/2}$=129

Since T > $W_{1-\propto/2}$ therefore Reject H0 in favour of H1

i.e. E (x) > E (y) i.e. Hypothesis (19) is accepted.

i.e. the performance of Bilateral moderate conductive hearing loss subjects with hearing aid is better than that of the telephone operators for PB list over the phone when received in the Trunk Exchange room.

20. Subscriber Telephone set up.

H_0: E(x) ≤ E(y)

H_1: E(x) > E(y)

x = Bilateral moderate conductive hearing loss with hearing aid.

y = normals.

n = 11 m=20 T = 128.5 $W_{\propto}$ = 70 $W_{1-\propto}$ =150

Since T < $W_{\propto}$ therefore accept H_0

i.e. E (x) ≤ E (y) i.e. reject hypothesis No. 20.

On further testing:

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

$W_{1-\propto/2}$ $W_{\propto/2}$= 63 $W_{1-\propto/2}$= 157 T= 128.5

Since $W_{\propto/2}$ < T < $W_{1-\propto}$ therefore accept H_0

i.e. E (x) = E (y)

i.e. There is no difference in the performance of Bilateral moderate conductive Hearing loss subjects with hearing aid and the performance of normals for PB lists over the phone, when received in a subscriber telephone set.

21. Subscriber setup

H_0: E(x) $\leq$ E(y)

H_1: E(x) > E(y)

x = Bilateral moderate conductive Hearing loss with hearing aid.

y = Telephone operators

m = 15 n=11 T=83 $W_{\propto}$ = 51 $W_{1-\propto}$ =114

Since T < $W_{1-\propto}$ therefore accept H_0

i.e. E (x) $\leq$ E (y) i.e. Hypothesis (21) is rejected.

On further testing.

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

$W_{\propto/2}$= 45 $W_{1-\propto/2}$= 120 T = 83

Since $W_{\propto/2}$ < T < $W_{1-\propto/2}$ therefore accept H_0

i.e. $E(x) = E(y)$

i.e. there is no difference in the performance of Bilateral moderate conductive hearing loss with hearing aid and telephone operators for PB lists overs the phone when received in a subscriber set.

22. Exchange Set up

H_0: $E(x) \leq E(y)$

H_1: $E(x) > E(y)$

x = Unilateral conductive hearing loss with hearing aid (Test ear is loss ear)

y = Normals.

n = 4 m=32 T = 117 $W_\propto$ =54.56 T' = 19

Since T' < $W_\propto$ therefore reject H_0 in favour of H_1

i.e. $E(x) > E(y)$ i.e. Hypothesis (22) is accepted

i.e. Unilateral conductive hearing loss subjects with hearing aid (when test ear is hearing los ear) perform better than normals for PB listsover the phone when received in the trunk exchange room.

23. Exchange set up

H_0: $E(x) \leq E(y)$

H_1: $E(x) > E(y)$

x = Unilateral conductive hearing loss with hearing aid (test ear is hearing loss ear)

y = Telephone Operators.

n = 4 m = 17 T= 44 $W_{\propto}$ = 16 T' = 24 $W_{1-\propto}$ = 52

Since T< $W_{1-\propto}$ therefore accept H_0

i.e. E(x) $\neq$ E (y) i.e. Hypothesis (23) is rejected.

on further testing:

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

Since $W_{\propto/2}$ = 12 $W_{1-\propto/2}$ = 56 T = 44

Since $W_{\propto/2}$ < T < $W_{1-\propto/2}$ therefore accept H_0 i.e E(x) = E(y).

i.e. There is no significant difference in the performance of the unilateral conductive hearing loss subjects with hearing aid (when hearing loss ear is the test ear) and the telephone operators for PB lists over the phone when received in the trunk exchange room.

24. Subscriber telephone set:

H_0: E(x) $\leq$ E(y)

H_1: E(x) > E(y)

x = Unilateral conductive hearing loss with hearing aid (Hearing loss ear is test ear).

y = Normals.

n = 4 m=20 T=30.5 $W_{\propto}$ = 19 $W_{1-\propto}$ = 61

Since T < $W_{1-\propto}$ therefore accept H_0.

i.e. Hypothesis (24) is rejected.

on further testing:

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

$W_{\propto/2}$ = 15 $W_{1-\propto/2}$=65 T= 30.5 i.e. E(x) = E(y) Since $W_{\propto/2}$< T < $W_{1-\propto/2}$ therefore accept H_0.

i.e. There exists no difference in the performance of the unilateral conductive hearing loss subjects with hearing aid (when hearing loss ear is the test ear) and the normals for PB lists over the phone when received in a subscriber telephone set.

25. Subscriber telephone set:

H_0: E(x) $\leq$ E(y)

H_1: E(x) > E(y)

x = Unilateral conductive hearing loss with hearing aid (test ear is hearing loss ear).

y = Telephone Operators.

n = 4 m=15 T=29 $W_{\propto}$ = 13 T' = 31

Since T' > $W_{\propto}$ therefore accept H_0

i.e. Hypothesis (25) is rejected.

on further testing :

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

$W_{\propto/2}$= 11 $W_{1-\propto/2}$=49 T= 29

Therefore $W_{\propto/2} < T < W_{1-\propto/2}$ and therefore accept H_0

i.e. E(x) = E(y).

i.e. There exists no difference in the performance of the unilateral conductive hearing loss subjects with hearing aid (when test ear is hearing loss ear) and the normal hearing telephone operators for PB lists over the phone when received in a subscriber telephone set.

26. Exchange:

H_0: E(x) $\leq$ E(y)

H_1: E(x) > E(y)

x= Unilateral conductive hearing loss without hearing aid (Normal ear is test ear)

y = Normals.

n = 3 m = 32 T = 81.0 $W_{\propto}$ = 39.9 T' = 15

Since T' < $W_{\propto}$ therefore reject H_0 in favour of H_1.

i.e. Hypothesis (26) is accepted.

i.e. Unilateral conductive hearing loss subjects without hearing aid (when normal ear is test ear) perform better than normals for PB lists over the phone when received in the Trunk exchange room.

27. Exchange set up:

H_0: E(x) ≤ E(y)

H_1: E(x) > E(y)

x = Unilateral conductive hearing loss without hearing aid (Normal ear is test ear)

y= Telephone operators.

n = 3 m= 17 T= 19.5 T'= 31.5 $W_{\propto}$ = 10 $W_{1-\propto}$ = 41

Since T< $W_{1-\propto}$ therefore accept H_0 i.e. E(x) ≤ E (y)

i.e. Hypothesis (27) is rejected.

on further testing:

H_0: E(x) = E (y)

H_1: E(x) ≠ E (y)

$W_{\propto/2}$= 7 $W_{1-\propto/2}$=44 T= 19.5

Accept H_0 Since $W_{\propto/2}$< T < $W_{1-\propto/2}$

i.e. E(x) = E(y)

i.e. There exists no difference in the performance of the unilateral conductive hearing loss subjects without hearing aid (when the normal ear is the test ear) and Telephone operators for PB lists over the phone when received in the Trunk exchange room.

28. Subscriber telephone setup:

H_0: E(x) ≤ E(y)

H_1: E(x) > E(y)

x = Unilateral conductive hearing loss without hearing aid (normal ear is test ear)

y = Normals

n= 30 m = 20 T=9 T' = 51 $W_{\propto} = 12$ $W_{1-\propto} = 48$

Since T < $W_{1-\propto}$ therefore Accept H_0

i.e. E(x) ≤ E (y)

i.e. Hypothesis (28) is rejected.

on further testing:

H_0: E(x) = E (y)

H_1: E(x) ≠ E (y)

$W_{\propto/2} = 9$ $W_{1-\propto/2} = 51$ T'= 51

Since T' = $W_{\propto/2}$ therefore Accept H_0 i.e. E(x) = E(y).

i.e. There exists no difference in the performance of unilateral conductive hearing loss subjects (without hearing aid, when normal ear is test ear) and normals for PB lists when received over the phone in a subscriber Telephone set up.

29. Subscriber Telephone set up:

H_0: E(x) = E (y)

H_1: E(x) ≠ E (y)

x = Unilateral conducive hearing loss without hearing aid (when normal ear is test ear).

y = Telephone operators.

n = 3 m = 15 T = 3 $W_{\propto/2}$ = 6

Since T < $W_{\propto/2}$ therefore reject H_0 in favor of H_1 .

Therefore E(x) ≠ E (y) i.e. Hypothesis (29) is rejected.

on further testing:

H_0: E(x) ≥ E(y)

H_1: E(x) < E(y)

$W_{\propto}$ = 3 T = 3 Since T < $W_{\propto}$ therefore reject H_0 in favour of H_1.

i.e. E (x) < E (y)

i.e. The unilateral conductive hearing loss subjects (without hearing aid, when the normal ear is test ear) perform than telephone operators for PB lists over the phone when received in a subscriber telephone set.

20. Exchange set up:

H_0: E(x) = E (y)

H_1: E(x) ≠ E (y)

x = Bilateral moderate mixed hearing loss subjects with hearing aid.

y = Normals

n = 4 m = 32 T = 79 $W_{\propto/2}$ = 52.7 $W_{1-\propto/2}$ = 75. 23

Since T > $W_{1-\propto/2}$ reject H_0 in favour of H_1

i.e. $E(x) \neq E(y)$.

i.e. Hypothesis (30) is rejected.

on further testing:

$H_0: E(x) \leq E(y)$

$H_1: E(x) > E(y)$

$W_{\propto} = 54.58$ T' 48.5

Since $T' < W_{\propto}$ therefore reject H_0 in favour of H_1.

i.e. $E(x) > E(y)$

i.e. Bilateral moderate mixed hearing loss subjects with hearing aid perform better than normals for PB lists over the phone when received in the Trunk exchange room.

31. Exchange:

$H_0: E(x) = E(y)$

$H_1: E(x) = E(y)$

x = Bilateral moderate mixed hearing loss with hearing aid.

y = Telephone operators

$n = 4$ $m = 17$ $T = 31$ $W_{\propto/2} = 12$ $W_{1-\propto/2} = 56$.

Since $W_{\propto/2} < T < W_{1-\propto/2}$ therefore accept H_0.

i.e. $E(x) = E(y)$

i.e. Hypothesis (31) is accepted.

i.e. Bilateral moderate mixed hearing loss subjects (with hearing aid) not significantly different from the performance of normals for PB lists over the phone, when received in the Trunk exchange room.

32. Subscriber Telephone Set:

$H_0: E(x) = E(y)$

$H_1: E(x) \neq E(y)$

x = Bilateral moderate mixed hearing loss with hearing aid.

y = Normal.

n = 4 m = 20 T = 23 $W_{\propto/2}$ = 15 $W_{1-\propto/2}$ = 65

Since $W_{\propto/2} < T < W_{1-\propto/2}$ therefore accept H_0

i.e. E(x) = E (y)

i.e. Hypothesis (32) is accepted.

i.e. Bilateral moderate mixed hearing los subjects with hearing aid to not significantly differ in their performance from normals for PB lists over the phone when received in a subscriber Telephone set.

33. Subscriber Telephone set up:

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

x = Bilateral moderate mixed hearing loss with hearing aid.

y = Telephone Operators

n = 4 m = 15 T = 14 $W_{\propto/2}$ = 11 $W_{1-\propto/2}$ = 49

Since $W_{\propto/2} < T < W_{1-\propto/2}$ therefore accept H_0

i.e. E(x) = E (y)

i.e. Bilateral moderate mixed hearing loss subjects with hearing aid do not significantly differ in their performance from the Telephone Operators for PB lists over the phone, when received in a subscriber Telephone set.

34. Trunk exchange room set up:

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

x = Trunk exchange set up.

y = Subscriber set up.

n = 8 T = 17 $W_{\propto/2}$ 4 $W_{1-\propto/2}$ = 32

Since $W_{\propto/2} < T < W_{1-\propto/2}$ therefore accept H_0

i.e. E(x) = E (y)

i.e. There is no significant difference in the performance of Bilateral conductive hearing loss subjects with hearing aid for PB list over the phone when received in the Trunk exchange room and when received in subscriber Telephone set.

35. Trunk exchange room:

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

x = Trunk exchange room set.

y = Subscriber Telephone set.

n = 4 T = 7 $W_{\propto}$ = 0 $W_{1-\propto}$ = 10

Since T < $W_{1-\propto}$ therefore Accept H_0 i.e. H_0: E(x) $\geq$ E(y)

i.e. Hypothesis (35) is rejected.

on further testing:

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

$W_{\propto/2}$ = 0 $W_{1-\propto/2}$ = 10 T = 7

Since $W_{\propto/2} < T < W_{1-\propto/2}$ accept H_0

i.e. E (x) = E (y)

i.e. There is no significant difference in the performance of the unilateral high frequency hearing loss subjects without hearing aid (when test car is hearing loss car) for PB lists over the phone when received in the Trunk exchange as compared to that received in the subscriber Telephone set.

SENTENCES

36. Exchange set up:

H_0: E(x) $\leq$ E(y)

H_1: E(x) > E(y)

x = Telephone Operators.

y = Normals

n = 15 m = 32 T = 416 $W_{\propto}$ = 219.41 $W_{1-\propto}$ = 260.58

Since T > $W_{1-\propto}$ reject H_0 in favour of H_1

i.e. E (x) > E (y) i.e. Hypothesis (36) is accepted.

i.e. Telephone operators perform better than normals for the sentences over the phone received in the Trunk exchange room.

37. Subscriber Telephone set up:

H_0: E(x) $\leq$ E(y)

H_1: E(x) > E(y)

x = Telephone operators

y = Normals.

n = 15 m = 11 T= 67 $W_{\propto}$ = 51 $W_{1-\propto}$ = 114

Since T < $W_{1-\propto}$ accept H_0

i.e. E(x) $\leq$ E(y) i.e. Hypothesis (37) is rejected.

on further testing:

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

$W_{\propto/2}$ = 45 $W_{1-\propto/2}$ = 120 T = 67

Since $W_{\propto/2} < T < W_{1-\propto/2}$ accept H_0

i.e. E (x) = E (y)

i.e. There is no significant difference in the performance of normal and normal hearing Telephone operators for sentences over the phone when received in a subscriber Telephone set.

38. Trunk exchange room:

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

x = Normal males

y = Normal females

n = 18 m = 14 T = 146 $W_{\propto/2}$ = 177 $W_{1-\propto/2}$ = 177

Since $W_{\propto/2} < T < W_{1-\propto/2}$ accept H_0

i.e. E (x) = E (y) i.e. Hypothesis (38) is accepted

i.e. There exists no significant difference in the performance of males and females (noramls for sentence over the phone received in the Trunk Exchange room.

39. Subscriber set up:

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

x = Normal males

y = Normal females

n = 6 m = 15 T = 11.5 $W_{\propto/2}$ = 4 $W_{1-\propto/2}$ = 26

Since $W_{\propto/2} < T < W_{1-\propto/2}$ accept H_0

i.e. E (x) = E (y) i.e. Hypothesis (39) is accepted

i.e. There exists no significant difference in the performance of males and females (normals) for sentences over the phone when received in the subscriber Telephone set.

40. Trunk exchange room:

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

x = Males (Telephone operators)

y = Females (Telephone Operators).

$n = 9$ $m = 6$ $T = 39$ $W_{\propto/2} = 11$ $W_{1-\propto/2} = 43$

Since $W_{\propto/2} < T < W_{1-\propto/2}$ accept H_0

i.e. E (x) = E (y) i.e. Hypothesis (40) is accepted.

i.e. There exists no significant difference in the performance of males and females (normals) Telephone Operators for sentences over the phone received on the Trunk Exchange room.

41. Subscriber Telephone set up:

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

x = Males (Telephone operators)

y = Females (Telephone Operators)

$n = 9$ $m = 6$ $T = 40.5$ $W_{\propto/2} = 11$ $W_{1-\propto/2} = 43$

Since $W_{\propto/2} < T < W_{1-\propto/2}$ accept H_0

i.e. E(x) = E (y) i.e. Hypothesis (41) is accepted.

i.e. There exists no significant difference in the performance of males and females (normal) Telephone operators for sentences over the phone when received in a subscriber telephone set.

42. Subscriber set up:

H_0: E(x) $\leq$ E(y)

H_1: E(x) > E(y)

x = Subscriber Telephone set up (normals)

y = Trunk exchange room (normal)

$n = 8$ $m = 1.5$ $W_{\propto} = 6$

Since $T < W_{\propto}$ reject H_0 in favour of H_1

i.e. E(x) > E (y) i.e. Hypothesis (42) is accepted

i.e. Normals perform better for sentences over the phone when received in the subscriber Telephone set than when received in the trunk exchange room.

43. Telephone operators:

H_0: E(x) ≤ E(y)

H_1: E(x) > E(y)

x = Subscriber Telephone set up.

y = Trunk exchange room

n = 8 T = 8 $W_{\propto}$ = 6

Since T > $W_{\propto}$ accept H_0 i.e. E (x)   E (y)

i.e. Hypothesis (43) is rejected.

on further testing:

H_0: E(x) = E (y)

H_1: E(x) = E (y)

$W_{\propto/2}$ = 4 $W_{1-\propto/2}$ =32   T= 8

Since $W_{\propto/2} < T < W_{1-\propto/2}$ accept H_0

i.e. E (x) = E (y)

i.e. There is no significant difference in the performance of the normal hearing Telephone operators for sentences over the phone when received in the Trunk exchange room and when received in the subscriber Telephone set.

44. Trunk exchange set up:

H_0: E(x) ≤ E(y)

H_1: E(x) > E(y)

x = Bilateral moderate conductive hearing loss with hearing aid.

y = Normals.

n = 11 m = 32 T = 303 $W_{\propto}$ = 158.94 $W_{1-\propto}$ = 193.058

Since T > $W_{\propto}$ reject H_0 in favour of H_1

i.e. E (x) > E (y) i.e Hypothesis (44) is accepted.

i.e. Bilateral moderate conductive hearing loss subjects with hearing aid perform better than normals for sentences over the phone when the received in the Trunk exchange room.

45. Trunk exchange set up:

H_0: E(x) $\leq$ E(y)

H_1: E(x) > E(y)

x = Bilateral moderate conductive hearing loss with hearing aid

y = Telephone operators

n = 11 m = 15 T=32 $W_{\propto}$ = 51 $W_{1-\propto}$ = 114

since T > $W_{1-\propto}$ reject H_0 in favour of H_1

i.e. E (x) > E (y) i.e. Hypothesis (45) is accepted.

i.e. Bilateral moderate conductive hearing loss subjects with hearing aid perform better than the normal hearing Telephone operators for sentences over the phone when received in the trunk exchange room.

46. Subscriber Telephone set:

H_0: E(x) $\leq$ E(y)

H_1: E(x) > E(y)

x = Bilateral moderate conductive hearing loss with hearing aid

y = Normals.

n = 11 m = 11 T = 40 $W_{\propto}$ = 35 $W_{1-\propto}$ = 86

Since T < $W_{1-\propto}$ accept H_0 i.e. E(x) $\leq$ E(y)

i.e. Hypothesis (46) is rejected

on further testing:

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

$W_{\propto/2}$= 31 $W_{1-\propto/2}$=90 T= 40

Since $W_{\propto/2}$< T < $W_{1-\propto/2}$ accept H_0

i.e. E(x) = E (y)

i.e. There is no significant difference in the performance of bilateral moderate conductive hearing loss subjects with hearing aid and normals for sentences over the phone when received in a subscriber Telephone set.

47. Subscriber Telephone set:

H_0: E(x) $\leq$ E(y)

H_1: E(x) > E(y)

x = Bilateral moderate conductive hearing loss with hearing aid

y = Telephone Operators.

n = 11 m = 15 T = 100 $W_{\propto}$ = 51 $W_{1-\propto}$ = 114

Since T < $W_{1-\propto}$ accept H_0 i.e. E(x) $\leq$ E(y)

i.e. Hypothesis (47) is rejected

on further testing:

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

$W_{\propto/2}$ = 45 $W_{1-\propto/2}$ =120 T= 100

Since $W_{\propto/2} < T < W_{1-\propto/2}$ accept H_0 i.e. E (x) = E (y)

i.e. There exists no significant difference in the performance of Bilateral moderate conductive hearing loss subjects with hearing aid and the normal hearing Telephone Operators for sentences over the phone when received in the subscriber Telephone set.

48. Trunk exchange set up:

H_0: E(x) $\leq$ E(y)

H_1: E(x) > E(y)

x = Unilateral conductive hearing loss with hearing aid (hearing loss ear is test ear).

y = Normals.

n = 4 m = 32 T = 111 $W_{\propto}$ = 54.56 $W_{1-\propto}$ = 73.42

Since T < $W_{1-\propto}$ reject H_0 in favour of H_1

i.e. E (x) > E (y) i.e. Hypothesis (48) is accepted.

i.e. Unilateral conductive hearing loss subjects with hearing aid (hearing loss ear is the test ear) perform significantly better than normals, for sentences over the phone received in the Trunk exchange room.

49. Trunk exchange room:

H_0: E(x) $\leq$ E(y)

H_1: E(x) > E(y)

x = Unilateral conductive hearing loss with hearing aid (hearing loss ear is test ear)

y = Telephone operators

n= 4 m= 15 T = 30 $W_{\propto}$ = 13 $W_{1-\propto}$ = 47

Since T > $W_{1-\propto}$ accept H_0 i.e. E(x) $\leq$ E(y)

i.e. Hypothesis (49) is rejected.

on further testing:

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

$W_{\propto/2}$ = 11 $W_{1-\propto/2}$ = 49

Since $W_{\propto/2}$ < T < $W_{1-\propto/2}$ accept H_0

i.e. E (x) = E (y)

i.e. Unilateral conductive hearing loss subjects with hearing aid (when hearing loss ear is the test ear) do not significantly differ in their performance from that of the Telephone operators for sentences over the phone received in the Trunk exchange room.

50. Subscriber telephone set:

H_0: E(x) $\leq$ E(y)

H_1: E(x) > E(y)

x = unilateral conductive hearing loss with hearing aid (hearing loss ear is test ear)

y = normals

n= 3 m =11 T= 14 $W_{\propto}$ = 6 $W_{1-\propto}$ = 27 since T < $W_{1-\propto}$ accept H_0 i.e. E(x) ≤ E(y)

i.e. Hypothesis (50) is rejected

on further testing:

H_0: E(x) = E (y)

H_1: E(x) = E (y)

$W_{\propto/2}$= 4 $W_{1-\propto/2}$=29 T= 14

since $W_{\propto/2}$< T < $W_{1-\propto/2}$ accept H_0

i.e. E (x) = E (y)

i.e. Unilateral conductive hearing loss subjects with hearing aid (when hearing loss ear is test ear) do not significantly differ from the performance of noramls for sentences over the phne when received in a subscriber Telephone set.

51. Subscriber Telephone set:

H_0: E(x) ≤ E(y)

H_1: E(x) > E(y)

x= unilateral conductive hearing loss subjects with hearing aid (hearing loss ear is the test ear).

y= Telephone Operators

n=3 m = 15 T = 21. 5 $W_{\propto}$ = 8 $W_{1-\propto}$ = 37

since T < $W_{1-\propto}$ accept H_0 i.e. E(x) ≤ E(y)

i.e. Hypothesis (51) is rejected

on further testing:

H_0: E(x) = E (y)

H_1: E(x) = E (y)

$W_{\propto/2}$= 6 $W_{1-\propto/2}$=39 T= 21.5

Since $W_{\propto/2}$< T < $W_{1-\propto/2}$ accept H_0 i.e. E (x) = E (y)

i.e. Unilateral conductive hearing loss subjective with hearing aid (when hearing loss ear is test ear) do not significantly differ in their performance from Telephone operators for sentences over the phone when received in a subscriber Telephone set.

52. Trunk exchange room:

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

x = Bilateral moderate mixed hearing loss with hearing aid.

y = Normals.

n = 4 m = 32 T= 55 $W_{\propto/2}$ = 52.76 $W_{1-\propto/2}$ = 75. 238

since $W_{\propto/2} < T < W_{1-\propto/2}$ accept H_0 i.e. E (x) = E (y)

i.e. Hypothesis (52) is accepted.

i.e. Bilateral moderate mixed hearing loss subjects with hearing aid do not significantly differ in their performance from normals for sentences over phone received in the Trunk exchange room.

53. Trunk exchange room:

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

x = Bilateral moderate mixed hearing loss with hearing aid (mixed type)

y = Normals (Telephone operators)

n = 4 m = 15 T= 0 $W_{\propto/2}$ = 11

Since T < $W_{\propto/2}$ reject H_0 in favour of H_1 i.e. E(x) $\neq$ E (y)

i.e. Hypothesis (53) is rejected.

on further testing:

H_0: E(x) $\geq$ E(y)

H_1: E(x) < E (y)

$W_{\propto}$ = 13 T = 0 Since T < $W_{\propto}$ reject H_0 in favour of H_1

i.e. E (x) < E (y)

i.e. Bilateral moderate mixed hearing loss subjects with hearing aid perform significantly poorer than the Telephone Operators for sentences over the phone when received in the Trunk exchange room.

54. Subscriber Telephone set:

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

x = Bilateral moderate mixed hearing loss with hearing aid.

y = Normals.

n =2 m = 11 T= 5 $W_{\propto/2} = 1$ $W_{1-\propto/2} = 21$

Since $W_{\propto/2} < T < W_{1-\propto/2}$ accept H_0 i.e. E (x) = E (y)

i.e. Hypothesis (54) is accepted.

i.e. Bilateral moderate mixed hearing loss subjects with hearing aid do not significantly differ from the performance of the normals for sentence over the phone received in a subscriber Telephone set.

55. Subscriber Telephone set:

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

x = Bilateral moderate mixed hearing loss

y = Telephone Operators.

n =24 m = 15 T= 0 $W_{\propto/2} = 2$

Since $T < W_{\propto/2}$ reject H_0 in favour of H_1

i.e E(x) $\neq$ E (y)

i.e Hypothesis (55) is rejected

on further testing:

H_0: E(x) $\geq$ E(y)

H_1: E(x) < E(y)

$W_\propto = 4$ T = 0

Since $T < W_\propto$ reject H_0 in favour of H_1 i.e. E (x) < E (y)

i.e. Bilateral moderate mixed hearing loss subjects with hearing aid perform significantly poorer than Telephone Operators for sentences over the phone received in a subscriber Telephone set.

56. Bilateral conductive hearing loss subjects with hearing aid:

H_0: E(x) $\leq$ E(y)

H_1: E(x) > E(y)

x= Subscriber Telephone set

y = Trunk exchange room set up

n = 6 $W_\propto = 3$ T = 0

Since T < $W_\propto$ reject H_0 in favour of H_1

i.e. E(x) > E (y) i.e. Hypothesis (56) is accepted.

i.e. Bilateral conductive hearing loss subjects with hearing aid perform significantly better for sentences over the phone, when received in the subscriber Telephone set than when received in the Trunk exchange room.

57. Trunk exchange room:

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

x = Bilateral moderate high frequency hearing loss subjects without hearing aid.

y = Normals

n= 3 m=32 T= 79 $W_{\propto/2}$= 38.399 $W_{1-\propto/2}$ = 57. 601

Since T > $W_{1-\propto/2}$ reject H_0 in favor or H_1

i.e. E(x) $\neq$ E (y) i.e. Hypothesis (57) is rejected.

on further testing:

H_0: E(x) $\leq$ E(y)

H_1: E(x) > E(y)

$W_\propto$ = 39.943 $W_{1-\propto}$ = 56.057 T = 79

since T > $W_{1-\propto}$ reject H_0 in favor of H_1

i.e. Bilateral moderate high frequency hearing loss subjects without hearing and perform significantly better than the noramls for sentences over the phone received in the Trunk exchange room.

58. Trunk exchange room:

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

x = Unilateral mild + moderate high frequency hearing loss without hearing aid (Normal ear is the test ear)

y = Normals.

n= 4 m=32 T= 88 $W_{\propto/2}$ = 52.762 $W_{1-\propto/2}$ = 75.238

Since T > $W_{1-\propto/2}$ reject H_0 in favour of H_1 i.e. E(x) $\neq$ E (y)

i.e. Hypothesis (58) is rejected .

on further testing:

H_0: E(x) $\leq$ E(y)

H_1: E(x) > E(y)

$W_{\propto}$ = 54. 568 $W_{1-\propto}$ = 73. 432

Since T > $W_{1-\propto}$ reject H_0 in favour of H_1 i.e. E(x) > E (y)

i.e. The performance of unilateral conductive high frequency hearing loss subjects without hearing aid (when normal ear is test ear) perform better than the normals for sentence over the phone when received in the Trunk exchange room.

59. Trunk exchange room:

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

x = Bilateral nocerate high frequency hearing loss subjects without hearing aid.

y = Telephone operators

n = 3 m=15 T = 16. 5 $W_{\propto/2}$ = 6 $W_{1-\propto/2}$ = 39

since $W_{\propto/2}$< T < $W_{1-\propto/2}$ accept H_0 i.e. E (x) = E (y)

i.e. Hypothesis (59) is accepted.

i.e. Bilateral high frequency hearing loss subjects without hearing aid do not differ in their performance from normal hearing Telephone operators for sentences over the phone, when received in the Trunk exchange room.

60. Trunk exchange room:

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

x= Unilateral mild + moderate high frequency hearing loss without hearing aid (normal ear is test ear) .

y= Telephone operators

n = 4 m = 15 T = 7 $W_{\propto/2}$ = 11

Since T < $W_{\propto/2}$ reject H_0 in favour of H_1 i.e. E(x) $\neq$ E (y)

i.e. Hypothesis (60) is rejected

on further testing:

H_0: E(x) $\geq$ E(y)

H_1: E(x) < E(y)

$W_{\propto}$ = 13 T = 7

Since T < $W_{\propto}$ reject H_0 in favour of H_1 i.e. E (x) < E (y)

i.e. the performance of unilateral mild + moderate high frequency hearing loss subjects without hearing aid (when normal ear is test ear) perform significantly poorer than the normal hearing telephone operators for sentences over the phone, when received in the Trunk exchange room.

61. Subscriber telephone set:

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

x= Bilateral moderate high frequency hearing loss subjects without hearing aid.

y= Normals

n = 3 n =1 T= 10 $W_{\propto/2}$ = 4 $W_{1-\propto/2}$ = 29

since $W_{\propto/2} < T < W_{1-\propto/2}$ accept H_0 i.e. E(x) = E (y)

i.e. Hypothesis (61) is accepted

i.e. Bilateral moderate high frequency hearing loss subjects without hearing aid do not significantly differ in their performance from the normals for substances over the phone received in the subscriber telephone set.

62. Subscriber telephone set:

H_0: E(x) = E (y)

H_1: E(x) = E (y)

x= Unilateral mild + moderate high frequency hearing loss without hearing aid (normal ear is test ear)

y = normals

n= 3   m = 11   T= 9.5 $W_{\propto/2}$ = 4 $W_{1-\propto/2}$ = 29

since $W_{\propto/2} < T < W_{1-\propto/2}$ accept H_0 i.e. E (x) = E(y)

i.e. Hypothesis (62) is accepted

i.e. Unilateral mild + moderate high frequency hearing loss subjects with out hearing aid (when normal ear is test ear) does not significantly differ from the normals for sentences over the phone when received in the subscriber Telephone set.

63. Subscriber Telephone set:

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

x= Bilateral moderate high frequency hearing loss without hearing aid (Normal ear is the test ear)

y= Normals bearing Telephone Operators.

n=3   m=15   T= 15.5 $W_{\propto/2}$ = 6 $W_{1-\propto/2}$ = 39

Since $W_{\propto/2} < T < W_{1-\propto/2}$ accept H_0 i.e. E(x) = E (y) i.e. Hypothesis (63) is accepted.

i.e. Bilateral moderate high frequency hearing loss subjects without hearing aid do not signfiicnatly differ in their performance from Telephone operators for sentences over the phone when receiver in the subscriber Telephone set.

64. Subscriber Telephone set:

H_0: E(x) = E (y)

H_1: E(x) $\neq$ E (y)

x = Unilateral mild + moderate high frequency hearingloss without hearing aid (Normal ear is test ear).

y = Telephone operators

n= 3 n=15 T = 10 $W_{\propto/2} = 6$ $W_{1-\propto/2}$ 39

since $W_{\propto/2} < T < W_{1-\propto/2}$ accept H_0 i.e. E (x) = E (y)

i.e. Unilateral mild + moderate high frequency hearing loss subjects without hearing aid (when normal ear is test ear) do not significantly differ in their performance from Telephone operators for sentences over the phone when subscriber Telephone set was used to receive the signal.

DISCUSSION

The results of the experiment – A in the audiometric set up indicates that the performance of the subjects increased as the intensity of the stimulus was raised above the SRT level. The maximum discrimination scores were obtained at 40 dB above SRT level.

An articulation curve was plotted with the mean values obtained. This curve, in Graph -, depicts the performance intensity function. The characteristics of the curve is that it represents a linear function, which undergoes saturation as was the case with auditory test no. 4 and 6 (Carhart, 1966).

For PB lists:

It can be thus seen that the performance of the normals and the Telephone operators in the audiometric set up is better than in the trunk exchange room and in the subscriber telephone set. This could be attributed to the following:

1. The head phone TDH 39 of the audiometer has a frequency response from 300 Hz to 5 KHz.
2. Head phone TDH 39 of the audiometric with its cushion sits completely on the ear lobe thus permitting an insignificant sound leakage,
3. The sound treated environment.

In the clinical group Viz., Bilateral moderate conductive hearing loss with hearing aid, Bilateral moderate mixed hearing loss with hearing aid, Bilateral high frequency hearing loss, results show that there is no significant difference in their performance in the audiometric set up as compared to that in the Trunk exchange room and in the subscriber telephone set up.

This shows that the ambient noise environment prevailing in the Trunk exchange room and in the subscriber telephone set up affects the performance of the normals and the Telephone operators, while it has no effect on these three clinical groups. The bilaterality of their hearing problem is a moderate degree. In the conductive and the mixed hearing loss subjects, their hearing loss is a boon to them, In the sense that it does not permit environmental noise to disturb then; the hearing aid, which is in the induction coil position picks up only electromagnetic signal, picked from the telephone receivers and head gear set receivers is amplified without the mixture of the ambient noise. The close proximity of the signal source to the induction coil, by placing the receiver over the hearing aid, resulted in an insignificant loss of signal in terms of strength of the signal picked up by the induction coil. Further, the hearing amplified the signal loud enough, up to the level of comfort, as adjusted by the subject before testing.

Also the hearing aid used had a frequency response from 300 Hz to 5 KHz, while the telephone transmits frequency from 300 Hz to 3.4 KHz. So, there is no clipping of the frequency of the telephone signal received by the hearing aid. Hence, the clinical subjects did not show any significant difference in their performance in the noisy environment and in the sound treated room. In the case of Bilateral high frequency hearing loss subjects, their hearing loss attenuates the high frequency components of the environmental noise, while in the normals, the high frequency components of noise may have interfered with their performances.

In the trunk exchange room set up, the telephone operators, performed better than the noramls, while the subscriber telephone set up, there was no significant difference between them. The telephone operators are already experienced in their jobs from 1 to 10 years in listening to telephone speech and are adapted to telephone listening in the trunk exchange noise environment. In the case of normals only some subjects had experienced to listening to telephone speech in the trunk room noise environment. The noise reaching the nontest exposed ear, therefore affected their performance greater than in the case of the telephone operators. The telephone operators may be said to be 'tuned' to the listening conditions i.e. they are greater vigilant than the normals inspite of noise and hence their better performance.

In the subscriber telephone set up, the ambient noise levels was not significant to cause any significant difference in the performances of normals and the telephone operators.

The difference in the ambient noise level in the trunk exchange room and the subscriber telephone set up conditions, variably affected the performances. The normals and the telephone operators performed better in less noisy environment viz., the subscriber telephone set than in the trunk exchange room.

Bilateral moderate conductive hearing loss subjects with hearing aid:

In the trunk exchange room, they performed significantly better than the telephone operators and the normals. This goes to show that the ambient noise did not cause any change in their performance, while the hearing aid assisted then to perform better than the normals and the experienced telephone operators. In terms of hearing efficiency, this category of clinical subjects are ideally suited for the performance of the job of a telephone operators i.e. to say, their hearing handicap is not an handicap, for the job of a telephone operator and rather they would perform optimally and more efficiently and hence may even be preferred for such jobs.

In the subscriber telephone set up this clinical category do not significantly differ from the normals or the telephone operators, since the environmental noised was not sufficient to affect the performance of the different groups of subjects. Hence all the three groups showed nearly same performance.

Unilateral conductive hearing loss subjects with hearing aid:

When the hearing loss ear was test ear, in the trunk exchange room, they performed better than the normals but there was no significant difference in performance when compared with that of the telephone operators.

The normal ear of these subjects was being exposed to the same environmental conditions as in the case of the normals and the telephone operators. But, probably due to the amplification provided by the hearing aid, they were able to score over the normals and not significantly differ from the performance of the normals hearing telephone operators. It may even be hypothesized, that with some experience for adaptation to telephone listening in the trunk exchange room environment, like the telephone operators, this clinical category may be expected to perform better than the telephone operators. This clinical category can use their poorer ear was amplification. However, they can use their normal ear without the hearing aid for such jobs to better advantage i.e. their non-test exposed ear having a conductive hearing loss helps in the performance of the normal ear, by attenuating the environmental noise components and thus increases the inter-aural attenuating the environmental noise components and thus increase the inter-aural attenuation far above the ambient noise level in the trunk exchange room. In such a condition it is seen in the trunk exchange set up, this clinical category perform better than the normals; they do not significantly differ from the performance of the telephone operators, probably since they lack the experience of listening to telephone speech in noisy environments. In the subscriber telephone set up they do not significantly differ from the telephone operators and the normals, for the reasons stated earlier.

Bilateral moderate mixed hearing loss subjects with hearing aid:

In the trunk exchange set up, they perform better than the normals. Here again the bilaterality of the hearing problem attenuates the environmental noise from reaching the exposed non-test ear, the hearing aid further assists them to receive amplified signal. The mixed hearing loss includes the conductive component and the sensori-neural component. The conductive component can simply be overcome by adequate amplification, the sensori-neural component can affect the discrimination of the subjects; the criteria for subject selection of this category was that they should score a minimum of 80% in standard speech auidometry, which normals and conductive hearing loss subjects scores; subjects who scores less than 80% in standard speech aduiometry for discrimination were expected to perform poorer than when listening conditions were more rigorous i.e. in the telephone and they have an inherent pathology which restricts their performance. This probably explains why this clinical category do not significantly differ from the performance of the telephone operators. This shows that this clinical category will not have a handicap in their performance as telephone operators since thy perform better than the normals and nearly equal to the telephone operators.

In the subscriber telephone set, this clinical category do not significantly differ from the performance of the normals and the telephone operators for the same reasons stated earlier.

The bilateral moderate conductive hearing loss subjects with hearing aid do significantly differ I their performance in the trunk exchange room and in the subscribers set showing that irrespective of varying ambient noise, their performance is not affected.

The unilateral high frequency hearing loss subjects without hearing aid (normal ear is that ear) also do not show any significant difference in their performance in the trunk exchange room and in the subscriber telephone set. The high frequency component of environmental noise did not affect them as in may have done to the normals and the telephone operators.

In the trunk exchange room, the results show that the normals males performed better then the normal females. However, in the subscriber telephone set, and in the audiometric set up, there was no significant difference in their performances.

The results showed that the normal male and female telephone operators do not significantly differ in their performances, in the trunk exchange room, in the subscriber telephone set up and in the audiometric set up. In terms of hearing efficiency both males and females are nearly equally good.

The better performance of the normal males can only be attributed to that the normal males are less affected by environmental conditions or to the other unknown factors. So, in terms of efficiency in hearing, both females and males get adopted to listening in the environmental conditions and perform nearly equally well as is seen I the telephone operators.

SENTENCES

the sentences were given only in the trunk exchange room set up and the subscriber telephone set up.

The explanations for PB lists performances hold good for sentence performances of the various groups. Any discrepancies seen from the PB list performance may be attributed to the context of speech available in the sentences. However, in certain discrepancies, which could not be explained, it can be only started that the sentences test was not adequate and that further tests may be developed.

The results showed that the environmental noise in the room reaching the non-test ear affects the performance to listening to telephone speech in the test ear to varying degrees in different groups of subjects. Experience in listening to telephone speech under noise conditions produce an adaptations effect to noise entering and competing messages and increases the vigilance of the listeners. This accounts for the better performance of the telephone operators group, compared to the normals, who had never been exposed to such a situation. The performance of the normal subjects may be considered as the minimum level of performance required for normals to apply for telephone operators jobs. The performance of the telephone operators may be considered as the optimum level of performance required to function as efficient as the experienced telephone operators. It has been already shown that standard speech audiometric discrimination tests may not reflect the efficiency of a listener on telephone listening in the trunk exchange room or in a subscriber telephone set under different environmental conditions. Hence persons who apply for the telephone operators job should undergo a hearing test for discrimination through the telephone and must attain the minimum levels of performances seen in the normals. Optimum levels of performance may be preferred.

The results also show that the statement, “A person who is hard of hearing obviously cannot be very efficient as a telephone operators” - is not true. The different categories of the hearing problem react differently when an amplified signal is fed to their ears. Furthermore, the amplification provided by the hearing aid is louder than the level of the signal received in the head gear set or the receiver.

The hearing loss in the non-test ear (exposed car) may be considered as an advantage for telephone communications as hearing loss overcomes the interference of the environmental noise and competing messages. Hence, it is observed that the clinical groups perform better than the normals in terms of hearing efficiency and do not significantly differ or better than the performance of the telephone operators, i.e. they suffice the optimum criteria and in some case even better it. Hence, it is fallacious to consider that all types of hard of hearing subjects will obviously not be very efficient as telephone operators. On the contrary, these categories of hearing loss subjects may be preferred during selection of telephone operators. This augments the rehabilitation of the hard of hearing population, as also at the same time, providing for better efficiency to telephone subscribers.

The tables show the levels of performance and maximum performance for PB lists and the sentence scores for normals, telephone operators and the clinical group in the trunk exchange room, the subscriber telephone set up and only PB lists in the audiometric set up.

Reliability testing showed correlation. Hence, the test is reliable. Table gives the reliability coefficients for the normal and telephone operators in the audiometric, trunk exchange and the subscriber telephone set up.

TABLE - I

TELEPHONE OPERATORS: Audiometric Sound Treated Room Set Up

Code No.	Sex	Mother Tongue	10 dB SL	20 dB SL	30 dB SL	40 dB SL	PB Max	Level of PB Max in dB (HL)
D 1	M	Ka	88	96	100	100	100	50 – 60
2	F	Ka	76	88	92	92	92	50 – 60
3	F	Ka	68	84	88	88	88	50 – 60
4	M	Ka	84	92	92	92	92	40 – 50 – 60
5	M	Ka	88	96	100	100	100	50 – 60
6	M	Te	84	96	96	96	96	40 – 50 – 60
7	M	Ka	76	88	92	88	92	50 – 60
8	F	Tu	88	92	92	92	92	40 – 50 – 60
9	F	Ka	60	84	96	92	96	50 – 60
10	F	Ka	80	84	88	88	88	50 – 60
11	M	Ka	64	84	96	96	96	50 – 60
12	M	Ka	72	88	88	88	88	40 – 50
13	F	Ta	68	76	72	76	76	40 – 50
14	M	Ka	80	92	92	92	92	40 – 50 – 60
17	M	Ka	92	92	92	100	100	50 – 60
Mean			69.14	88.880	91.73	92.00	92.53	

(Scores are in percentage)

Codes used in all the Table:

M = Male, F = Female , Ka = Kannada, Ta = Tamil , Tu = Tulu, Te = Telugu, Ma = Malayalam, Hi = Hindi, Pu = Punjabi, Gu = Gujarathi, Be = Bengali, Ko= Konkani and Ur = Urdu, Co= Coorgi, Mr = Marathi, Or = Oriya.

TABLE - II

TELEPHONE OPERATORS: Subscriber Telephone set up.

Code No.	Sex	Mother Tongue	80 dB SPL	90 dB SPL	100 dB SPL	PB Max	Level of PB Max in SPL	Sentence scores
D 1	M	Ka	72	84	80	84	90	4
2	F	Ka	92	88	84	92	80	4
3	F	Ka	100	92	92	92	100	3
4	M	Ka	76	80	80	80	90-100	5
5	M	Ka	80	88	92	92	92	4
6	M	Te	84	92	96	92	100	4
7	M	Ka	76	88	92	92	100	5
8	F	Tu	72	72	76	76	100	3
9	F	Ka	72	88	84	88	90	4
10	F	Ka	84	88	88	88	90-100	5
11	M	Ka	68	68	84	88	100	4
12	M	Ka	80	88	88	88	90-100	4
13	F	Ta	68	76	72	76	90	3
14	M	Ka	44	72	72	72	90-100	4
17	M	Ka	80	92	88	92	90	5
Mean			76.53	80.40	84.53	86.40		4.06

All PB list scores for all Tables are given in percentage.

Sentence scores are given out of a maximum of 5 points, in all the Tables.

TABLE - III

TELEPHONE OPERATORS: Trunk Exchange Room Set Up.

Code No.	Sex	Mother Tongue	80 dB SPL	90 dB SPL	100 dB SPL	105 dB SPL	PB Max	Level of PB Max in SPL	Sentence scores
D 1	M	Ka	60	64	96	-	96	100	3
2	F	Ka	16	48	64	68	68	110	4
3	F	Ka	16	60	64	68	68	110	3
4	M	Ka	16	60	68	60	68	100	5
5	M	Ka	76	88	80	84	88	90	4
6	M	Te	68	76	84	84	84	100-105	5
7	M	Ka	40	60	84	80	84	100	4
8	F	Tu	10	60	60	60	60	90-100-105	3
9	F	Ka	72	72	72	60	72	80-90-100	4
10	F	Ka	72	76	80	84	84	110	3
11	M	Ka	32	68	60	76	76	110	5
12	M	Ka	44	68	80	76	80	100	3
13	F	Ta	36	60	72	80	80	110	3
14	M	Ka	16	44	56	-	56	100	3
15	M	Ka	16	28	32	-	32	100	4
16	M	Ka	84	88	100	76	100	100	-
17	M	Ka	80	92	84	80	92	90	-
Mean			44.70	65.41	72.70	74.32	75.76		3.73

TELEPHONE OPERATORS : Exposed to PB lists before test.

18	F	Ka	64	88	88	92	92	100	-
19	F	Ka	72	92	92	88	92	100	-
20	F	Ka	76	88	88	84	88	100	-
21	M	Ta	84	92	92	92	92	90-100-105	-
22	F	Ka	80	92	96	92	96	100	-

TABLE – IV

NORMALS: Audiometric Sound Treated Room Set Up.

Code No.	Sex	Mother Tongue	10 dB SL	20 dB SL	30 dB SL	40 dB SL	PB Max	Level of PB Max in dB (HL)
a 1	F	Ta	68	92	100	100	100	30-40
2	F	Ka	72	88	92	96	96	40
3	F	Gu	60	80	92	100	100	40
4	M	Ka	76	82	96	100	100	40
5	M	Pu	72	80	88	96	96	40
6	M	Ka	84	92	92	100	100	40
7	M	Ka	84	76	88	84	88	40
8	F	Ka	64	68	84	92	92	40
9	F	Ka	72	92	92	96	96	40
10	F	Ka	72	68	64	80	80	40
11	M	Or	72	80	88	84	88	40
12	M	Be	56	76	96	96	96	40
13	M	Hi	52	72	92	96	96	40
b 1	M	Gu	56	84	88	88	88	30-40
2	M	Ta	80	88	100	100	100	30-40
3	M	Ma	84	92	96	96	96	30-40
4	M	Ka	80	84	92	96	96	40
5	M	Hi	88	100	100	100	100	20-30-40
6	M	Te	84	84	96	100	100	40
7	M	Ka	48	72	80	100	100	40
8	F	Ko	60	88	96	100	100	40
9	F	Te	92	100	100	100	100	20-30-40
10	F	Ur	72	88	96	100	100	40
11	F	Ka	96	96	100	100	100	30-40
12	F	Ta	76	88	92	100	100	40
13	F	Ka	80	100	100	100	100	20-30-40
14	F	Ta	76	80	88	80	88	30
15	F	Ko	84	92	96	96	96	30-40
16	M	Hi	76	84	80	84	88	30
17	M	Ka	92	96	100	100	100	30-40
18	M	Ma	76	88	96	96	96	30-40
19	M	Ta	72	84	92	100	100	40
Mean			74.25	85.43	92.50	95.50	95.81	

TABLE – V

NORMALS: Subscriber Telephone Set Up.

Code No.	Sex	Mother Tongue	80 dB SPL	90 dB SPL	100 dB SPL	PB Max	Level of PB Max in SPL	Sentence scores
i	F	Ka	76	88	100	100	1000	-
j	M	Ta	88	68	64	88	80	-
k	F	Gu	96	100	100	100	90-100	-
l	F	Ma	48	68	68	68	90-100	-
m	M	Ta	72	80	76	80	90-100	-
n	M	Ka	44	60	72	72	90	-
o	M	Ka	60	76	76	76	100	-
p	M	Ka	60	76	76	76	90-100	-
q	M	Ka	80	80	80	80	80-90-100	-
a12	M	Be	88	88	92	92	100	4
b19	M	Ta	100	88	76	100	80	5
b16	M	Hi	72	80	76	88	90	5
b9	F	Te	100	100	92	100	80-90	5
b10	F	Ur	68	64	76	76	100	5
a3	F	Gu	76	80	80	80	100	5
b8	F	Ko	72	88	76	88	90	5
b2	M	Ta	64	92	88	92	90	2
a7	M	Ka	36	76	80	80	100	1
b5	M	Hi	100	100	100	100	80-90-100	5
a1	F	Ta	60	60	80	80	100	1
Mean			73.00	80.60	81.40			3.91

TABLE – VI

NORMALS: Trunk Exchange Room Set up

Code No.	Sex	Mother Tongue	80 dB SPL	90 dB SPL	100 dB SPL	105 dB SPL	PB Max	Level of PB Max in SPL	Sentence scores
a 1	F	Ta	4	0	24	16	24	100	1
2	F	Ka	4	0	12	24	24	110	0
3	F	Hi	32	48	48	60	60	110	3
4	M	Ka	16	33	48	40	48	100	2
5	M	Pu	56	68	72	72	78	100-105	4
6	M	Ka	20	60	48	60	60	90-105	4
7	M	Ka	8	16	48	20	48	100	1
8	F	Ka	4	16	24	20	24	100	0
9	F	Ka	0	20	40	8	40	100	0
10	F	Ka	-	4	40	40	40	100-105	0
11	M	Or	0	0	8	20	20	110	0
12	M	Be	20	36	80	80	80	100-105	4
13	M	Hi	40	40	48	44	48	100	2
b 1	M	Gu	24	36	56	60	60	110	2
2	M	Ta	32	52	64	64	64	100-105	3
3	M	Ma	36	56	56	44	56	90-105	2
4	M	Ka	44	60	44	52	60	90	2
5	M	Hi	72	64	80	76	80	100	2
6	M	Te	36	36	72	76	76	110	0
7	M	Ka	8	40	24	4	24	100	0
8	F	Ko	20	60	80	64	80	100	4
9	F	Te	8	24	36	20	36	100	4
10	F	Ur	0	32	48	48	48	100-105	2
11	F	Ka	16	40	40	24	40	90-105	2
12	F	Ta	12	44	48	40	48	100	4
13	F	Ka	12	32	44	20	44	100	0
14	F	Ta	8	24	12	20	24	90	0
15	F	Ko	20	28	52	48	52	100	1
16	M	Hi	28	32	56	48	56	100	0
17	M	Ka	68	64	56	64	68	80	2
18	M	Ma	16	40	40	20	40	90-105	1
19	M	Ta	32	72	48	44	72	90	2
Mean			22.45	35.93	40.50	41.87	50.50		1.64

TABLE – VIII **Test- Retest Reliability**

TELEPHONE OPERATORS: Audiometry Sound Treated Room Set Up.

Code	Mother Tongue	10 dB SL		20 dB SL		30 dB SL		40 dB SL		PB Max	
		Test	Retest	Test	Retest	Test	Retest	Test	Retest	Test	Retest
D 13	Ta	68	64	76	72	72	72	76	72	76	72
D 7	Ka	76	72	88	80	92	84	88	84	92	84
D 10	Ka	80	76	84	80	88	84	88	84	88	84
D 2	Ka	76	80	88	88	92	88	92	88	92	88
D 17	Ka	92	96	100	96	100	100	100	100	100	100
Reliability Coefficient Rtt		0.99		0.99		0.99		1.00		0.99	

NORMALS: Audiometric Sound Treated Room Set Up

b11	Ka	96	92	96	92	100	96	100	100	100	100
a10	Ka	72	68	68	72	64	68	80	72	80	72
a 9	Ka	72	76	92	88	92	92	96	92	96	92
a 8	Ka	64	58	68	72	84	88	92	96	92	96
a 8	Ko	60	56	58	84	96	92	100	96	100	96
Reliability Coefficient Rtt		0.66		0.99		1.00		0.99		0.99	

TELEPHONE OPERATORS: Subscriber Telephone Set Up.

Code	Mother Tongue	80 dB SL		90 dB SL		100 dB SL		PB Max	
		Test	Retest	Test	Retest	Test	Retest	Test	Retest
D 13	Ta	68	64	76	68	72	76	76	76
D 9	Ka	76	72	88	84	92	88	92	88
D 2	Ka	84	80	88	84	88	92	88	92
d 10	Ka	92	88	88	88	84	88	92	88
D 17	Ka	80	76	92	88	88	88	92	88
Reliability Coefficient Rtt		0.99		0.99		1.00		1.00	

NORMALS: Subscriber Telephone Set Up.

j	Ta	88	80	68	64	64	60	88	80
n	Ka	44	48	60	64	72	76	72	76
b 19	Ta	100	96	88	84	76	80	100	96
b 9	Te	100	96	100	100	92	96	100	96
b 5	Hi	100	100	100	96	100	96	100	100
Reliability Coefficient Rtt		0.99		1.00		1.00		0.99	

TABLE – VIII **Test- Retest Reliability**

TELEPHONE OPERATORS: Trunk Exchange Room set up.

Code	Mother Tongue	80 dB SL		90 dB SL		100 dB SL		105dB SL		PB Max	
		Test	Retest	Test	Retest	Test	Retest	Test	Retest	Test	Retest
D 12	Ka	44	48	68	60	80	76	76	76	80	76
D 6	Te	68	64	76	72	84	80	84	80	84	80
D 4	Te	16	24	60	52	68	60	60	64	68	60
D 3	Ka	16	20	60	60	64	64	68	64	68	64
D 2	Ka	16	20	48	48	64	60	68	64	68	64
Reliability Coefficient Rtt		0.99		0.96		0.98		0.98		0.98	

NORMALS : Trunk Exchange Room Set up.

a 4	Ka	16	24	32	36	48	40	40	44	48	44
a 5	Pu	56	60	68	64	72	68	72	68	72	68
b 2	Ta	32	28	52	48	64	68	64	68	64	68
b 6	Te	36	32	36	40	72	76	72	76	72	76
a 3	Or	32	32	48	44	48	52	48	52	48	52
Reliability Coefficient Rtt		0.91		0.97		0.98		0.98		0.98	

BILATERAL CONDUCTIVE HEARING LOSS SUBJECT (With Hearing Aid)

Trunk Exchange Room Set up

p 1	Ka	76	68	80	76	88	84	-	-	88	84
p 3b	Ma	68	64	68	64	88	84	-	-	88	84
p 4	Ka	68	64	80	76	88	84	-	-	88	84
p 5	Ka	76	72	88	80	88	84	-	-	88	84
Reliability Coefficient Rtt		0.98		0.98		1.00				1.00	

TABLE - IX

AUDIOMETRIC SOUND TREATED ROOM SET UP

Bilateral Mild and Moderate Conductive Hearing Loss Subjects.

Code No.	Mother Tongue	Sex	Age	Test Ear	10 dB SL	20 dB SL	30 dB SL	40 dB SL	PB Max
P 1	Ka	F	23	R	72	72	76	80	80
P2	Ur	M	25	L	56	60	88	88	88
P 3a	Ma	M	19	R	56	68	76	88	88
P 3b	Ma	M	19	L	60	60	76	76	76
P 4	Ka	M	18	L	60	72	76	80	80
P5	Ka	M	41	R	60	80	88	86	96
P 6	Ka	M	17	R	60	76	84	92	92
P 7a	Ma	M	40	L	72	72	88	96	96
P 7b	Ma	M	40	R	76	72	92	100	100
P 8a	Ka	M	25	L	64	76	76	92	92
P 8b	Ka	M	25	R	60	72	76	88	88
Mean					63.27	70.90	81.45	88.72	88.72

Unilateral Mild and Moderate Conductive Hearing Loss Subjects (With Hg. Aid)

(i. Hearing Loss Ear is Test Ear)

P 10a	Ka	M	23	R	88	92	96	100	100
P 11a	Ta	M	23	R	88	92	96	100	100
P 12a	Ka	M	25	R	20	80	84	84	84
Mean					36.00	82.66	86.66	92.00	92.00

Unilateral Mild and Moderate Conductive Hearing Loss Subjects (Without Hg. Aid)

(ii. Normal Ear is Tested)

P 9b	Ko	F	23	R	64	84	100	100	100
P 10b	Ka	M	23	L	76	96	96	100	100
P 11b	Ta	M	26	L	52	72	84	96	96
Mean					64.00	84.00	93.33	98.66	98.66

Bilateral Moderate High Frequency Hearing Loss Subjects (Without Hg. Aid)

P 12b	Ka	M	25	L	88	88	92	92	92
P 13	Ka	M	23	R	60	72	76	88	88
P 14	Ka	M	25	L	60	72	72	88	88
Mean					69.33	77.33	80.00	89.33	89.33

Cont…….

Unilateral Mild and Moderate High Frequency Hg. Loss Subjects (Test Ear Hg. Loss Ear)

P 15	Ka	M	35	R	60	68	60	72	72
P 7 b	Ma	M	40	L	72	72	88	96	96
Mean					66.00	70.00	74.00	84.00	84.00

Unilateral Mild and Moderate High Freq. Hg. Loss Subjects (Normal Ear is Test Ear)

P 16	Ma	M	18	R	56	72	88	88	88
P 17	Te	M	19	R	60	72	88	-	88
Mean					58.00	72.00	88.00	88.00	88.00

Bilateral Moderate Mixed Hearing Loss Subjects (With Hg. Aid)

P 18a	Ta	M	27	R	56	60	72	-	72
P 18b	Ta	M	27	L	52	56	68	-	68
P 19a	Ka	M	22	R	52	76	100	-	100
P 19b	Ka	M	22	L	80	96	100	-	100
Mean					60.00	72.00	85.00	-	85.00

TABLE - X SUBSCRIBER TELEPHONE SET UP

Bilateral Mild and Moderate Conductive Hearing Loss Subjects (With Hearing Aid)

Code No.	Sex	Age	Mother Tongue	Test Ear	80 dB SL	90 dB SL	100 dB SL	PB Max	Sentence Scores
P 1	F	23	Ka	R	72	84	84	84	4
P 2	M	23	Ur	L	68	84	92	92	4
P 3a	M	19	Ma	R	72	72	88	88	5
P 3b	M	19	Ma	L	68	76	88	88	5
P 4	M	18	Ka	L	60	76	88	88	4
P 5	M	41	Ka	R	76	84	92	92	5
P 6	M	17	Ka	R	40	56	84	84	2
P 7a	M	40	Ma	L	64	84	88	88	4
P 7b	M	40	Ma	R	52	80	84	84	4
P 8a	M	25	Ka	L	64	80	88	88	5
P 8b	M	25	Ka	R	72	84	92	92	5
Mean					64.36	78.54	88.00	88.00	4.09

Unilateral Mild and Moderate Conductive Hearing Loss Subjects (With Hg. Aid)

Hearing Loss Ear is Test Ear

P 9a	F	23	Ko	L	64	60	72	72	5
P 10a	M	23	Ka	R	76	76	80	80	3
P 11a	M	26	Ta	R	64	80	92	92	4
P 12a	M	25	Ka	R	44	76	80	80	4
Mean					62.00	73.00	80.00	80.00	4.00

Unilateral Mild and Moderate Conductive Hearing Loss Subjects (Without Hg. Aid)

Normal Ear is Test ear

P 9b	F	23	Ko	R	40	48	68	68	4
P 10b	M	23	Ka	L	72	80	80	80	2
P 11b	M	26	Ta	L	44	56	72	72	3
Mean					52.00	61.33	73.33	73.33	3.00

Bilateral Moderate High Frequency Hearing Loss Subjects (With Hg. Aid)

P 12b	M	25	Ka	L	48	72	76	76	3
P 13	M	23	Ka	R	64	76	80	80	4
P 14	M	25	Ka	L	64	72	80	80	4
Mean					58.00	73.33	78.66	78.66	3.66

Cont……..

Unilateral Mild and Moderate High Frequency Hg. Loss Subjects (Without Hg. Aid)

Test ear is Hearing loss ear.

P 15	M	35	Ka	R	60	68	76	76	3
P 7 b	M	40	Ma	L	64	84	88	88	4
Mean					62.00	76.00	82.00	82.00	3.50

Unilateral Mild and Moderate High Freq. Hg. Loss Subjects (Without Hg. Aid)

Test ear is normal ear.

P 16	M	18	Ma	R	68	76	80	80	3
P 17	M	19	Te	R	68	72	72	72	3
Mean					68.00	74.00	76.00	76.00	3.00

Bilateral Moderate Mixed Hearing Loss Subjects (With Hg. Aid)

P 18a	M	27	Ta	R	40	40	52	52	1
P 18b	M	27	Ta	L	44	48	52	52	1
P 19a	M	22	Ka	R	84	88	88	88	2
P 19b	M	22	Ka	L	80	76	88	88	2
Mean					62.00	63.00	70.00	70.00	1.50

TABLE - XI
TRUNK EXCHANGE ROOM SET UP

Bilateral Mild and Moderate Conductive Hearing Loss Subjects With Hearing Aid.

Code No.	Sex	Age	Mother Tongue	Test Ear	80 dB SL	90 dB SL	100 dB SL	PB Max	Sentence Scores
P 1	F	23	Ka	R	76	80	88	88	4
P 2	M	25	Ur	L	60	84	88	88	4
P 3a	M	19	Ma	R	64	72	92	92	4
P 3b	M	19	Ma	L	68	68	88	88	4
P 4	M	18	Ka	L	68	80	88	88	4
P 5	M	41	Ka	R	76	88	88	88	5
P 6	M	17	Ka	R	72	88	92	92	2
P 7a	M	40	Ma	L	60	80	96	96	3
P 7c	M	40	Ma	R	44	60	44	60	3
P 8a	M	25	Ka	L	60	80	88	88	3
P 8b	M	25	Ka	R	64	76	88	88	4
Mean					64.72	77.81	88.45	86.90	3.63

Unilateral Mild and Moderate Conductive Hearing Loss Subjects with Hg. Aid

Hearing Loss Ear is the test ear

P 9a	F	23	Ko	L	56	76	52	76	4
P 10a	M	23	Ka	L	78	80	84	84	3
P 11a	M	26	Ta	R	76	92	92	92	5
P 12a	M	25	Ka	R	64	68	76	76	3
Mean					67.00	79.00	76.00	82.00	3.75

Unilateral Mild and Moderate Conductive Hearing Loss Subjects Without Hg. Aid

Normal Ear is Test ear

P 9b	M	23	Ko	R	28	40	64	64	5
P 10b	M	23	Ka	L	68	80	88	88	2
P 11b	M	26	Ta	L	44	44	64	64	4
Mean					40.00	54.00	72.00	72.00	3.66

Bilateral Moderate High Frequency Hearing Loss Subjects Without Hg. Aid

P12b	M	25	Ka	L	52	60	64	64	3
P 13	M	23	Ka	R	64	76	76	76	4
P 14	M	25	Ka	L	56	64	76	76	3
Mean					57.33	66.66	72.00	72.00	3.33

Cont…….

Unilateral Mild and Moderate High Frequency Hg. Loss Subjects (Without Hg. Aid)

Test ear is Hearing loss ear.

P 15	M	35	Ka	R	36	48	64	64	3
P 7 b	M	40	Ma	L	60	80	96	96	3
Mean					48.00	64.00	80.00	80.00	3.00

Unilateral Mild and Moderate High Freq. Hg. Loss Subjects Without Hg. Aid

Test ear is normal ear.

P 16	M	18	Ma	R	60	68	76	76	3
P 17	M	19	Te	R	64	68	68	68	2
Mean					62.00	68.00	72.00	72.00	2.50

Bilateral Moderate Mixed Hearing Loss Subjects with Hg. Aid

P 18a	M	27	Ta	R	28	36	36	36	1
P 18b	M	27	Ta	L	36	40	40	40	1
P 19a	M	22	Ka	R	84	96	84	96	2
P 19b	M	22	Ka	L	80	88	88	88	1
Mean					47.00	65.00	62.00	65.00	1.25

TABLE – 12

PILOT EXPERIMENT NO. 2.

Code No.	80 dB SPL	90 dB SPL	100 dB SPL	70 dB SPL	Level of Max. Performance- dB	PB Max (%)
a	76	80	84	76	100	84
b	52	76	60	72	90	76
c	52	64	68	76	70	76
d	64	52	72	56	100	72
e	36	48	56	36	100	56
f	40	48	44	52	70	52
g	60	60	56	60	70,80,90	60
h	52	60	68	20	100	68
Mean	54	61	63.5	56		68

PILOT EXPERIMENT No. 4

i	76	88	100	-	100	100
j	88	68	64	-	80	88
k	96	100	100	-	90,100	100
a	100	100	100	-	80,90,100	100
m	72	80	76	-	90	100
l	48	68	68	-	90,100	100
n	44	60	72	-	100	72
o	60	78	78	-	90,100	78
p	68	86	68	-	90	86
q	80	80	80	-	80,90,100	80
r	88	88	92	-	100	92
s	100	88	76	-	80	100
Mean	96.6	82	82	-		87

TABLE – 13

AVERAGE NOISE LEVELS MEASURED WITH SPL METER DURING EXPERIMENTAL SESSIONS.

1. Send End Telephone Room: A Scale - 54 dB SPL

B ” - 54 dB ”

C ” - 70 dB ”

Cont…….

2. Subscriber Telephone Set Room: Receiver End

A Scale	-	55 dB SPL
B ”	-	58 dB ”
C ”	-	70 dB ”

3. Trunk Exchange Room: Receiver End

Large Boards		**Centre**		**Small Boards**	
A Scale	- 74 dB SPL	A Scale	- 68 dB SPL	A Scale	- 68 dB SPL
B ”	- 68 dB ”	B ”	- 68 dB ”	B ”	- 70 dB ”
C ”	- 85 dB ”	C ”	- 90 dB ”	C ”	- 92 dB ”

Noise levels in Audiometric sound treated at Audiology Dept. of AIISH.

A	B	C	L	31.5	63	125	250	500	1K	2K	4K	8K	16K	31.5K
22	22	34	45	28	28	19	14	12	14	10	12	9	20	21

Key for all the Graphs

Normals: Black

Telephone Operators: Blue.

Conductive Hearing Loss: Green

i) Continuous line: Bilateral with hearing aid.

ii) Broken line: Unilateral a) Dash: Hearing Loss ear is test ear

b) Dotted: Normal ear is test ear.

High frequency hearing loss: Red

i) Continuous line: Bilateral

ii) Broken line: Unilateral a) Dash: Hearing loss ear is test ear.

b) Dotted: Normal ear is test ear.

Mixed Hearing loss: Violet

In graphs 1, 2, a3

Abscissa = PB Max and Presentation level in dB SPL. 6mm = 1 dB

Ordinate = % discrimination score 3mm = 1 %

In graph 4,

Y axis = 10 % = 3 mm

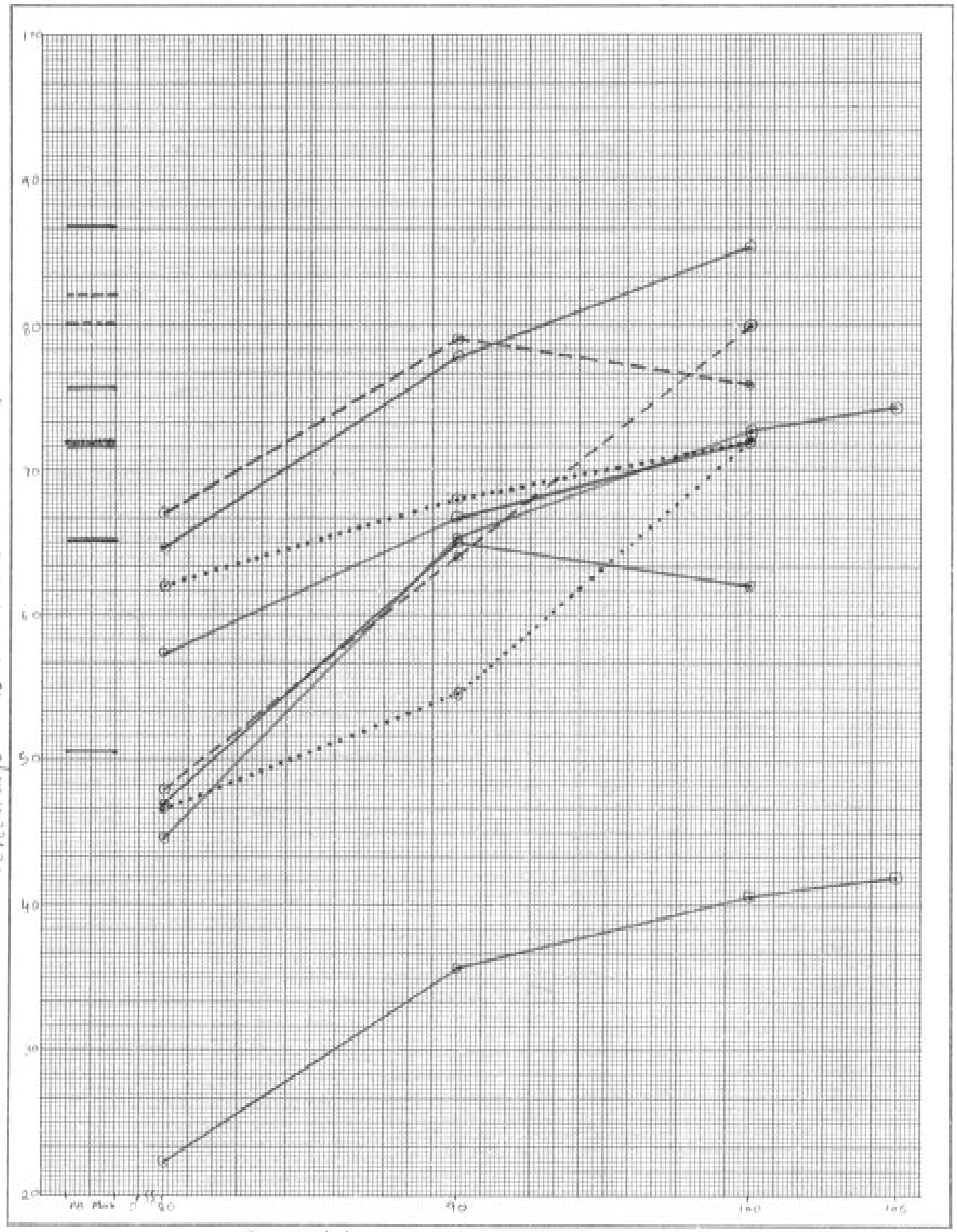
X axis = different groups of subjects.

In graphs 5,

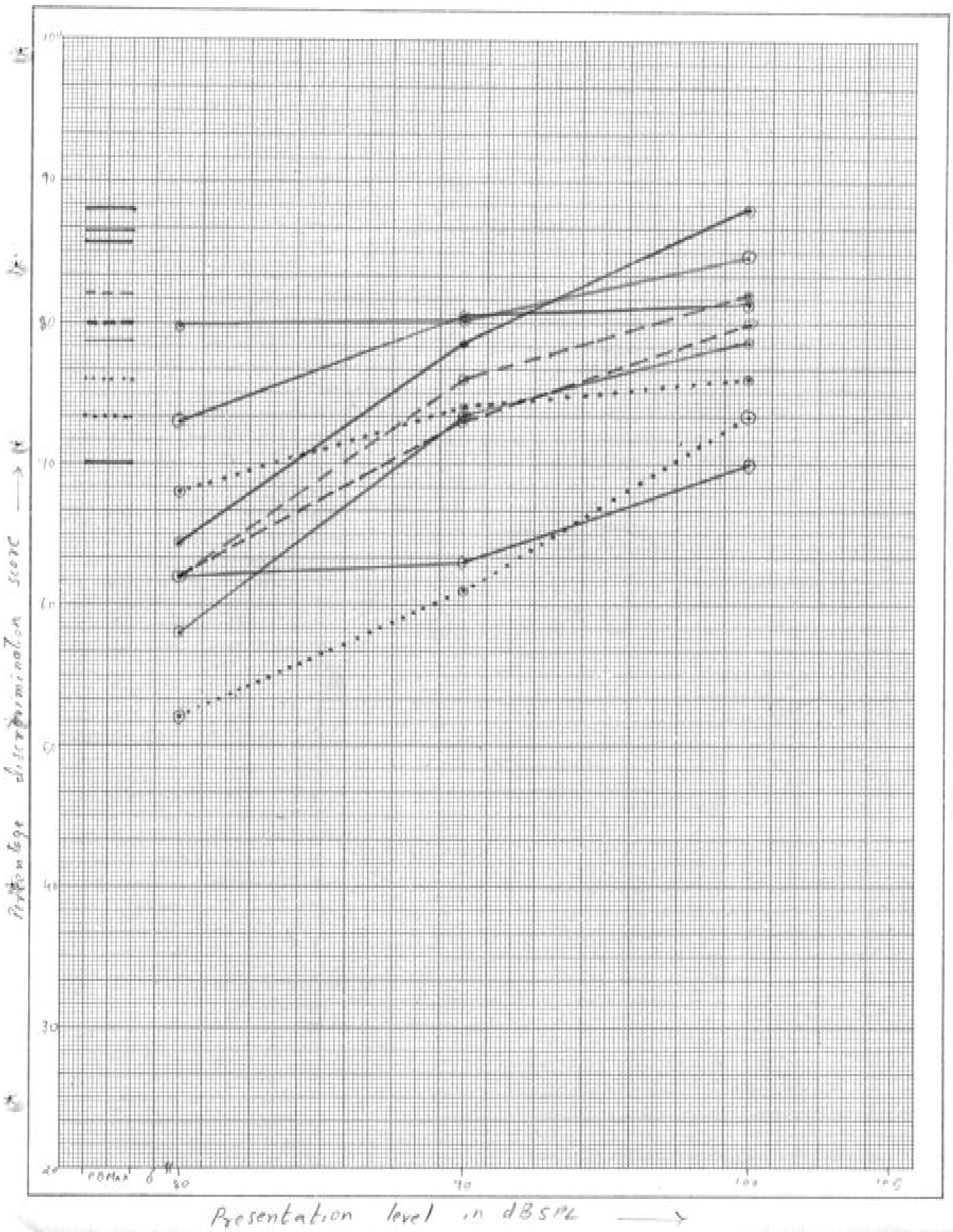
Y axis = 30 mm = 1 point

X axis = different groups of subjects.

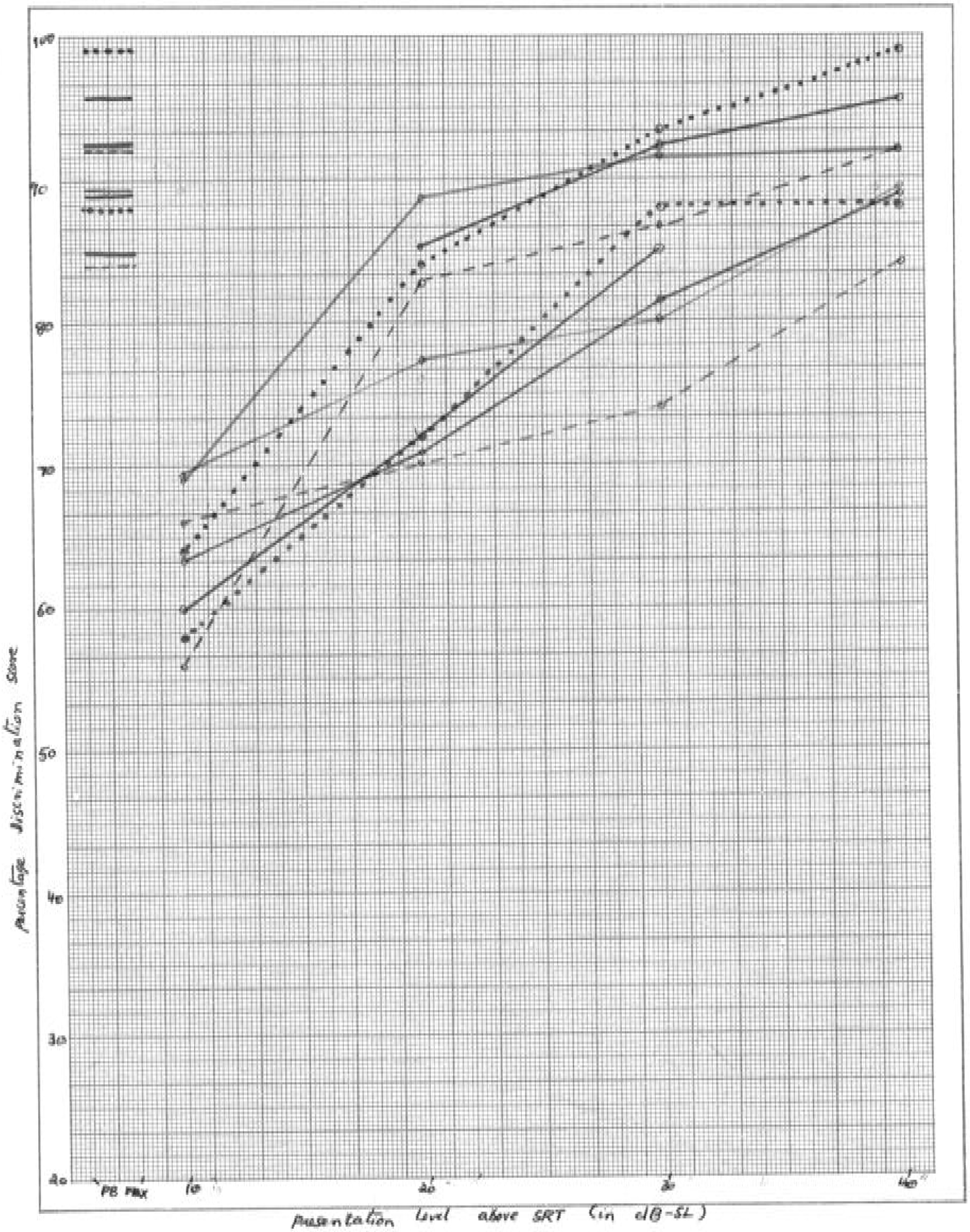
over the phone received in the Trunk Exchange Room.



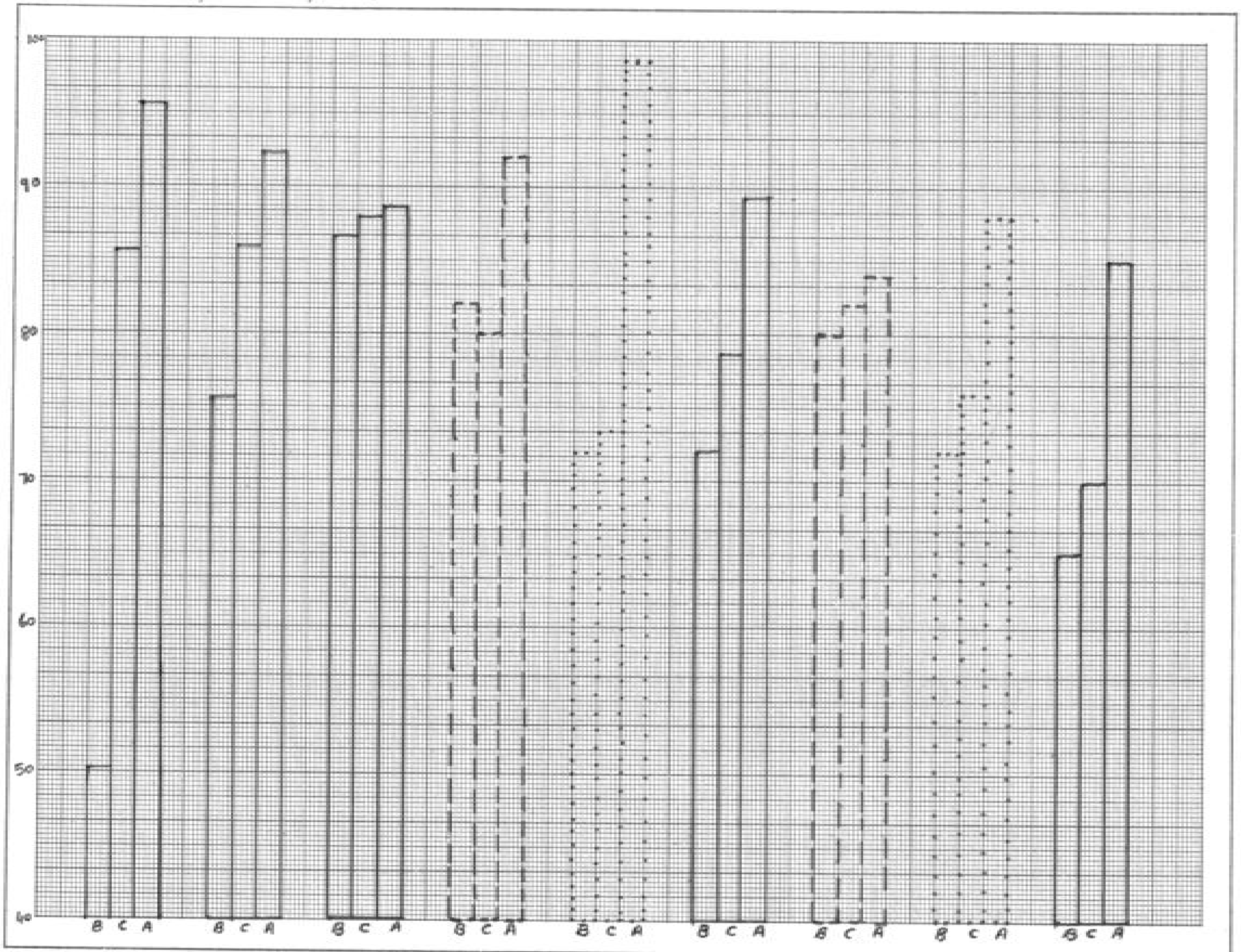
[2] Graph showing the performance of different groups for PB lists received over the phone in the subscriber Tel. set



[3] in standard speech audiometry

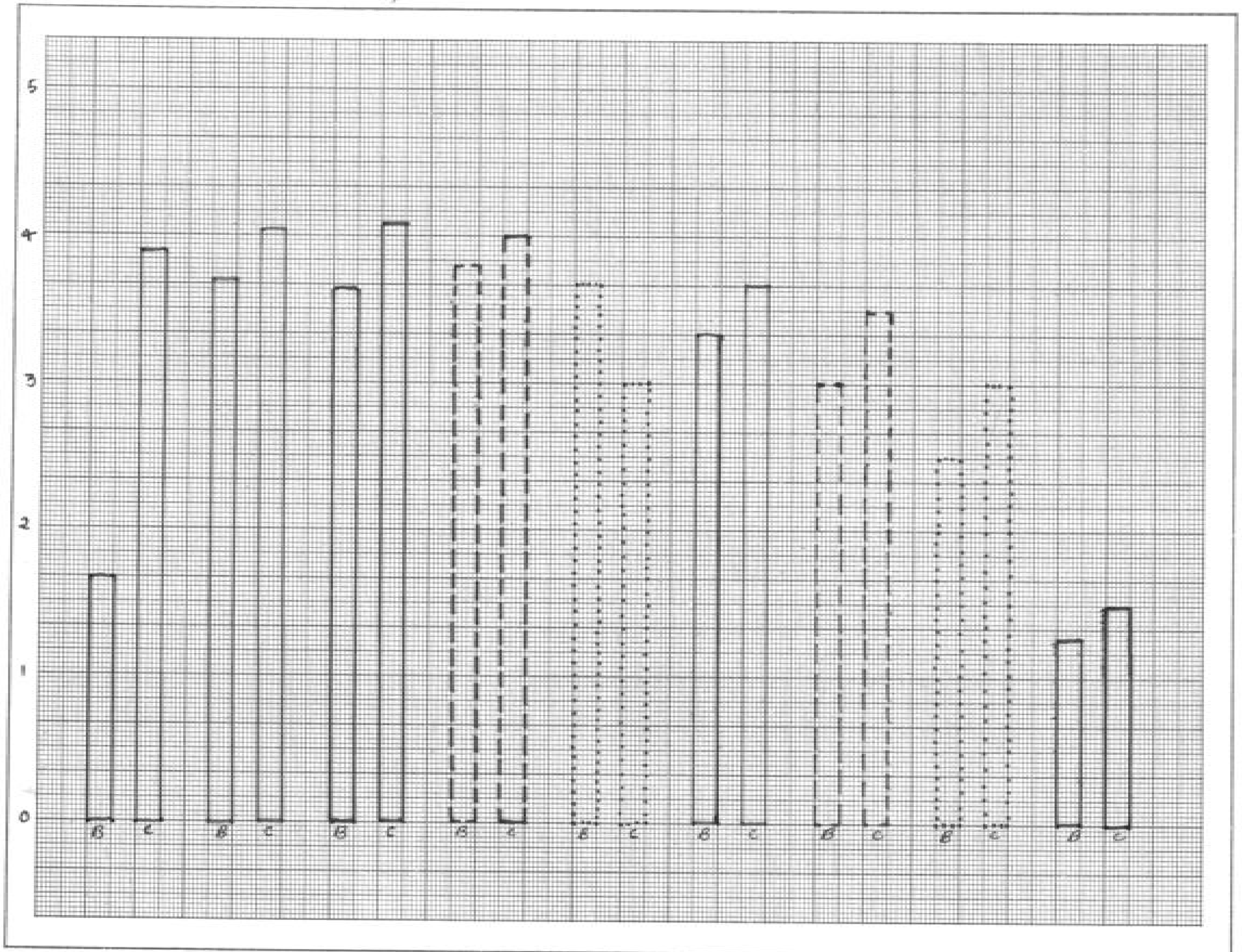


4] P.B. Max performance of the various groups for PB lists in Standard Speech Audiometry (A), Trunk Exchange set up (B), and Subscriber Tel set (C)



-] P.B. Max performance of the various groups for PB lists in Standard Speech Audiometry (A), Trunk Exchange Set up (B), and Subscriber Tel set (C)

5] Performance of the various groups to Sentence Test material received over the phone in the Trunk Exchange Room and Subscriber Tel set



5] Performance of the various groups to Sentence Test Material received over the phone in the Trunk Exchange Room (B) and Subscriber Tel. set (C)

CHAPTER - V

Summary and Conclusion

The Government of India had indicated to the all India Institute of Speech and Hearing, to develop standardized tests for fixing the levels of hearing which is essential for a telephone operator to perform his duty efficiently. The problems becomes more acute when a telephone operator, who is already appointed developed a hearing problem. Even during recruitment, no standardized hearing test has been specified by the government to judge the hearing efficiency of the applicants is terms of telephone speech in trunk exchange environments.

This study was therefore undertaken by the investigator to develop and standardize a hearing test for telephone operators over the telephone in realistic conditions of listening environment.

Speech audiometry provides a measure of the listener's response to speech. The telephone transmits speech frequencies ranging from 300 Hz to 3. 4 KHz. Speech audiometry does not reflect the performance of a listener over the telephone. Speech discrimination testing over the telephone hence, provides the yardsticks to judge the hearing efficiency of the telephone operators.

For discrimination testing, conventionally PS monosyllables were used, with reference to Indian conditions, Swarnalatha (1972) had developed a PS list meant for English speaking population. Naguraja (1973) had developed a synthetic speech identification test meant for Kannada speaking using disyllabic words in Telugu, Tamil and Malayalam. Abrol (1971) and De (1973) developed test material in Hindi. The above materials were developed for clinical discrimination testing in standing speech audiometry.

So, an attempt was made to develop and standardize a discrimination testing procedure over the telephone. For this purpose, PB lists standardized on Indian population and sentences made sentences made from frequently heard words, phrases and digits were used at test materials.

The final procedure for administering the test was arrived at, after a series of five pilot experiments. The PB lists and the sentences were presented live voice by a male speaker on to a subscriber telephone no. 22502. The handset of the telephone was kept in normal talking position and the intensity of the input was monitored by an SPL meter, placed such that its condenser microphone and the telephone transmitter were equidistant from the lips. The four PB lists were presented at 80 dB SPL, 90 dB SPL, 100 dB SPL and 105 dB SPL respectively. The sentences were presented at 100 dB SPL. The noise level in the send end telephone room was round 70 dB (C scale).

The test materials were received through the headgear set (ITI manufactured) in the Mysore telephone exchange room through the boards and in a subscriber telephone no. 20715 at the All India Institute of Speech and Hearing.

Three groups of subjects were tested – normals, telephone operators and the clinical group. The clinical group was provided with otican extra supra super hearing aid wherever deemed necessary. Most of the subjects were provided with custom made ear moulds. A few of them were provided with stock ear moulds.

All the subjects were screened for their hearing in the audiometric set up. For clinical group, the entire audiological test battery was administered. The four PB lists were presented at 10 dB, 20 dB, 30 dB and 40 dB above their SRT's for normals and telephone operators, it was presented at 30 dB HL, 40 dB HL, 50 dB HL and 60 dB HL. PI functions were plotted and PB max was found.

For al the groups, PI functions were also plotted for PB lists in the trunk exchange room set up and the subscriber telephone set up. These tests were done after sufficient laps of time of eliminate the practice effect.

The performance of these groups was compared using non-parametric statistics –viz. Mann-Whitney test for independent samples and Wilcoxon signed rank test for dependent samples (Conover, 1971).

The test-retest reliability was established by computing the reliability coefficient (Garret, 1971) between test rest scores.

The following conclusions were made from the study:

1. The mean PB max for PB lists performance for normals in the trunk exchange room set up is 50, 50%. This may be considered as the minimal level of performance required in terms of the hearing efficiency over the phone, for normals who apply for the job of a telephone operators. (PB max in %)

2. The mean PB max for PB lists performance for the telephone operators in the trunk exchange room set up is 75.76%. This may be considered as the optimum level of performance desired in terms of hearing efficiency over the phone for persons who apply for the job of a telephone operator.

3. The performance of the normals for PB lists in standard speech audiometry is significantly better than over the telephone received in trunk exchange room.

4. The performance of the telephone operators for PB lists standard speech audiometry is significantly better than over the telephone received in the trunk exchange room.

5. The performance of normals for PB lists in standards speech audiometry is significantly better than over the telephone received in a subscriber telephone set.

6. The performance of the telephone operators for PB lists in standard speech audiometry is better than over the telephone received in a subscriber telephone set.

7. The performance of the bilateral moderate conductive hearing loss subjects with hearing aid for PB lists received over the phone is the trunk exchange room does not significantly differ from their performance in standard speech audiometry.

8. The performance of the bilateral moderate conductive hearing loss subjects with hearing aid for PB lists received over the phone in the subscriber telephone set does not significantly differ from their performance in standard speech audiometry.

9. The performance of bilateral moderate high frequency hearing loss subjects without hearing aid for PB lists received over the phone in the trunk exchange room does not significantly differ from the performance in standard speech audiometry.

10. The performance of the bilateral moderate mixed hearing loss subjects with hearing aid for PB lists received over the phone in the trunk exchange room doe not significantly differ from their performance in standard speech audiometry.

11. The performance of the bilateral moderate high frequency hearing loss subjects without hearing aid for PB lists received over the phone in the subscriber telephone set does not significantly differ from their performance in standard speech audiometry.

12. The performance of the bilateral moderate mixed hearing loss subjects with hearing aid for PB lists received over the phone in the subscriber telephone set does not significantly differ from their performance in standard speech audiometry.

13. The performance of the telephone operators for PB lists received over the phone in the trunk exchange room in significantly better than the normals.

14. The performance of the telephone operators for PB lists received over the subscriber telephone set does not significantly differ from that of normals.

15. Males perform significantly better than females (normal group) for PB lists received over the phone in the trunk exchange room.

16. There exists no significant difference in the performance of males and females (normal group) for PB lists, received over the phone in the subscriber telephone set up.

17. There exists no significant difference in the performance of males and females (normal group) for PB lists in standard speech audiometry.

18. There exists no significant difference in the performance of meals and females (telephone operators) for PB lists received over the phone in the trunk exchange room.

19. There exists no significant difference in the performance of males and females (telephone operators group) for PB lists received over the phone in the subscriber telephone set.

20. There is no significant difference in the performance of males and females (telephone operators group) for PB lists in the standard speech audiometry.

21. The performance of the normals for PB lists received over the phone is significantly better in the subscriber telephone set than in the trunk exchange room set up.

22. The performance of the telephone operators for PB lists received over the phone is significantly better in the subscriber telephone set than in the trunk exchange room set up.

23. There exists no significant difference between the performance of telephone operators who are exposed to the PB lists before the testing and those telephone operators who are not exposed to the PB lists before testing, when received over the phone in the trunk exchange room.

24. The bilateral moderate conductive hearing loss subjects with hearing aid performance significantly better than normals for PB lists received over the phone in the trunk exchange room.

25. The bilateral moderate conductive hearing loss subjects with hearing aid perform significantly better than the telephone operators for PB list received over the phone in the trunk exchange room.

26. There exists no significant difference in the performance of the bilateral moderate conductive hearing loss subjects with hearing aid and the normals for PB lists received over the phone in the subscriber telephone set.

27. There exists no significant difference in the performance of the bilateral moderate conductive hearing loss subjects with hearin aid and the telephone operators for PB lists received the phone in the subscriber telephone set.

28. The unilateral conductive hearing loss subjects with hearing aid (when hearing loss ear is the test ear) perform significantly better than the normals for the PB lists received over the phone in the trunk exchange room.

29. There exists no significant difference in the performance of the unilateral conductive hearing loss subjects with hearing aid (when the hearing loss ear is the test ear) and the telephone operators for PB lists received over the phone in the trunk exchange room.

30. There exists no significant difference in the performance of the unilateral conductive hearing loss subjects with hearing aid (when hearing loss ear is the test ear) and the normals for PB lists received over the phone in the subscriber telephone set.

31. There exist no significant difference in the performance of the unilateral conductive hearing loss subjects with hearing aid (when hearing loss ear is the test ear) and the telephone operators for PB lists received over the phone in the subscriber telephone set.

32. The unilateral conductive hearing loss subjects without hearing aid (when normal ear is the test ear) perform significantly better than the normals for PB lists received over the phone in the trunk exchange room.

33. There exists no significant difference in the performance of the unilateral conductive hearing loss subjects without hearing aid (when normal ear is the test ear) and the telephone operators for the PB lists received over the phone in the trunk exchange room.

34. There exists no significant difference in the performance of the unilateral conductive hearing loss subjects without hearing aid (when normal ear is the test ear) and the normals for PB lists received over the phone in the subscriber telephone set.

35. The unilateral conductive hearing loss subjects without hearing aid (when normal ear is test ear) perform significantly poorer than the telephone operators for PB lists received over the phone in the subscriber telephone set.

36. The bilateral moderate mixed hearing loss subjects with hearing aid perform significantly better then the normals for PB lists received over the phone

in the trunk exchange room.

37. The bilateral moderate mixed hearing loss subjects with hearing aid do not significantly differ from the normals in their performance for PB lists received over the phone in the trunk exchange room.

38. The bilateral moderate mixed hearing loss subjects with hearing aid to not significantly differ from the normals in their performance for PB lists received over the phone in the subscriber telephone set.

39. There exist no significant difference in the performance of the bilateral moderate mixed hearing loss subjects with hearing aid and the telephone operators for PB lists received over the phone in the subscriber telephone set.

40. There exists no significant difference in the performance of the bilateral conductive hearing loss subjects with hearing aid the PB list received over the telephone in the trunk exchange room and the subscriber telephone set.

41. There exist no significant difference in the performance of the unilateral high frequency hearing loss subjects without hearing aid (when test ear is hearing loss ear) for PB lists received over the phone in the trunk exchange room and in the subscriber telephone set.

42. The telephone operators perform significantly better than the normals for sentences received over the phone in the trunk exchange room.

43. There exist no significant difference in the performance of the normals and the telephone operators for sentences received over the phone in the subscriber telephone set.

44. There exist no significant difference in the performance of males and females (normals group) for sentences received over the phone in the trunk exchange room.

45. There exists no significant difference in the performance of males and females (normals group) for sentences received over the phone in the subscriber telephone set.

46. There exists no significant difference in the performance of males and females (telephone operators group) for sentences received over the phone in the exchange room.

47. There exists no significant difference in the performance of the males and females (telephone operators group) for sentences received over the phone in the subscriber telephone set.

48. Normals perform significantly better for sentences received over the phone in the subscriber telephone set than in the trunk exchange room.

49. There exist no significant difference in the performance of the telephone operators for sentences received over the phone in the trunk exchange room and the subscriber telephone set.

50. The bilateral moderate conductive hearing loss subjects with hearing aid perform significantly better than the normals for sentences received over the phone in the trunk exchange room.

51. The bilateral moderate conductive hearing loss subjects with hearing aid perform significantly better than the telephone operators for sentences received over the phone in the trunk exchange room.

52. There exist no significant difference in the performance of bilateral moderate conductive hearing loss subjects with hearing aid and normals for sentences received over the phone in the subscriber telephone set.

53. There exists no significant difference in the performance of the bilateral moderate conductive hearing loss subjects with hearing aid and the telephone operators for sentences received over the phone in the subscriber telephone set.

54. The unilateral conducive hearing loss subjects with hearing aid (when hearing loss ear is test ear) perform significantly better than the normals, for sentences received over the phone in the trunk exchange room.

55. The unilateral conductive hearing loss subjects with hearing aid (when hearing loss ear is test ear) do not significantly differ in their performance

56. The unilateral conductive hearing loss subjects with hearing aid (when hearing loss ear is the test ear) do not significantly differ in their performance from the normals for sentences received over the phone in the subscriber telephone set.

57. The unilateral conductive hearing loss subjects with hearing aid (when hearing loss ear is the test ear) do not significantly differ in their performance from the telephone operators for sentences received over the phone in the subscriber telephone set.

58. The bilateral moderate mixed hearing loss subjects with hearing aid do not significantly differ in their performance from the normals for sentences received over the phone in the trunk exchange room.

59. The bilateral moderate mixed hearing loss subjects with hearing aid perform significantly poorer than the telephone operators for sentences received over the phone in the trunk exchange room.

60. The bilateral moderate mixed hearing loss subjects with hearing aid do not significantly differ in their performance from the normals for sentences over the phone received in the subscriber telephone set.

61. The bilateral moderate mixed hearing loss subjects with hearing aid perform significantly poorer than the telephone operators for sentences received over the phone in the subscriber telephone set.

62. The bilateral moderate conductive learning loss subjects perform significantly better for sentences received in the subscriber telephone set than in the trunk exchange room.

63. The bilateral moderate hearing loss (high frequency) subjects without hearing aid perform significantly better than the normals for sentences received over the phone in the trunk exchange room.

64. The unilateral high frequency hearing los subjects without hearing aid (when normal ear is test ear) perform significantly better than the normals for sentences received over the phone in the trunk exchange room.

65. The bilateral moderate high frequency hearing loss subjects without hearing aid do not significantly differ in their performance from the telephone operators for sentences received over the phone in the trunk exchange room.

66. The unilateral high frequency hearing loss subjects with hearing aid (when normal ear is the test ear) perform significantly poorer than the telephone operators for sentences received over the phone in the trunk exchange room.

67. The bilateral moderate high frequency hearing loss subjects without hearing aid do not significantly differ in their performance from the normals for sentences received over the phone in the subscriber telephone set.

68. The unilateral high frequency hearing loss subjects without hearing aid (when normal ear is test ear) do not significantly differ in their performance form the normals for sentences received over the phone in the subscriber telephone set.

69. The bilateral moderate high frequency hearing loss subjects without hearing aid, do not significantly differ in their performance from the telephone operators for sentences received over the phone in the subscriber telephone set.

70. The unilateral high frequency hearing loss subjects without hearing aid (when normal ear is the test ear) do not significantly differ in their performance from telephone operators for sentences received in the subscriber telephone set.

71. For all the subjects, performance intensity function could be done while testing discrimination. The results indicated that to get maximum score PI function should be obtained, since the maximum score was obtained at different levels.

cont………

72. The responses for PB lists, analyzed revealed that words containing high frequency sounds and the nasals were mostly correct.

73. The responses for sentences analyzed revealed that digits and their sequencing of telephone numbers and initials of proper nouns were mostly correct.

The ambient noise reaching the non-test exposed ear affects the performance to listening to telephone speech in the test ear is varying degree in the different groups.

Experience in listening to telephone speech under noise conditions increase the vigilance of the listeners. Hence the telephone operators perform better than the normals.

The performance of normals subjects may be considered as the minimum level of performance in terms of hearing efficiency essential for normals to apply for the telephone operators job.

The performance of normal hearing telephone operators may be considered as the optimum level of performance for hearing efficiency essentials for persons to apply for operators jobs.

The standard speech audiometric discrimination test does not reflect the efficiency of a listener over a telephone listening in the trunk exchange room or in the subscriber telephone set, under different environmental conditions.

Persons who apply for telephone operators jobs should undergo a hearing test for discrimination over the telephone and must satisfy the minimum levesl of performance as seen in normals. Optimum levels of performance may be preferred.

“A person who is hard of hearing obviously cannot be efficient as a telephone operator” is not true.

The different categories of the hearing problems react differently, when an amplified signal is fed to their ears. The amplification provided by the hearing aid sis louder than the level of the signal received in the headgear set or the telephone receiver.

The hearing loss in the non-test ear (exposed ear) may be considered as an advantage for telephone communication, as hearing loss overcomes the interference of environmental noise and competing messages.

The clinical groups, therefore perform better than the normals in terms of hearing efficiency i.e they suffice the optimum criteria and in some cases, even better it. Hence, these categories of hearing loss subjects may be preferred, during selection for telephone operators obs. The results augment rehabilitation of the hard of hearing population, as also providing for better efficiency to the telephone subscribers.

IMPLICATIONS OF THE STUDY:

Discrimination testing over the telephone in actual environmental condition is important to judge the hearing efficiency of a subject who is to be appointed as a telephone operator or who is already working as a telephone operators and has developed a hearing problem.

This test could be used as a speech discrimination test in all the circles telephone districts while recruiting telephone operators and also a periodic check up of the telephone operators who are already recruited.

This test could be administered to the hard of hearing population to find their suitability to be employed as a telephone operator.

This test could be administered by any recruiting officer, in any of the telephone exchanges.

This test suggests that persons with certain types of hearing problems with the help of a hearing aid are ideally suited to function as telephone operators in terms of hearing efficiency.

LIMITATIONS OF THE STUDY:

1. This study was limited to the equipment of Mysore city.

2. It would have been better if study was conducted on more number of hearing loss subjects.

3. Strict control on environmental noise could be achieved because of practical problems. However, the time of listening and overall noise level were taken into account as for as possible.

4. Test retest reliability testing could not be done in most of the subjects of the clinical population due to their non-availability.

Recommendations for further Research

1. Standardizing the test on larger clinical and normal population.
2. Standardizing the test at various trunk exchanges of the county.
3. Developing synthetic sentence test materials for discrimination testing over the phone in different languages.
4. Standardizing the test using standardizing monosyllabic lists in various regional languages.
5. Standardizing the test on long distance national and international trunk net works.
6. Standardizing the test on all the available types of telephone sets and type of new work in the country.
7. Developing headgear receiver sets, which could completely fit on body level or ear level type of hearing aids.
8. Test may be developed using conversational speech since they are more natural in all languages.

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APPENDICES

Four lists of PB words

I	II	III	IV
leave	given	move	ran
bill	poor	year	ten
oil	with	my	what
fate	her	hand	kite
two	near	though	start
arm	kite	deaf	does
deaf	young	bill	give
then	ten	oil	near
year	ran	oil	near
my	does	leave	with
hand	start	ten	young
move	what	fate	leave
through	arm	poor	fate
start	year	give	two
kite	my	her	bill
ten	move	young	oil
does	hand	with	then
what	though	near	deaf
ran	deaf	what	arm
with	two	ran	hand
poor	oil	start	though
give	fate	then	year
young	bill	does	move
near	leave	kite	my
her	then	arm	her

Sentence Test Material

1. Hello, 20715 speaking.
2. Which are the English pictures showing now
3. Give me the number of K.S. Basaviaih.
4. Urgent call to Mangalore number 42596.
5. Ticket number I for India 387

(Key words are underlined).

APPENDIX – III

Experiment conducted at Indian Telephone Industries (Bangalore to measure reference equivalent measurements with telephone Type 332 using objective Reference Equivalent Meter:

I. Reference equivalent meter gives integrated Volume/loudness efficiency developed in the 6 C.C. coupler using objective reference equivalent meter.

Reference equivalent measurements were taken on operators headgear set by connecting the operators headgear set in the exchange operators telephone circuit. A 332 type telephone was sued as in the sending telephone. The hand set of 332 type telephone was mounted on the test head of B & K OREM – B equipment. A cable of 3.7 miles of 6 and half 1bs/miles was used to simulate the worst condition. The SPL at the transmitter of the sending telephone was 10.75 dynes/sq.cm equivalent to 94.6 dB SPL. The SPL developed in the 6 c.c. coupler to which the headgear set receiver was coupled was also measured. The readings are as follows:

1. OREM – A reading + 9 dB
2. SPL measures on spectrometer – varied from 90 to 96 dB and
3. Overall frequency response of the sending transmitter and the headgear set receiver was also observed on B & K response tracer 3352 system. The readings were plotted on calibrated graph paper.

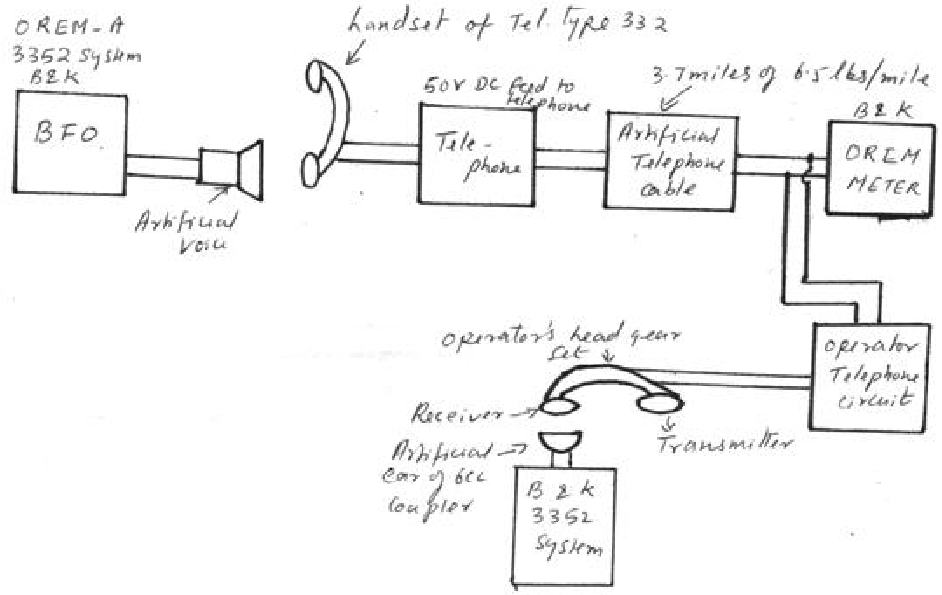
CCITT testing method for operators headgear set result – OREM – A Receiving + 3.5 dB. This test indicates that two operators telephone circuit gives sufficient listening level and meets the CCITT recommendations.

II. Experiments were also conducted to know the extend of increase/decrease in the loudness of operator's headgear set receiver by corresponding increase / decrease in SPL at the artificial voice at

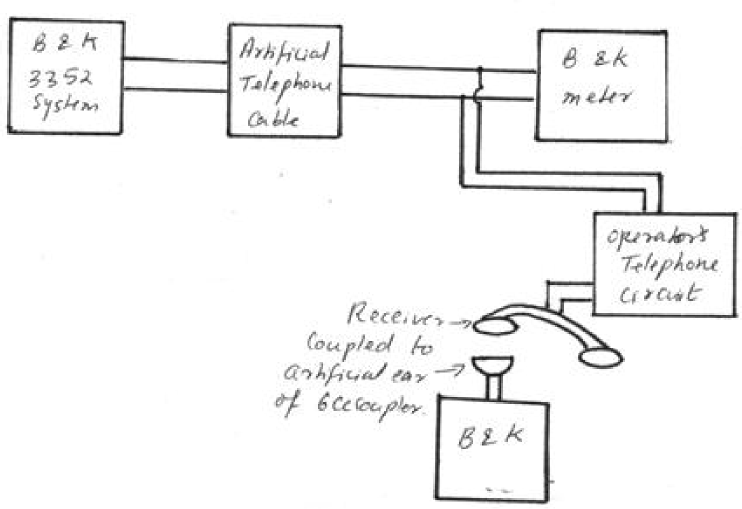
at 94.6 = + 10 dB } only 2 dB increase
at 104.6 = + 9 dB }
at 84.6 = + 16 dB - only 4 dB reduction

This is because of the non-liner distortion and saturation effect of the transmitter and receiver. The equipmental arrangements are shown in block diagrams.

[19] Block Diagram for Reference Equivalent Measurements



[20] Receiving Reference Equivalent Measurement: Block Diagram



AUDIOMETRIC THRESHOLDS: Bilateral Conductive Hearing loss (Mild & Moderate).

Code No		Ear	250 Hz	500 Hz	1 K Hz	2 K Hz	4 K Hz	6 K Hz	8 K Hz	SRT
P1	AC	R	60	60	50	85	50	40	40	50
	BC		10	10	15	20	15			
	AC	L	65	65	50	40	40	45	35	60
	BC		5	15	15	20	5			
P2	AC	R	90	80	70	75	45	65	60	80
	BC		10	20	20	25	20			
	AC	L	65	55	50	60	45	40	70	55
	BC		10	15	25	35	30			
P 3a	AC	R	50	45	35	25	45	40	35	35
	BC		10	15	20	20	20			
3b	AC	L	60	55	45	30	55	35	30	35
	BC		5	15	5	15	15			
P4	AC	R	70	80	90	85	100	NR	NR	90
	BC		20	15	20	20	20			
	AC	L	50	45	30	15	40	15	25	30
	BC		15	15	10	10	20			
P5	AC	R	40	45	30	35	50	30	25	35
	BC		10	10	10	10	10			
	AC	L	55	50	35	35	45	40	25	35
	BC		5	10	10	5	5			
P6	AC	R	45	45	20	35	50	30	20	35
	BC		0	0	15	0	10			
	AC	L	35	25	15	10	20	20	15	20
	BC		10	10	10	10	10			
P 7b	AC	R	30	30	10	15	20	25	20	25
c	BC		20	20	10	20	5			
7ac	AC	L	25	30	5	10	10	40	30	25
	BC		20	20	10	20	5			
P 8b	AC	R	35	30	30	5	25	30	45	30
	BC		5	10	5	10	0			
8a	AC	L	40	25	35	25	35	45	45	45
	BC		5	5	10	5	5			

AUDIOMETRIC THRESHOLDS: Unilateral Conductive Hearing Loss (Mild & Moderate)

Code No		Ear	250 Hz	500 Hz	1 K Hz	2 K Hz	4 K Hz	6 K Hz	8 K Hz	SRT
P 9b	AC	R	20	15	0	5	35	10	10	15
	BC		10	10	0	0	5			
a	AC	L	55	50	50	30	50	55	65	50
	BC		15	10	15	15	15			
P 10a	AC	R	45	50	50	35	20	35	45	50
	BC		10	10	10	15	15			
b	AC	L	15	10	10	10	10	10	10	10
	BC		10	10	10	10	10			
P 11a	AC	R	20	15	25	10	35	30	15	20
	BC		5	5	5	5	15			
b	AC	L	10	15	15	10	20	25	5	15
	BC		5	5	5	5	15			
P 12 a	AC	R	25	20	30	30	40	50	60	25
	BC		10	15	5	20	10			

Bilateral Moderate High Frequency Hearing Loss

P 12b	AC	L	15	10	10	10	15	40	50	25
	BC		5	10	10	10	10			
P 13	AC	R	10	10	10	15	50	75	80	20
	BC		10	5	5	15	50			
	AC	L	10	10	10	10	50	95	85	15
	BC		5	10	10	10	30			
P 14	AC	R	30	35	35	30	30	60	70	30
	BC		10	15	15	15	25			
	AC	L	20	20	20	15	15	30	40	15
	BC		5	5	15	10	15			

AUDIOMETRIC THRESHOLDS: Unilateral High Frequency Hearing Loss (Mild & Moderate)

Code No		Ear	250 Hz	500 Hz	1 K Hz	2 K Hz	4 K Hz	6 K Hz	8 K Hz	SRT
P 15	AC	R	15	20	20	15	30	25	30	25
	BC		5	10	10	15	25			
	AC	L	15	15	20	20	25	25	25	20
	BC		5	10	10	15	25			
P 7b Audiogram shown earlier.										
P 16	AC	R	25	25	25	10	45	30	25	20
	BC		10	5	5	0	10			
	AC	L	25	25	15	5	10	15	10	15
	BC		10	5	5	0	10			
P 17	AC	R	10	15	15	10	40	55	35	20
	BC		10	15	15	10	15			
	AC	L	10	15	10	5	15	10	10	15
	BC		10	15	15	15	15			

Bilateral Moderate Mixed Hearing Loss

P 18a	AC	R	75	85	65	70	80	90	85	75
	BC		15	20	30	30	40			
b	AC	L	75	80	65	65	80	85	85	75
	BC		25	30	40	40	50			
P 19a	AC	R	60	50	55	50	45	55	50	60
	BC		15	20	15	25	25			
b	AC	L	40	45	40	30	25	50	60	45
	BC		25	25	15	30	20			

APPENDIX

THE TYPE 332 TELEPHONE INSTRUMENT

General

The type 332 telephone instrument is basically designed to meet the special requirements demanded by subtropical or fall tropical conditions. The design and the general appearance is pleasing. Each instrument t is entirely self-contained, the ringer and induction coil being accommodated, together with the other components, on a readily removable metal plate.

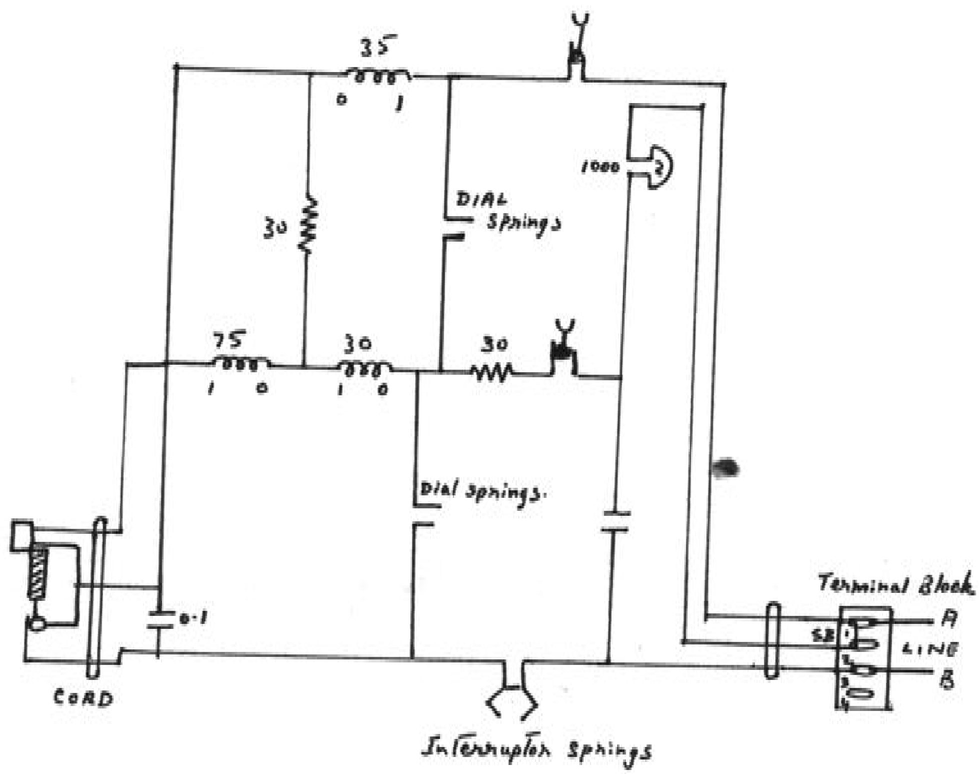
Handset

The handset is of the British Post Officer standard design incorporating an inset transmitter and an inset receiver.

Circuit

The standard circuit shown in Figure 4 incorporates an anti-sidetone induction coil (A.S.T.C.) with five windings. This coil gives improved sidetone suppressed on when compared with earlier circuits in which a spate antisidestone transformer was used. The reception properties of

[18] CIRCUIT DIAGRAM - TYPE 332 TELEPHONE



the latest model, the No. 27 (Mark I) induction coil, shows an improvement of nearly 3 db, as compared with the earlier No. 32 and 24 coils. The 30 ohms non-inductive windings of the induction coil, in conduction with the 2 microfarad capacitor, forms an effect absorption circuit across the impulse contacts of the dial during impulsing.

A.0.1microfarad capacitor is permanently connected across the transmitter and serves the double purpose of reducing radio interference to a minimum and elimination any tendency of the carbon granules to pack to current surges caused by automatic switching etc.

Instrument Wiring

The internal inter-point wiring of the instrument is by means of a small cable form, the individual wires being No. 25SWG copper tinned enameled, a lapping of “Cotopa” with a braiding of “Cotopa” overall. The individual wires are appropriately colored for indication purposes.

Connecting Cords

The short dial cord inside the instrument has 5 conductors, each of which is composed of 19 No. 42 SWG annealed copper wires uniformly and evenly stranded together.

Each conductor is lapped with cotton and impregnated. The outer insulation consists of a braiding of polished cotton suitably colored. The 5 conductors are laid up evenly and uniformly together.

The connecting cords for the handset and terminal block consists of tinsel thread conductors having an electrical resistance of not more than 0.36 ohms per yard. In the case of the terminal block cord each conductor is covered with two close braiding of cotton, the outer braiding being mercerized. Each conductor of the handset cord is completely covered with a lapping of soft cotton followed by a lapping of pure rubber tape so as to form a watertight covering. A close lapping of soft colored cotton is placed over the rubber and overall is a close braiding of mercerized cotton. The color of the braiding is in accordance with customer's orders. The individual conductors of these cords are uniformly plaited together.

Transmission Losses

Regarding transmission losses, the position is somewhat involved because at the present time there is no international agreement as to datum line, although the C.C.I.F. have this matter under urgent consideration. The B.P.O.

methods of effective transmission testing, direct comparison will continue to be difficult unitl an agrred basis is decided upon.

1. Amplitude Basis

	Db reference to SFERT	
Loop	Sending	Receiving
Zero	-0.4	Zero
300	-3.2	-2.3
600	-6.0	-4.1

2. Effective Transmission Basis

The attached two sheets of graphs figures 5 and 6 show firstly, the superiority of the Type 332 instrument over the previous Type 162 instrument and secondly, the very pronounced effect of the make-up of the local loop, especially on the longer loops of up to 1000 ohms. It will be observed that mere ohmic resistance is not in itself a satisfactory basis for fixing the limits for subscribers loops, since so much depends upon the copper weight per mile of the cable employed.

Sidetone Level, SFERT Basis Approximately

22 dB when connected to a line of 600 ohms impedance. The corresponding figure for the earlier 162 telephone is -11 db.

Electrical Data –

Receiver inset BL 51069

Resistance	Nominal	80 Ohms
	Minimum	78 Ohms
	Maximum	90 Ohms
Impedance	Approx.	$350/60^{o}$ Ohms

Transmitter inset BL 38020A

Maximum resistance, when quite or when speaking, with 50 mA flowing and with plance of diaphragm vertical is 70 ohms maximum.

Induction coil BJL 285914 B.P.O. No. 27 (Mark 1)

Winding	D.C. Resistance	Impedance at 800 c/s 1 volt not less than :
1^{st}	35±10%	$1100/83^{o}$ ohms
2^{nd}	75±10%	$560/76^{o}$ ohms
3^{rd}	30±10%	$120/67^{o}$ ohms
4^{th}	30 (N.I.) ±5%	------------------------
5^{th}	30 (N.I.)±5%	-------------------------

Magneto Bell

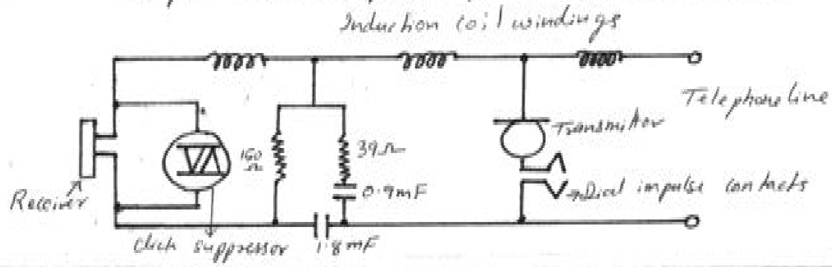
Resistance 500 + 500 ohms

Impedance at 800 cycles: $14,000/52^{o}$ ohms (approx).

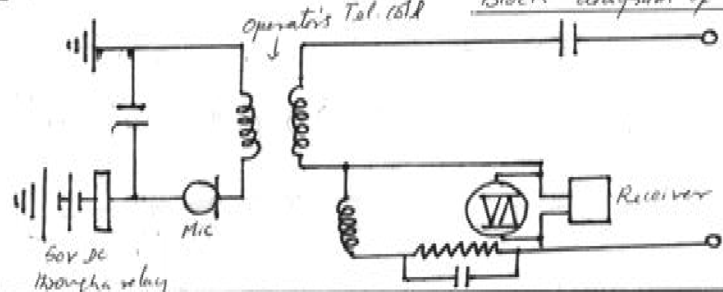
DIMENSIONS AND WEIGHT OF TELEPHONE

Width	-	9”
Depth	-	7 1/2”
Height	-	6”
Weight	-	5 lbs. 12 ounces
Length of handset cord	-	3’6”
Length of cord from instrument to terminal block	-	4’6”

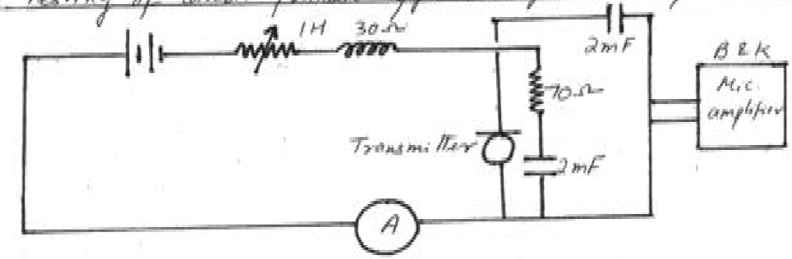
21 Simple Block diagram of a subscriber Tel. set.



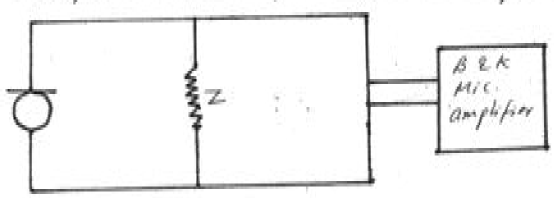
22 Block diagram of a headgear set receiver.



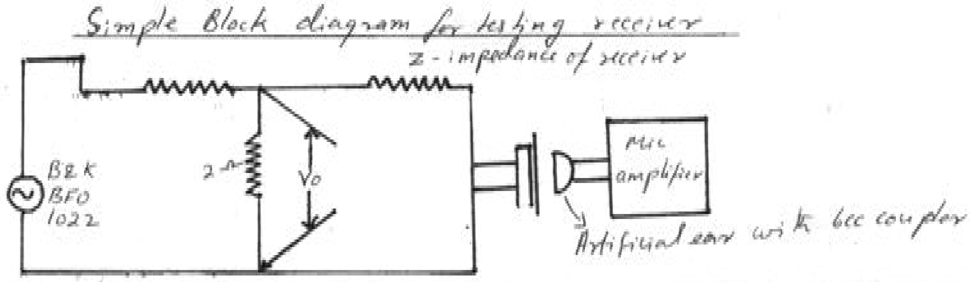
23 Testing of carbon granule type microphone: Simple Block diagram



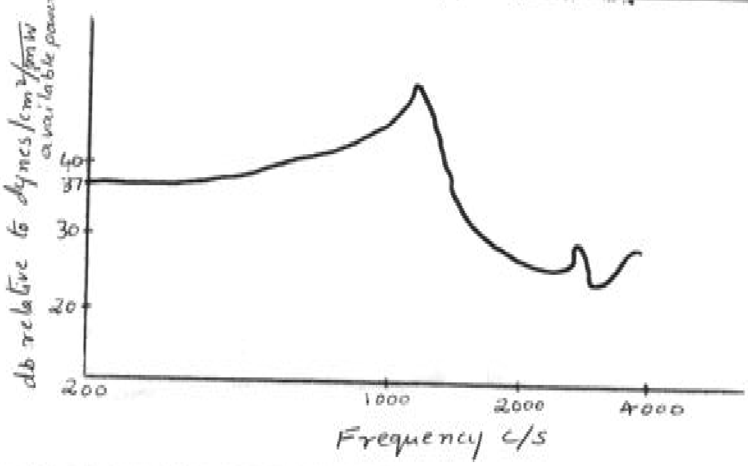
24 Simple block diagram for testing electromagnetic microphone



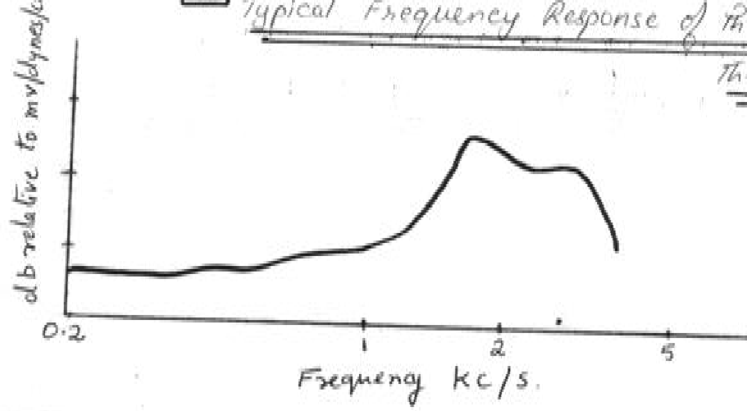
25 Simple Block diagram for testing receiver



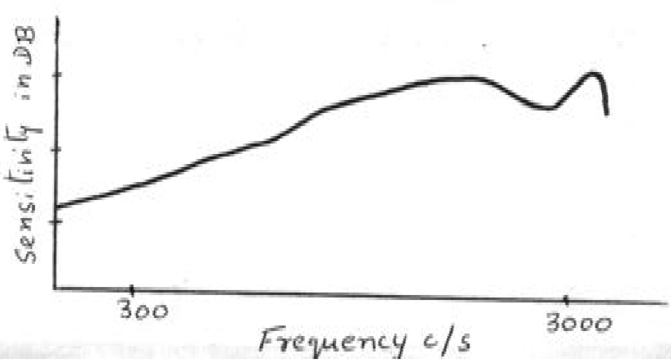
15 Sensitivity Frequency characteristics of Receiver of Tel. Type 332 and headgear set Receiver



16 Typical Frequency Response of the microphone of the headgear set.



17 Typical Microphone characteristics of Tel. Type 332



Artificial Mastoid Type 4930

The Artificial Mastoid consist basically of an inertial mass of 3.5 kg, which approximates the mass of an average human head, into which a smaller mass is et. Between the two is a piezoelectric transducer, which measures the vibration force exerted by a bone vibrator.

Each of the major components simulates some part of a human hand. The seismic mass represents the mass of the head itself, the loading mass, coupled with the two rubber caps, duplicates as nearly as possible the complex action of the skin under vibrational load.

The seismic mass is machined from brass and is nickel plated. Above this is a smaller, domed mass made of stainless steel. The two aer connected by a high strength steel bolt, which applies a pre-load to the piezoelectric discs. Sandwiched between the two masses are three parids of lead zirconate titanate discs which make up the built in transducer. The discs are artificially aged for long-term stability. A Teflon pin passes through the center of each pair of discs and is anchored in the seismic mass. An electrode connected to the discs carries the signal down to the coaxial output socket. The socket has a 10-32 NF external thread and connects to a standard B & K coaxial mini cable.

The rubber pads which covers the domed mass are manufactured according to the formulate set down in BS 40089:1966. They are made in England and checked for quality at the National physical Laboratory before shipment to Bruel & Kjaer. They are extremely stable. The loading mass is made of brass and weighs 0.750 grams.

The mounting is vibrationally isolated from the bottom plate by plastic spacers around the hold-down bolts. The suspension itself has a resonance of less than 5 Hz., that is, less than 1/10 of the lower limit of the frequency range, so that minor disturbances, such as someone bumping the table during use, are unlikely to disturb the performance of the mastoid. The springs are filled with rubber from to help damp vibration.

Operation and Application

Since the impedance of the mastoid changes according to the static load applied to it, it is important to get the static load adjusted correctly. For this reason, a spring balance and level indicator are provided.

B & K Sound Level Meter Type 2203.

The Type 2203 Sound Level Meter is an instrument with practical combination of characteristics that will achieve a high degree of stability and accuracy. The accuracy and validity of the results are, however, determined by the manner of use, which must be chosen to suit the situation. In particular, care must be taken so that the presence of the observer does not invalidate the calibration. The instrument is not intended for measuring sound of very short duration or discontinuous sounds.

The Precision Sound Level Meter Type 2203 is a highly accurate instrument designed for outdoor use as well as for precise laboratory measurements. It is easily portable, battery driven and completely self-contained for ordinary sound level and vibration measurements. Used in conduction with a suitable filter set e.g. the B & K Octave Filter Set Type 1613, the instrument becomes a handy and easily operated frequency analyzer.

There are no requirements stated in the IEC Draft Specification regarding dynamic range, but the B & K Type 2203 covers the range 18 to 134 dB (or 39 to 148 dB using a ½" microphone) and as will be seen this covers most sound levels which need to be measured. All three weighting networks (A, B and C) are included in the instrument as well as a linear characteristic and means for connecting external filter circuits for further shaping of the frequency characteristic if necessary.

Condenser Microphone and Cathode Follower

The microphone supplied with the Sound Level Meter is a precision measuring condenser microphone designed for long term stability and high accuracy. Particular care has been taken to make it insensitive to variations in ambient conditions such as temperature, pressure and relative humidity. The construction of the microphone can be inferred from the schematic diagram. It consist essentially of a thin metallic diaphragm mounted in close proximity to a rigid back plate. Diaphragm and back plate are electicially insulated from each other and constitute the electrodes of a capacitor. The capacitor is charged by a DC polarization voltage and the charging time constant is made so high that for the frequency range of ordinary acoustical measurements the charge on the capacitor will be constant.

When the distance between the diaphragm and the back plate changes because of variations in pressure on the diaphragm the capacity will also change and so an alternating voltage appears across the capacitor, This voltage component is proportional to the pressure fluctuations within the linear range of the microphone.

The low internal capacitance of the microphone requires a high input impedance in the succeeding amplifier stage in order to ensure a minimum loss in sensitivity due to loading. A source-follower stage has therefore been introduced between the microphone and the input amplifier. The source-follower stage consists of a low noise silicon field-effect transistor (PET) and two other silicon planar transistors. This stage has a very high input impedance of approximately 2 Gohm (2×10^9 ohm) and a low output impedance.

Input Amplifier and Attenuator

The input attenuator follows immediately after the source follower stage and is designed for accurate attenuation of the input signal in steps of 10 dB. A greater amount of negative feedback is introduced in the amplifier in order to ensure a high input impedance and stable operation. For calibration purposes the amplification of this stage can be altered a few dB by means of a potentiometer which changes the amount of negative feedback in the circuit.

Weighting Networks

The weighting networks (A, B and C) are introduced between the input amplifier and the first output amplifier. They are built into the instrument and can be switched into circuit by means of a knob on the front plate. Terminals are also provided for the connection of external filters such as octave or 1/3 octave filters for sound analysis. The output impedance of the EXT. FILTER IN terminals is approximately 25 ohm, while the input impedance of the EXT. FILTER OUT terminals is 146 Kohm in parallel with 45 PR.

Output Amplifiers and Attenuators

The output from the filter circuits is fed through two amplifier stage with associated attenuators. The attenuation can be varied accurately in steps of 10 dB. Stable operators are ensured by means of a lager amount of negative feedback.

Rectifier and Indicating Meter

After frequency weighting and amplification the signal is fed to rectifier and then to the indicating meter.

The rectifier is a full wave rectifier with characteristics as required in the IEC standard for sound level meters (Publication 179), providing a rectified single which corresponds to the RMS value of the input form the microphone. This rectified signal is fed to a moving coil indicating meter which includes two different degrees of damping, “Fast” and “Slow”, both in accordance with the IEC standard for precision sound level meters. The meter itself is ribbon suspended in order to make it less sensitive to shock and vibration.

Power Supply

The Sound Level Meter is powered by three ordinary 1.5 V torch batteries, and to avoid had contact due to corrosion the battery clips are gold plated, ensuring a negligible contact resistance.

The HT is obtained from a high stabilized transistor oscillator working at a frequency of 1 KHz. The same generator supplies a signal which is used as a calibration signal for the amplifiers and meter circuit, and also one that is rectified and used as polarization voltage (200 V) for the microphone.

Condenser Microphone 4145

The condenser microphone's operating characteristics of high stability, flat linear response, and reasonably high sensitivity, combined with its minimal effect on the sound fields in which it is placed, make it for most purposes, the most suitable transducer available for measuring sound pressure.

The 4145 has a response which is corrected for free field measurements giving a linear output from 1.5 Hz ± 0.5 Hz (-3 dB) to 18 KHz (± 1.5 dB). 4145 for free field use. They are of rugged construction and are suitable for field use but are not deigned for permanent exposure outsider unless special precautions are taken.

Principle of condenser Microphone

A condenser microphone consists essentially of a thin metallic diaphragm mounted in close proximity to a rigid back plate, both being electrically insulated and forming the electrodes of a capacitor. A stabilized DC polarization voltage maintains a constant charge between the electrodes, provided the time constant of the charging circuit is much longer than the period of the sound pressure variations.

When sound pressure waves are incident on the diaphragm, the capacitance changes and an E.M.F. is produced. By careful design, the output voltage is made proportional to the sound pressure level through extend frequency and dynamic ranges.

The Type 4145 microphone cartridge is supplied in a mahogany case with an individual calibration chart and a protective silicon gel cap UA 0135. The cap serves as a dust cover and keeps the air in the microphone dry during storage. The sensitivity of the microphone with any preamplifier is

$$S_1 = S_o \, . \, A. \, \frac{C_t}{C_t + C}$$

where A is the voltage gain of the preamplifier.

Telephone Operator's Head-gear Receiver set:

Literature available at ITI Bangalore. The frequency characteristic of the receiver set is identical to the frequency characteristics of the receiver of telephone set type 332 described ahead.