THE EFFECT OF COMPRESSED SPEECH

AND INTERIM ACTIVITY

ON COMPREHENSION

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CHAPTER I

PRESENTATION OF THE PROBLEM

Introduction

Two major tools or methods utilized by the learner in the teaching-learning process are the receptive skills of reading and listening. Reading has historically received greater attention in terms of course offerings, research efforts and resource allocations. The rapid expansion of knowledge has inundated the schools, industries, libraries and the various publics with the printed word in multiple forms. Individuals are constantly being required to read more to maintain their position in society and work; thus, efforts to develop a variety of techniques for increasing the rate of reading have resulted.

The technological and population explosions have provided a comparable flood of spoken communications which adds volumes of work to the spoken word in the work-a-day world of individuals. The preface of Duker's (1974) monumental three volume anthology pointed out that oral communication skills

> ... are much more widely needed than reading skills. The amount of oral communication, even in a country such as ours -- a so-called 'literate' one -- far exceeds the amount of written communication. On a worldwide basis, the preponderance of oral communication is even greater (p. 28).

In elementary, secondary and higher education the proportion of student time spent in listening provided an impressive justification for the increasing efforts, through research, to develop techniques for improving listening skills. In a study for the National Education Association, Taylor (1964) found that over 50 percent of the class time in the elementary school and almost 90 percent of the class time in high schools and colleges was spent in listening.

Ralph Nichols (1957) has been expounding for almost 20 years the theory that an individual's brain processes information at a much more rapid rate than is presented in a normal conversation or lecture. Only in recent years has it become possible to subject his theory to empirical research and evaluation. This has been made possible through the development of recording devices capable of compressing or expanding recorded speech. A number of such devices are described in Appendix B of this study.

The significance of compressed speech was clearly stated by Orr [1968(a)] in the statement,

> Basically, the significance of time compressed speech lies primarily in two directions, one related to applied areas, and one related to basic research area. The applied dimension lies most clearly in the realm of education. Today's pressures on education, created by the burgeoning knowledge and culture to be transmitted to the next generation demand an efficient educational process. It is clear that auditory educational methods are assuming a larger and larger role in our educational process since some children learn better auditorially; since the use of audio-visuals is growing; and since the new educational technologies such as computer-assisted instruction, dial-access tape lectures, telelectures, etc. involve auditory presentations (p. 6).

Statement of the Problem

The research problem of this study was directly related to the educational application dimension of compressed speech. Briefly the statement of the problem was, "Determine the effect of an interim activity and rate of compression on the comprehension of compressed speech". The term interim activity as used throughout this study has referred to an activity which followed the listening exercise. The particular interim activity required selected listeners to immediately verbalize their perceptions of a tape recorded message. The listeners were advised that they would have five minutes to record, in their own words, comments relating to the lecture. They also were directed,

> Include in your comments those portions which seem crucial or of extreme importance in understanding the concept of work and its application. This may include definitions, formulas, rules to remember, important relationships or any statement that helps you clarify that to which you have just listened (Appendix C, p. 76).

The problem addressed in this research was concerned with the utilization of the time saved by compression and the effect of compressed speech on the comprehension of technical subject matter recorded on Engineering Science audio-tapes.

The use of compressed speech has been frequently advocated because of its capacity to conserve time. In light of the growing demands on individuals to listen to increasing oral communications, the conservation of time justified the use of compressed speech. A large proportion of current research has addressed the problem of determining if, to what extent, and at what maximum rate learners can listen to compressed speech without major loss of comprehension. Few studies have been directed toward the problem of identifying appropriate interim or supplementary activities to be used in the time saved by compression. This study has attempted to contribute additional information to this less developed area and has provided recommendations for additional areas of needed research.

The Purpose

The Division of Engineering has been offering selected audio-tutorial courses for more than four years. The Dean, Associate Dean of Engineering and the staff members directly involved with these courses have indicated a need to investigate possible techniques of improving the effectiveness of the audio-tutorial tapes. There was also a concern expressed regarding the time required to utilize the tapes and the degree of effeciency in such use. Questions were raised regarding the voluntary utilization of the audio-tapes and the potential for increasing their utilization if the required listening time could be reduced. In addition questions were raised regarding the possible manipulation of the time saved, by means of compressed speech, in an interim learning activity.

The purpose of this research was to determine whether students were able to comprehend a taped engineering lecture in less time than was normally required and to determine whether the interim activity contributed to improved comprehension.

The outcome of this research has important implication for the design of audio-tutorial classes. If students are in fact able to comprehend a lecture in less than the normal time, then there are numerous potential applications of the time conserved by compression. This study has examined only one of the potential activities.

A secondary purpose was to determine if it was possible to cause gains in comprehension through providing a compressed speech stimulus and requiring a subsequent activity. Numerous studies have demonstrated that material may be compressed considerably without significant loss of comprehension or retention by the listener, e.g. Friedman (1967), Foulke (1964). While these findings were encouraging, no studies were discovered which were able to demonstrate a significant gain in comprehension or retention.

The results of the few studies which attempted to show that time saved could be used to increase learning have been disappointing, Friedman *et al.*, (1967). A section of Chapter II summarizes the techniques used in these studies and reveals that the majority involved more of the same; that is, the subjects (S's) merely utilized the extra time gained by listening to more compressed speech of the same or related material.

This study has approached the problem in a somewhat different manner by utilizing the additional time in a non-listening activity. The technique called for S's verbal participation and thus involved another mode of learning. The theory supporting this approach was not novel in education, but its application to compressed speech did represent a unique approach which had not been extensively researched. The activity's purpose was to "reinforce" the comprehension of the content in a compressed speech presentation. Reinforcement, as defined in this study (see Glossary of Terms) was primarily concerned with the strengthening of meaning. The term reinforcement was not defined herein as reward, operant conditioning nor as the classical Pavovian conditioned response.

The Objectives

1.0 The first objective was to identify an Engineering Science class meeting the following criteria:

1.1 Adequate enrollment permitting random selection and random assignment in sufficient numbers to each control and experimental group.

1.2 Audio-tutorial being used as a major form of instruction.

1.3 Access and control providing a captive audience in the sense that the Ss' schedules allowed them to meet for several sessions during the experiment.

2.0 The second objective was to develop and produce instructions and a practice listening tape as follows:

2.1 Instructions developed to introduce the listener to compressed speech.

2.2 Practice listening tape having a total listening time of approximately 30 minutes excluding instructions. The practice tape to contain two listening sessions at two rates of compression and two sets of pre-listening comments. The listening sessions to be compressed to 80 percent and 60 percent of their normal listening time.

3.0 The third objective was to prepare, record and transcribe one lecture for the experiment as follows:

3.1 Lecture content related directly to Engineering Science 3213.

3.2 Taped lecture prepared and recorded by Dr. Robert L. Robinson, Professor of Chemical Engineering.

4.0 The fourth objective was to prepare a test to measure comprehension of the taped presentations.

5.0 The fifth objective was to locate and make arrangements for the use of a facility to accomodate administration of the experiment.

6.0 The sixth objective was to prepare and record instructions to introduce the techniques being used in the experiment.

7.0 The seventh objective was to evaluate the various modes of compression available to the researcher (Varispeech-I, VOCOM-I, and Copycorder CC103) and to select the mode(s) for use in this experiment.

8.0 The eighth objective was to record three tapes of the lecture at 100 percent, 80 percent and 60 percent of the normal listening time.

9.0 The ninth objective was to introduce participants to compressed speech and the practice listening tape prior to their participation in the experimental sessions.

10.0 The tenth objective was to conduct the experiment with S's randomly selected and assigned to a control or experimental group.

11.0 The eleventh objective was to apply appropriate statistical analysis to the scores of the experimental and control groups and to report the results, conclusions and recommendations for further research.

CHAPTER II

THE REVIEW OF LITERATURE AND CONCEPTUALIZATION

Review of Related Literature

There are three major objectives of the first portion of Chapter Two. They are:

1. Identify the major contributors to the development of compressed speech and their unique contributions in order to provide a broad historical perspective of compressed speech.
2. Identify for subsequent researchers a small number of key sources which have the greatest potential for facilitating the pursuit of further research.
3. Cite studies which have direct implications for and are most pertinent to the problems addressed in this study.

An underlying consideration in all of the above has been to report the related literature in a meaningful and pertinent narrative form and to avoid, when possible, long lists of authors in the body of the review.

With regard to objective number one and two above, it should be noted that the authors and sources cited reflected a personal valuing. No claim was made for the inclusiveness of the sources listed. Arbitrary decisions were made about "major contributors" to be included after an extensive review of the available literature on the subject, but the list could be extended to include numerous others. The "key sources" cited were those which proved to be most productive in the search for related studies. The intent was to provide a service to subsequent researchers by providing them with a few sources containing the most extensive bibliographic references and providing an efficient beginning in the study of compressed speech.

The section reflecting Objective Number Three contains references to specific areas in the study of compressed speech. The specific areas outlined were those found to be most directly related to this study and those which provided informational bases for research decisions. The scope of this section is thus narrower as it attempts to address specific areas under consideration in this study.

Major Contributors

The term "Major Contributors" was used to indicate those individuals, their research findings and inventions which have had the greatest impact on the development of compressed speech. These sources may be thought of as the classics. They have a depth of historical value and are especially pertinent to the development of a broad overview of compressed speech. This elevated status was primarily bestowed on the basis of consistent recognition of their importance by other authors.

The earliest pioneer and most frequently cited authority on altering the oral rate of presentation was Harry Goldstein (1940) whose primary concern was to compare the efficacy of written and oral materials. He compared these two modes by varying the rate of presentation. The reading was paced visually through a filmed presentation while the auditory rate was controlled by the reader's ability to increase his rate of speech and by acceleration of a phonograph.

In addition to his major concern with the effect of reading and listening rate on comprehension, Goldstein considered twelve other aspects of the problem which were as follows: S's characteristics (i.e. age, intelligence, reading skills, general culture), difficulty level of material, specific and optimum rates in each modality, order of presentation and grouping of S's. The attempt was made (with little apparent success) to equate twenty-eight groups of ten S's each.

One reported result of great significance in stimulating subsequent research was the assertion by Goldstein that, "listening comprehension is reliably superior to reading comprehension although quantitatively the difference is very slight" (p. 28). The findings of particular importance to compressed speech research dealt with differentials in comprehension as a function of rate. Goldstein's findings provided the empirical seed of encouragement which fostered expanded research efforts. The essence of his research stressed that listening was superior for the first four rates tested (100, 137, 174 and 211 words per minute) and that there was little difference at the last three rates (248, 285 and 322 w.p.m.).

Ralph G. Nichols (1957) was included because he has provided a continuing emphasis of the theory which supports the concept of compressed speech. Duker (1974) describes Nichols as "The man who, above all other others, has made 'listening' a respectable household word in the educational world and in training programs of all kinds and varieties: MR. LISTENING himself...." (p. 21).

Although Nichols conducted no systematic research to verify his theory it has nonetheless provided the theoretical base for numerous studies. In capsule form it was Nichol's contention that man can process information approximately four times faster than the rate at which he normally receives it aurally. He thus drew attention to what appears to be a discrepancy between the speed of speech and the speed of the thought process.

William D. Garvey (1949) had the distinction of being the first to compress speech by removing segments of words and abutting the remaining parts. He accomplished this by the painstaking process of manually and systematically chopping out, from tape recordings, segments of words and splicing together the remaining parts. This method is identified in the literature as the "chop and splice" or "cut and splice" method (Duker, 1974). Garvey was concerned primarily with intelligibility and used a list of spondaic words from the Harvard Psycho-Acoustic Auditory Test rather than connected discourse.

In reporting the results of his study, Garvey found that better than 95 percent intelligibility was obtained for speed-ups of 1.5, 1.67, 1.75 and 2.0 times faster than normal (1.0). For a speed-up of 2.5 an intelligibility score above 90 percent was obtained by the chop and splice method while intelligibility dropped drastically at 1.75 when compressed by the frequency shifting method. The frequency shifting method involved speech compression which increased the playback speed of a record or tape and resulted in a "donald duck effect". It would seem that for discrete words the critical point was around the 2.5 speed-up point, for it was not until this point was reached that the intelligibility scores showed a significant drop. Consideration was also given to the effect of the size of "chop" or removed segment and it was found to be a highly significant variable affecting intelligibility.

In his doctoral thesis Garvey (1950) expanded his master's thesis and conducted several experiments to investigate other variables operating to affect the intelligibility of compressed speech. The variables examined were: (1) frequency shift, (2) type of speech material, (3) intensity, (4) signal-noise ratio, (5) familiarity of material to subjects and (6) slowdown (with frequency shift) of speeded speech. His dissertation study was a refinement of the initial cut and splice research, and an attempt to discover causes of the loss of intelligibility. Garvey verbalized a need which recent technological achievements satisfied, for he pointed out that the chops needed to be much smaller and more frequent than was possible to accomplish by his mannual techniques.

Another "classic" study related to compressed speech was conducted by George A. Miller and J. C. Licklider (1950). They, like Garvey, removed portions of speech, but, unlike Garvey, they did not abut the remaining portions. The purpose of their study was to measure the effect on intelligibility of listening to a tpae recorded list of interrupted words. It was not in the strict sense a compressed speech study since the listening time was of the same duration for the interrupted and uninterrupted tape.

The interruptions utilized in the Miller and Licklider study were brought about by an automatic electronic on-off switch which was capable of varying the interruptions from 0.1 to 10,000 per second. The variables considered by Miller and Licklider were: "(1) The number and frequency of interruptions; (2) The proportion of the time the speech is on, the speech-time fraction; and (3) The degree of the interruptions" (p. 168). In addition they considered the effect of speech interrupted by noise or the variable of signal-to-noise ratio. In this case the speech was interrupted by regular and irregular bursts of noise as opposed to regular and irregular bursts of silence.

An interesting result of the Miller-Licklider study was what they called the "Picket Fence Effect". The effect they described was brought about by masking the silent intervals with noise which seemed to make the words sound continuous. As a landscape is seen through a picket fence and is perceived as continuing behind the pickets so bursts of noise in the intervals seemed to make the speech sound continuous. No actual improvement in intelligibility was obtained by adding noise.

The authors and researchers cited in the preceding paragraphs served in the vital role of generating the idea that man could listen faster if it were required or if given the opportunity. None of these authors had, however, developed a practical or feasible way of compressing speech. Garvey's monumental work, though impressive from the standpoint of tenacity and persistence, was not a practical technique for compressing speech. Its greatest value was as a demonstration that listeners could recognize words with portions of their sounds deleted. The great need was for a technological breakthrough so that speech could be compressed economically and automatically. The problem was one requiring the skills of an engineer.

Grant Fairbanks has been generally recognized as the "giant" who first developed the machinery which enabled researchers to compress speech in the modern sense. Fairbanks, Everitt and Jaeger (1953) reported to the 1953 National Convention of Radio Engineers on a method which made possible time or frequency compression-expansion of speech. At the time of their report an application was on file with the U. S.

Patent Office for their recording device; the patent was granted in May of 1959. This invention was the great breakthrough which enabled researchers to put speech compression theory into an empirical format.

Following the development of the speech compression machine, Fairbanks and associates conducted a number of studies on the effects of its use [(1957(a) and (b)]. The studies served as prototypes for numerous current research efforts and are listed in the bibliography. In addition to the research bearing his name, there are a number of doctoral dissertations by his students which bear the mark of his brand of meticulous and thorough research and have extended the impact of his initial study e.g. Hutton (1955).

In addition to these "Major Contributors", or the giants of compressed speech, two others deserving such recognition were Emerson Foulke and Sam Duker. Comments about their research were reserved, however, for the following section which lists key sources of information.

Key Sources

If only one resource could be chosen for the study of compressed speech, that choice would without question be Sam Duker's three volume anthology entitled, Time-Compressed Speech: An Anthology and Bibliography.

The three volumes (in excess of 1300 pages) constitute a five part work. An abreviated annotated outline of the contents follows:

Part I - BASICS (Vol. I)

(16 Chapters containing 31 articles covering the theory and and fundamentals of time-compressed speech.)

Part II - RESEARCH (Vol. I and II)

(14 Chapters containing 40 research and development studies of time-compressed speech.)

Part III - PRACTICAL APPLICATIONS (Vol. II)

(6 Chapters containing 20 articles which move into the application of technology.)

Part IV - PATENTS (Vol. II)

(19 Patents including the full text with illustrations.)

Index for Part I through IV (Vol. I and II)

(1 - 403 references to authors)
(2 - 237 subject references)

Part V - ANNOTATED BIBLIOGRAPHY (Vol. III)

(456 Annotated articles on time-compressed speech.)

Index for Part V (Vol. III)

(1 - 456 references to authors)
(2 - 406 subject references)

Another key source was Emerson Foulke who is probably the most prolific researcher and disseminator of information on compressed speech and its applications. Foulke is associated with the University of Louisville's Perceptual Alternatives Laboratory and the Center for Rate Controlled Recordings (CRCR). The initial area of interest to Foulke was the utilization of compressed speech by the blind. His involvement with compressed speech spanned more than a decade during which time he has exerted leadership in a number of significant developments.

One of the major contributions of Foulke [(1966(a)] was made when he and Robert Bray organized the First Louisville Conference on Time Compressed Speech for the purpose of,

> ... determining the present status of research and development with respect to the production and use of rate controlled speech, informing interested people of its current status, and for formulating plans relating to the future development of the area (p. 7).

At this three day conference papers were presented, group discussions conducted and recommendations developed for further research. Out of this conference and the Second Louisville Conference in 1971 two publications on the conference proceedings were prepared (Foulke, 1966 and 1969). The proceedings also had excellent bibliographic references, some of which were not contained in Duker's anthology.

A major contribution of CRCR is its monthly newsletter which permits the reader to remain abreast of developments in the area of compressed speech. The newsletter publishes abstracts of recently completed research, research under way, descriptions of compression equipment, and bibliographic material. A subscription and most of the back issues may be purchased for a small cost per copy; these are a recommended investiment for the researcher who wishes to develop an appreciation of the state of the art in compressed speech. In addition to its dissemination of information, the Center also provides service to researchers by preparing compressed tapes and by providing a variety of ready-made listening and test materials which may be purchased by the researcher (Foulke, n.d.).

Herbert L. Friedman and David B. Orr, who in many instances were co-authors, have provided a wealth of research on compressed speech. The most helpful publication by Friedman, et al. (1967) was the final report of Further Research on Speeded Speech as an Educational Medium. This report, in which Orr was the principal investigator, brought together in one five-part volume all the related experiments conducted by Friedman and others over a two year period. The experiments were stimulated by a U. S. Office of Education grant and covered a wide range of variables pertinent to educational applications of compressed speech.

Listed below are some of the areas of experimentation:

1. The effect of compressed speech listening practice (amount, duration, content, intervals, continuity of exposure, and rates of compression) on comprehension.
2. The effect of listening aids, (a printed precis, a printed outline, note taking, key word list, and a tone on the tape to signal an important passage) on comprehension and retention of compressed speech.
3. Self-pacing versus externally paced listening to compressed speech.
4. Compressed speech as a review technique.
5. Retention of compressed materials.
6. The minimum practice required to reach a criterion of 90 percent of normal speech comprehension.
7. Monetary rewards for achievement.
8. Message repetition.
9. Listener characteristics.

In all the studies conducted, only practice was found to have a significant effect on comprehension of a compressed speech message. All the types of practice examined in their research led to improved comprehension.

In an immersion study, seven S's were paid to listen and be tested for twelve hours a day for five consecutive days. They listened to speech compressed to 425 w.p.m. While there was a marked improvement in comprehension it was not as great as the improvement of previous groups who had only twelve to fourteen hours of practice extended over a longer period of time.

Although no means, other than practice, were found to significantly improve comprehension, Friedman, _et al_. suggested that the research tended to demonstrate that students could learn to comprehend college level material at better than twice the normal rate.

There were a few limitations to the experiments of Friedman and Orr which should be mentioned. In several of the studies the number of S's was extremely small, S's were recruited to participate for cash and were not randomly selected. In one study which utilized a cash bonus for the best comprehension score of the day, it was discovered, following the study, that the S's had made an agreement to share in the bonus thus tending to negate its intended motivational influence.

Literature Relating Directly to the Study

The Unit of Rate Dilemma

A basic problem encountered in all compressed speech research was to define the terminology to be used in specifying the amount of compression. John B. Caroll (1966) pointed out "Measuring speech rate is not a simple matter of counting words per minute..." (p. 88). One obvious problem was that using specifications such as 75 percent of normal listening time or 325 w.p.m. will not always represent speech at equivalent rates from one speaker to another. This problem stemmed from the fact that output rate was dependent on the input rate, speaker vocabulary, rate of speaking, etc. The problem was related, as Foulke and Sticht (1966) pointed out, to the fact that, "There is no 'normal' word rate that can safely be assumed since ther is considerable variability in the published estimates of normal word rate" (p. 17). Illustrative of this discripancy Nichols and Stevens (1957) found a conversational rate of 125 w.p.m., while Johnson, et al. (1963) found a median oral reading rate of 176.5 w.p.m. Foulke (1968) found a comparable mean oral reading rate of 174 w.p.m. and also found considerable variation in oral reading rates among individuals with a range of more than 47 w.p.m. from the slowest to the fastest.

Rate specification may be expressed in one, or a combination, of the following units:

1. Percent
   a) Percent of original time.
   b) Percent compressed.
2. Words per minute (w.p.m.).
3. Syllables per minute (s.p.m.).
4. Phonemes per minute (p.p.m.).

While Foulke and Sticht (1966) and Carroll (1966) agree that syllables yielded a more accurate specification of rate than w.p.m. they differed in their recommendation of a preferred unit of rate. Carroll endorsed using syllables as the unit of rate, whereas Foulke encouraged the use of words as the unit of rate for most purposes. Carroll took the position that phonemes were more accurate than syllables and syllables more accurate units than words. He recommended the syllable, however, due to the difficulty associated with counting phonemes. Foulke and Sticht (1966) used a similar argument in endorsing w.p.m. instead of s.p.m. They state, "Specification in terms of syllable rate is even more precise, but in most cases, the gain in precision is not worth the cost in time and effort." They explained their preference for word rate as "... the most meaningful dimension in terms of the cognitive and perceptual processes of the listener" (p. 6).

For the purposes of this research, two units of rate were utilized. Time was an important factor since the interim activity represented a possible manipulation of the time saved by compression. The most convenient means of expressing the proportion of listening time available for activity was percent. For this reason percent of original time was used. In addition w.p.m. was computed to satisfy the need for a specification of greater accuracy than percent and to provide greater comparability with other research studies.

Choice of Listening Rate

A problem related to the preceding rate dilemma is the choice of a particular listening rate or rates to be utilized in an experiment. A large proportion of the research studies conducted have sought to determine the optimum or maximum listening rate. The two major criteria for selecting or evaluating a given rate of compression have been intelligibility and comprehension. The question to be answered was "At what rates or percent compression should Ss in this study listen to the taped presentations?" To deal with this question necessitated a review of the literature for guidelines in choosing rates of compression. This research used rates which would permit significant savings of time while maintaining adequate levels of comprehension of a technical message. It was assumed that intelligibility would be more than adequate if comprehension were maintained adequately. This assumption rested on the consistent research findings such as Foulke [1969(b)] that intelligibility decreases less rapidly than comprehension at increasing listening rates. Stated in somewhat different terms, the assumption rests on research findings which indicated that comprehension losses occurred prior to and at a slower rate of compression that intelligibility losses e.g. Fairbanks, et al. [1957(b)].

A pattern did appear to be reflected in the research studies dealing with comprehension of compressed speech. Although the reported original (or normal) rates in the literature varied from 125 to 175 w.p.m. there did appear to be a threshold or maximum word rate beyond which comprehension of compressed speech dropped significantly. Fairbanks, Guttman and Miron [1957(b)] studied the effects of time compression on the comprehension of connected speech and found the S's were able to listen to a message at 282 w.p.m. (50% compression) with only a slight loss of comprehension. The S's yielded a mean test score which was approximately 90 percent of that achieved by those who heard the original at 141 w.p.m.

Foulke [1966(a)] cited unpublished research in which he compressed a listening selection read at three rates (149, 165 and 196 w.p.m.). This research reported that regardless of the input rate (w.p.m.) comprehension was limited to approximately 275 w.p.m. beyond which comprehension was found to drop rapidly.

In an earlier study, Diehl, White and Burk (1959) manipulated listening rate by lengthening or shortening pauses and leaving the words intact. Their conclusion was that, "... rate may range from 125 w.p.m. to 225 w.p.m. without appreciable loss in comprehension". This conclusion was, however, not totally the direct result of their research as the range of rates actually used was from 126 to 172 w.p.m. in rather small increments. The significance of their research was most noted for its attempt to vary rate solely by selective deletion of pauses instead of the traditional Fairbanks type of systematic deletions. This study served to stimulate a number of research studies concerning the effect of altering pause time and the effect on comprehension of compressing speech by deletion of pauses e.g. Miron and Brown (1974), Agnello (1963). Technological advances have now enabled the researcher to automatically delete pauses by an electro-mechanical process. The required equipment is manufactured by the P.K.M. Corporation and is described in Appendix B.

The preceding paragraphs have suggested that the maximum effective rate of w.p.m. cannot be specified exactly but the threshold appeared to be around 275 w.p.m. Beyond this rate the research tended to show that comprehension dropped drastically. The decision was thus made to restrict the maximum w.p.m. rate to less than 275 w.p.m. in this study.

Practice Listening

An additional variable found to influence the comprehension of compressed speech was the amount of practice or experience S's had listening to compressed speech. This variable was of importance to this study as it was necessary to make a determination concerning the frequency and duration of practice required to prepare S's for participation in the listening experiment. The question to be answered was "What is the minimum practice time required to assure optimum comprehension?" The literature, as in the case of the rate dilemma, was not entirely consistent in its reported results. This was possibly due to basic differences in the design of the various studies. This diversity was reflected in the variables listed below and in Table I which follows. These variables were found to vary considerably in the studies reviewed and may account in part for the differing results.

TABLE I

COMPARATIVE STUDIES OF COMPRESSED SPEECH

RESEARCH STUDY	TOTAL PRACTICE LISTENING-TIME AND RATE (W.P.M.)	SUBJECTS	LISTENING CONTENT	TEST CONTENT	COMPRESSION MODE	REPORTED RESULT OF PRACTICE
Klineman (1963)	6 X 45 minutes Constant 300 w.p.m.	11 Blind Subjects 5th-6th Grades	High Interest Stories	Gates Reading 300 w.p.m.	Fairbanks	Experimental S's Significant Gain
Resta (1968)	2 X 60 minutes Grad. to 244 w.p.m.	70 Blind Subjects 7th-12th Grades	2 to 15 Paragraphs appropriate	Mult. Choice on Practice Content	Frequency Shifted	Significant Gain
Friedman, et al. (1967)	5 X 7 hours Constant 425 w.p.m.	7 Males, 19 to 20 College Frosh-Soph.	12 Novels	Benchmark Tests Written Quiz	Tempo Regulator	Is Effective but not Efficient
Orr, Friedman & Williams (1965)	12 to 16 hours 1 to 2 hrs. each Gp-1 175-475 w.p.m. Gp-2 325-475 w.p.m.	32 College Freshmen-Sophmore	5 Passages 16th Century English History 4 Novels	Nelson-Denny-Read Mult. Choice on Passage/Novels	Tempo Regulator	No Sign. Difference on Reading Sign. Difference on Passage/Novel
Rawls (1971)	16 Sessions Graduated 10% to 50%	Blind & Visually Handicapped High School	Stories	Standardized Listening-Reading Tests	Fairbanks	Sign. Improvement of Listening Skills No Improv. in Reading
Robinson (1971)	3 Stories per day for 19 Consecutive Days; Grad. 112 to 320 w.p.m.	6th-Grade Boys 18-Poor Readers (PRs) 18-Good Readers (GRs)	60 Stories	Gates-MacGinitie Reading	Unknown	Both (PRs) (GRs) able to process more info. (GRs) most gain
Woodcock (1969)	Not Reported (5 wks) Graduated 200 to 400 w.p.m.	700 Ss-(Normal, M.R., Cult. Disadv.) 3rd thru 6th Grades	23 Biograph. Passages 2000 - 4000 Words w/correlated slides	Biographies	Not Reported	No Sign. Improvement with practice but better with slides
Bruland (1970)	20 Stories over 5 wk period 178 or 275 w.p.m.	Six 5th Gr. Classes Ability Interaction Randomly Assigned	20 Stories read by a Professional	Experimenter made, Gates-MacGinitie, and S.T.E.P. Listening Test	Whirling Dervish	Practice Effective to prevent compreh. losses. Comp. Speech not better but as good as normal

Duker (1974) in reviewing research studies stated,

> Fundamentally there are three variables that can be studied in research work on compressed speech: variables in the material that is compressed; variables in the process of compression; and variables in the listeners to compressed speech (p. 506).

A number of these variables are listed below for each of the categories.

I. Variables in the Material Compressed

1. Practice listening content.
2. Relatedness of material to student interests and needs.
3. The voice quality and enunciation of the one who records the tapes.
4. The sex of the one who records the tape.
5. Difficulty of textual material.
6. The noise ratio.
7. Intelligibility.
8. The effect of pauses.
9. Semantic, syntactic and grammatical content.
10. Simultaneous presentation of visual materials.
11. The effect of redundancy.
12. the purpose of the message.

II. Variables in the Mode or Process of Compression

1. The type of compression equipment utilized.
2. The rates of compression.
3. The effect on intelligibility or comprehension of the various types of compression.
4. Audio quality of compressed speech.

III. Variables relating to the Listeners

1. Age.

2. Intelligence.

3. Sex.

4. Emotional stability.

5. Previous experience.

6. Motivation.

7. Socioeconomic factors.

8. Physical limitations (sight, hearing and speech).

9. Selection and assignment in the study.

10. Reaction time.

11. Academic achievement.

12. The effect of practice.

13. Rate preferences.

As a means of comparing the results of various studies and illustrating their differences, Table I was developed which reflected a few of the significant variables influencing those results. The table does not represent an exhaustive comparison of studies but is representative of the great diversity of approaches.

The term "training" was used in the title of some of the studies, but in reality they dealt with practice or exposure to compressed speech. Friedman and Orr (1966) discussed the dilemma at the Louisville Conference when reporting the extensive research conducted by the American Institute for Research on speeded speech. "We should have liked to train the comprehension of compressed speech, but the training of listening is something which is as yet primarily unexplored" (p. 71). In the preceding study, and most of the other sources cited, the experiments consisted primarily of manipulating the type of exposure as the independent variable and the measurement of comprehension as the dependent variable.

There was no clear or consistent indication as to the amount of exposure required to assure adequate or optimum comprehension. The exposure or practice time in Table I ranged from the two hours of Resta (1968) to the thirty-five hours of massed exposure reported by Friedman, et al. (1967). Generalizations are sometimes risky, but one did seem justified at this point. The generalization was not especially profound or unique but did provide a basis for decisions about the exposure or practice required prior to the collection of experimental data. The generalization was: Practice listening or exposure to compressed speech results in the improvement of comprehension.

Two variables which appeared to influence the amount of duration of practice required were age and intelligence. A more subtle variable believed to affect comprehension, and one about which very little empirical evidence has been collected, was the S's motivation. As might be anticipated, intuitively, the older, or mature, bright student tended to benefit most from the least exposure (Friedman and Johnson, 1969).

Practice effect was not limited to a specific period prior to experimental conditions. Each subsequent exposure during the experimental phase of a research effort may be considered a continuation of practice and may also influence final performance on a given comprehension test. Since there was no empirical evidence establishing the "minimum" practice required, and assuming that any practice effect during the experiment was randomly distributed, a decision was made arbitrarily about the amount of practice for this experiment. In the final analysis the decision was made on the basis of pragmatic considerations, that is, the availability of S's and the instructor's willingness to release them.

It was thus necessary to limit the practice listening to one class period.

One factor which may have helped offset limitations due to the relatively short practice period was the fact that all S's had previously completed courses which utilized a similar audio-tutorial approach. In these classes they had been required to use taped engineering lectures similar to those in Engineering Science 3213. The S's have demonstrated a degree of capability in this type of course based on their successful completion of the prerequisite audio-tutorial courses.

There was some reason to believe that another subtle event had been effective in prescreening S's. That event was natural and significant attrition of students during the freshman and sophomore years. One of the reasons a student drops-out of engineering is that the courses have been too demanding. The grade point average of drop-outs is generally low which further indicates the difficulty being experienced. Another group of drop-outs is comprised of those students who have changed majors. The preceding has suggested that a natural screening process has been operational which may have a beneficial effect on S's performance.

Conceptual Framework

The stated purposes of this research were to improve instruction and investigate the effect on comprehension of an interim activity and compressed speech.

Comprehension was the educational objective or intended student behavior to be measured at the conclusion of the unit of instruction. An educational objective is concerned with the specific ways in which students are expected to change their thinking, feeling and actions. There were many changes that could take place in students but there were limits of time and resources which necessitated selection of a limited number. It was thus considered important to address only the major objective under consideration in this experiment, that is, comprehension. In the following paragraphs comprehension has been described, for purposes of conceptualization, in a systematic fashion and in keeping with a well defined theory. The instrument utilized to measure student comprehension was not constructed to assess achievement of each projected result of comprehension.

Bloom, et al. (1956) classified educational objectives in a hierarchical manner from the simple to more complex (i.e. concrete to abstract). Within each of the cognitive categories there was also a hierarchy of a similar nature. Bloom and his associates perceived the cognitive objectives to be subsumed in two major groups or clusters. One major division was classified as knowledge and represented the less complex behaviors in which recognition or recall were the major psychological processes. Knowledge was identified as the first category in the taxonomy.

The second cluster of educational objectives was labeled "intellectual abilities and skills" (p. 28) which included the five more complex categories of the taxonomy. Comprehension was the first and lowest of the categories in the abilities and skills cluster. Bloom discussed the relationship of knowledge to the more complex intellectual categories and pointed out the inadequacy of information or knowledge recognition alone. He suggested,

> What is needed is some evidence that the students can do something with their knowledge, that is, that they can apply the information to new situations and problems. It is also expected that students will acquire generalized techniques for dealing with new problems and new materials (p. 38).

Knowledge was defined as, "... those behaviors and test situations which emphasize the remembering, either by recognition or recall, of ideas, material, or phenomena" (p. 62). Knowledge as defined above was viewed as an extremely important aspect in the development of the subsequent categories (Comprehension, Application, Analysis, Synthesis and Evaluation). It represented the specific elements which a learner must possess in his chosen field if he is to solve any of the problems in it. It consists of both the universals and the abstractions in a field. Thus knowledge was depicted, as was the taxonomy, from simple to complex. Contained within the highest level was the knowledge of principles, generalizations, theories and structures.

The definition of comprehension set forth by Bloom, _et al_. (1956) and utilized for this study follows:

> ... comprehension is not made synonymous with complete understanding or even the fullest grasp of a message. Here we are using the term 'comprehension' to include those _objectives_, _behaviors_, or _responses_ which represent an understanding of the literal message contained in a communication. In reaching such understanding, the student may change the communication in his mind or in his overt response to some parallel form more meaningful to him (p. 89).

An examination of the various types of behavior associated with comprehension provided support for the inclusion of the interim activity and was directly related to the explanation of the conceptual framework. The three types of behaviors considered under comprehension were: translation, interpretation and extrapolation. Each of these behaviors had implication for the inclusion for the interim activity.

Translation was viewed as the transitional position between the category of knowledge and the more complex behaviors in the subsequent categories. It is pointed out that "... competence in translation is dependent on the possession of the requisite knowledge" (p. 90). The definition of translation dealt with an individual's ability to put a communication into another language, other terms or another form of communication. It involved, for example, the ability to translate an abstract problem or communication into a concrete or less abstract phraseology. It further involved the ability to reduce a lengthy communication into briefer or more abstract terms.

All of the preceding behaviors required the learner to rephrase or repeat parts of the communication. The next step was interpretation and it presumed the learner's ability to translate the communication. The ability to identify relationships between parts, to reorder or rearrange them, to derive a total view of a communication and to relate it to one's own experiences represented the essential elements defining interpretation according to Bloom. Interpretation was described as going beyond part-for-part rephrasing. The behavior manifested at this level of comprehension includes the ability to recognize warranted or unwarranted conclusions.

> The essential behavior in interpretation is that when given a communication the student can identify and comprehend the major ideas which are included in it as well as understand their interrelationships (Bloom, et al. 1956, p. 93).

The third type of behavior considered in the category of comprehension was extrapolation, described as the ability to go beyond the limits of a communication to apply some of the ideas in it to situations and problems not included explicitly in the communication.

> Accurate extrapolation requires that the student be able to translate as well as interpret the document, and in addition, he must be able to extend the trends or tendencies beyond the

> given data and finding of the document to determine implications, consequences, corollaries, effects, etc. which are in accordance with the conditions as literally described in the original (Bloom, *et al*. 1956, p. 95).

Explanation of the Conceptual Model

The preceding paragraphs have outlined Blooms taxonomy which served as the theoretical base for the conceptual framework. The conceptual model, Figure 1, represents graphically the conceptual issues that were addressed in this study. The hypotheses examined in this study were generated on the basis of the conceptual framework and review of related literature.

The model has presented two approaches to the teaching of a given unit of instruction (Content X), has represented two manipulations of the time variable, ordered the potential educational outcomes hierarchically and projected educational results based on the two approaches. The projected results are extrapolated from the conceptual framework.

The underlying assumptions for the conceptualization were:

1. Oral communication is not as efficient as it might be in terms of student time spent listening, the typical speaking rate of instructors, the rate at which the mind is capable of processing information and the passive nature of most listening exercises.
2. Comprehension and movement to more complex educational behavior is improved as the learner is actively involved in the translation, interpretation and extrapolation of the specifics, universals, or abstractions communicated to the learner.
3. Educational outcomes can be favorably influenced.

4. Educational behaviors are ordered sequentially from simple to complex and the development of each is a prerequisite to the development of the next higher level.

Conceptual Model Summarized

The conceptual model has graphically suggested that improved educational results will be achieved by those students who use the available class time listening and in a subsequent interim activity. The interim activity required students to immediately verbalize the communication received. The skills required to effectively perform the interim activity should contribute to the improved accomplishment of the projected results by reinforcing the content of the communication.

The projected results in Figure 1 represent the specific skills which are related to the achievement of the educational outcomes (Figure 1) of Knowledge and Comprehension. The interim activity was intended to require the students to translate the communication, interpret relationships and to extend the data beyond the specific framework of the communication. Translation, interpretation and extrapolation presume the existence of the lower skills e.g. recalls specifies, organizes facts etc.

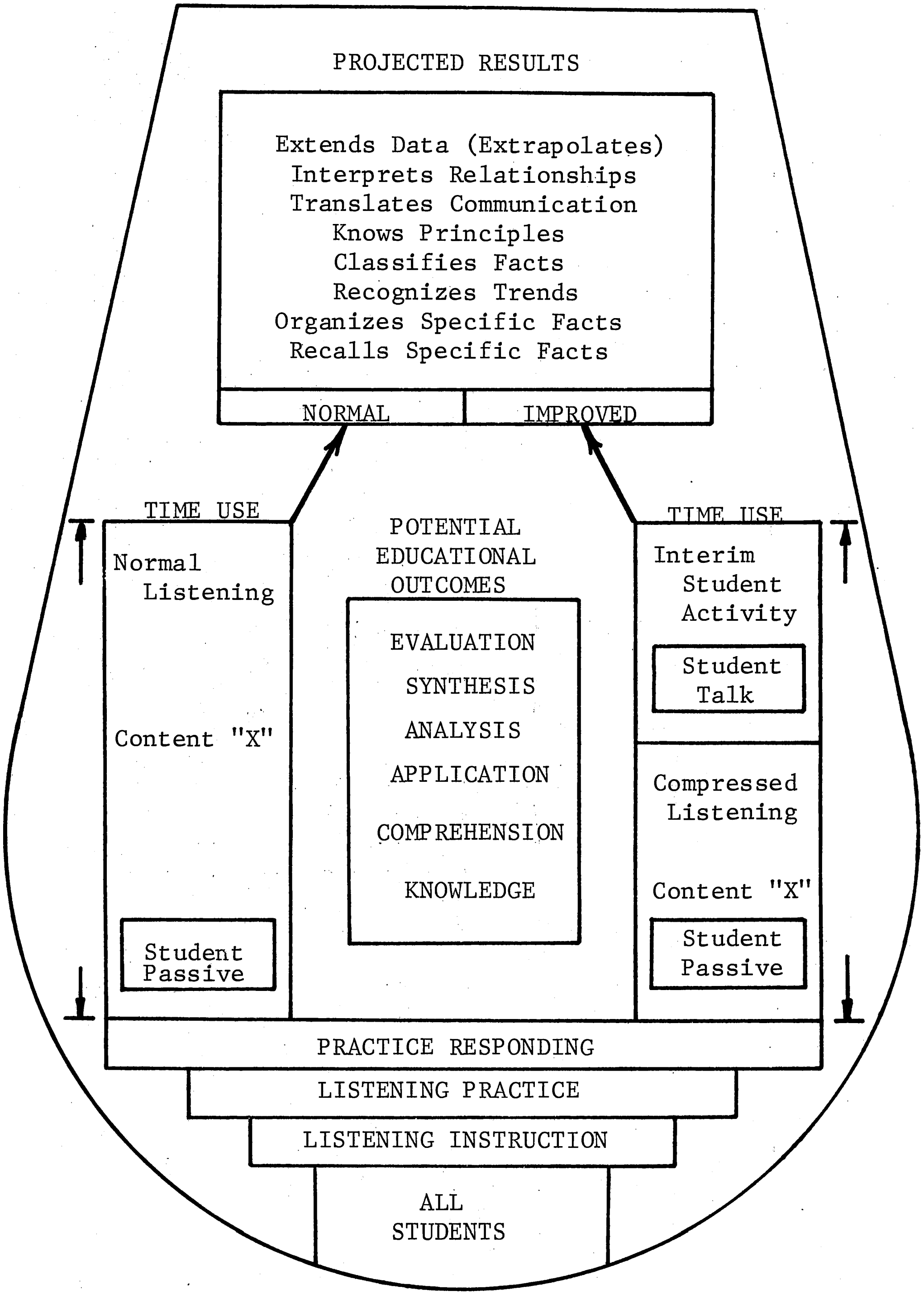

Figure 1. Conceptual Model

CHAPTER III

METHODOLOGY AND DESIGN

Introduction

The purpose of this research was to investigate the effect of a compressed audio-tutorial lecture and an interim activity on the comprehension of students enrolled in Engineering Science 3213. A question asked was: Will a non-listening interim activity, requiring the listener to immediately verbalize a compressed lecture, result in a significant improvement in comprehension of that lecture?

Hypotheses

Data were obtained by using a taped thermodynamics lecture recorded at three rates of compression, the use of individual cassette recorders and evaluation instruments designed to measure differences in comprehension. Differences were measured and analyzed statistically to test the following hypotheses:

Hypothesis 1: Varying rates of compression will not differentially effect comprehension of taped material.

Hypothesis 2: An interim activity will not differentially effect comprehension of taped material.

Hyopthesis 3: Varying rates of compression and an interim activity will not interact to effect comprehension of taped material.

Limitations of the Study

This research was conducted with a sample of S's enrolled in the Division of Engineering at Oklahoma State University. Oklahoma State University is a land grant university with an on campus enrollment (Fall 1974) of 19,500. The total enrollment in the Division of Engineering in the Fall of 1974 was 1,484 and was composed of 378 freshmen, 243 sophomores, 163 juniors, 300 seniors and 400 graduate students.

The sample was limited to students enrolled in Engineering Science 3213 (Thermodynamics) which was predominantly a junior level course required for all students seeking a degree in engineering. Generalizations from this study should, therefore, be limited to populations which have characteristics similar to those of engineering students attending Oklahoma State University.

Sample Selection

A corrected class roll was obtained during the first week of the Engineering Science 3213 class. Each of the 98 students was assigned a number 1 through 98 and 60 numbers were drawn using a table of random numbers. The S's were then identified by name, and assigned to one of six groups by a random process utilizing the table of random numbers. Finally each of the groups drawn from the random sample was randomly assigned to one of the six listening treatments.

All students in the Engineering Science 3213 class were directed verbally by the instructor and by memo to report to the language laboratory on the days of the experiment. Those S's randomly identified to participate in the experiment were then directed to the appropriate booth in the lab. All other students were directed to a classroom where they were also exposed to the practice listening tape and one of the compressed experimental tapes in a classroom setting which utilized a tape recorder and a public address system presentation. The announcements were made and memos distributed in each section of the thermodynamics lab during the first and second week of the semester. The practice listening occurred on Monday of the second week and the experimental session was conducted on Monday of the third week in the semester.

Organization of the Study

The preparation of the materials utilized in this experiment were developed in conjunction with Robert L. Robinson Jr., Professor of Chemical Engineering. The topic chosen for the listening-interim activity experiment was a portion of the fourth unit in thermodynamics dealing with the topic of work. This particular unit was chosen on the basis of the following considerations.

One consideration was the necessity to use a recorded message which was an integral part of the content in the thermodynamics course and that it further be introduced to S's during the same week it was to be discussed in the regularly scheduled classes. This was essential due to the technical nature of the course content and the importance of the preceding units to the comprehension of any subsequent unit studied. It was also the belief of the researcher that the utilization of listening content relevant to the course and of importance to S's would be received with a higher degree of attention than would occur if the listening content was totally unfamiliar and unrelated to the class in which the S's were enrolled. It was assumed that the Ss' motivation to listen and respond as requested in the experiment would be greater if the listening content and interim activities were closely related to the course of study.

A second consideration, more directly influencing the choice of unit four, was the nature of the course content. Most of the units in thermodynamics were predominantly of a problem solving nature with a minimum of uninterrupted narrative content. The format of these problem solving units did not lend themselves to an unbroken narrative message. The audio-tutorial tapes used with the problem solving units were typically broken into parts as follows: Introduction of a problem; introduction of a tool, technique or formula for its solution (contained on a worksheet); and presentation of a practice problem to be solved. The derivation of the solution generally took fifteen to forty-five minutes during which time the listener turned off the tape. This consideration thus negated the use of many of the units for the purpose of this study. Unit four was ideally suited to the study because of the predominance of narrative material containing a balance of concepts and facts.

A third consideration was time. It was essential that the recorded material represent a complete segment of the unit and that it be subject to recording in one tape of approximately 30 minutes. Unit four was found to be the most acceptable in satisfying this requirement.

A final consideration had to do with the comprehension test to be administered following the listening-interim activities. The unit chosen needed to cover an adequate number of facts, theories and concepts to yield a sufficient number of test items. The test also had to be completed in thirty minutes, thus ruling out the complex problem solving units or the solution of typical thermodynamics problems as a part of the test.

The practice listening tape and the unit four tape were developed prior to the experiment. A transcript of representative portions of the practice and experimental tapes, instructions, tape notes and tests are included in the Appendices E, C, D, F and G, respectively.

Unit four was scheduled for the third week of classes in the spring semester of 1975. The S's were identified during the first week of class meetings for participation in this study at which time they were also advised that they were to report to the language lab in the Math Science Building for the next two class meetings.

At the second class meeting all S's were exposed to identical practice listening materials at identical rates of compression. The purpose of this session was to prepare S's for listening to compressed speech through practice listening exercises and to familiarize them with the equipment to be utilized in the experiment. The content of the practice listening tapes was taken from unit one which was primarily a review of concepts and definitions considered essential to success in the thermodynamics course. Most of the information covered in the practice tapes had been presented in the courses which were prerequisites to thermodynamics (Physics 2414, Chemistry 1515, Calculus 2265, Engineering 1112).

At the third class meeting S's were exposed to the various experimental or control conditions to which they had been randomly assigned. Figure 2 and Table II represent the activities of each of the six groups (G-1, G-2, G-3, G-4, G-5 and G-6). All S's listened to the same lecture, were presented the same audio-tape notes and took the same test. The differences between the groups were in the listening time and interim activity. The three rates utilized in this study were 100 percent, 80 percent and 60 percent of the speakers normal rate with resultant word rates of 125, 174 and 223 w.p.m., respectively. Dr. Robinson's normal speaking rate of 125 w.p.m. was slower than the rate of speaking for the average speaker. Due to the slow input rate the 80 percent compression resulted in a rate considered to be within the average range.

TABLE II

DESCRIPTION OF EXPERIMENTAL GROUPINGS

Group	Listen Time (Min)	Percent Compressed	Percent of Normal	Interim Activity (Min)	Test Time (Min)	Total Time (Min)	N
G-1	31	0	100%*	0	30	61	10
G-2	31	0	100%	5	30	66	10
G-3	24.8	20%	80%*	0	30	54.8	10
G-4	24.8	20%	80%	5	30	59.8	10
G-5	18.6	40%	60%*	0	30	48.6	10
G-6	18.6	40%	60%	5	30	53.6	10

*Percent Equivalancies in Words Per Minute

100% of Normal - 125 w.p.m.
80% of Normal - 174 w.p.m.
60% of Normal - 223 w.p.m.

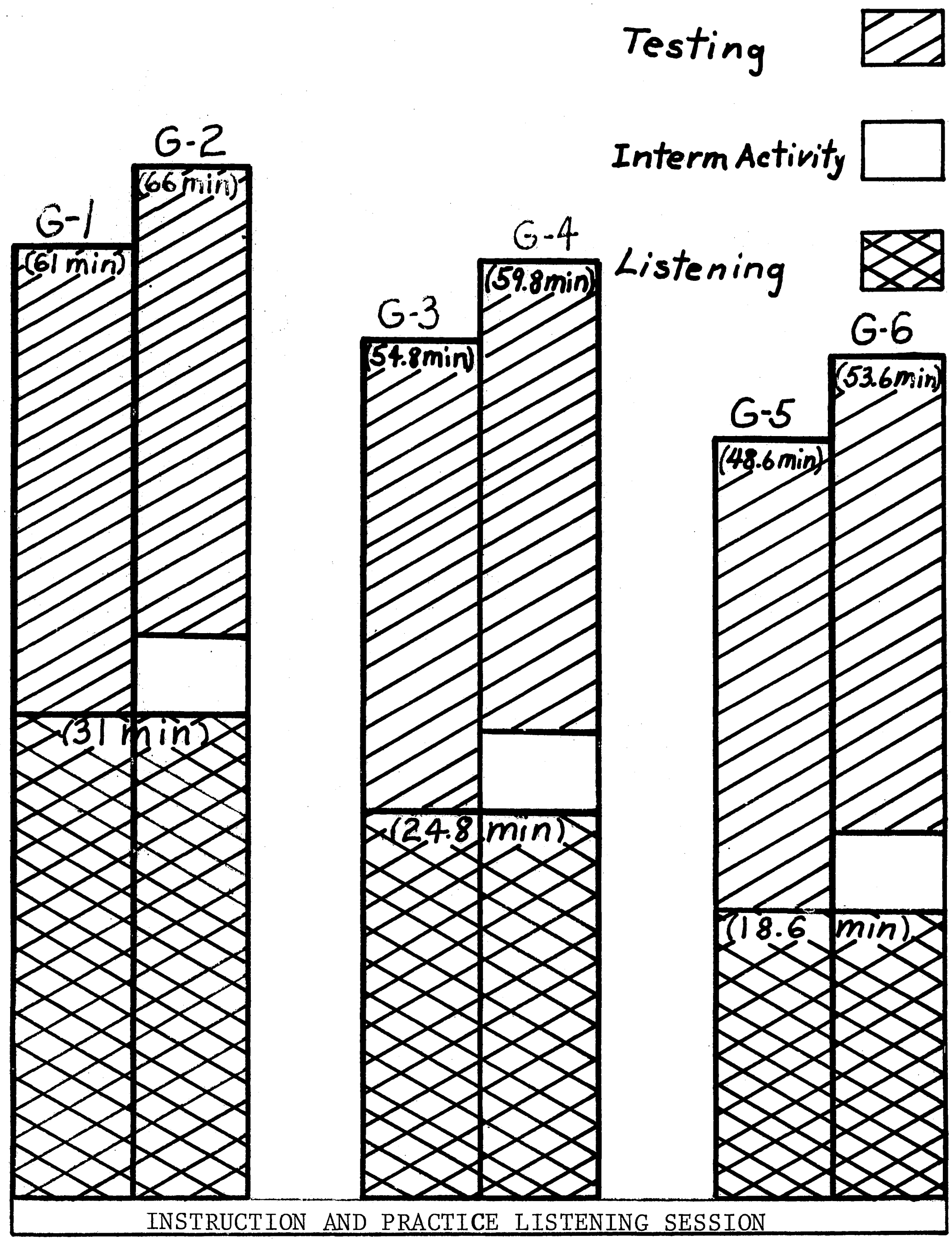

Figure 2. Experimental Design

In summary it may be seen that three control groups (G-1, G-3 and G-5) listened to the lecture at one of three rates and took a thirty minute test while the three experimental groups (G-2, G-4 and G-6) listened to the same message at one of three rates, participated in the interim activity and took the same thirty minute test.

The variables in this study were the rate of compression, the interim activity and the students' comparative performance on a post-test of comprehension. Appropriate statistical tests were utilized to determine if there were any significant differences in comprehension scores between treatments. Additional statistical tests were administered to determine if rate of compression and the interim activity interacted to cause significant differences in comprehension scores on the post-test.

Evaluation Instruments

The evaluation instrument used in this study to measure comprehension was designed by the instructor, Professor Robert L. Robinson, who also developed the audio-tapes, tape notes and evaluation instruments for the entire course. He was thus experienced in the instruction of thermodynamics and familiar with the audio-tutorial technique of instruction utilized in this course. In addition the instructor was aware of the capacities of engineering students and experienced in designing evaluative instruments to measure their comprehension of course content. Items were developed which the instructor judged to be most valid. Items were also selected which were judged to require differing levels of understanding. The test contained seventeen multiple choice items.

The test instrument was administered to a pilot group of eighty students enrolled in Engineering Science 3223 (Fluid and Heat Transfer). Student responses were recorded on IBM optically marked response cards, graded and scored by the Oklahoma State University Computer Center. The computer center furnished the following information: The mean; standard deviation; frequency of responses for each item; the difficulty index, number in the top and bottom third; discrimination index; student's raw score, percent correct and T score; class listing ranked by score; and a histogram distribution.

The only scores used in the above computations were those of students who had previously completed thermodynamics. The imposition of this criteria necessitated discarding only three scores from consideration. Three additional student scores were unuseable due to incomplete information or improperly completed tests. On the seventy-two useable tests the following information was provided by the students regarding their completion of the thermodynamics course:

44 had completed it during the previous semester.
23 had completed it two semesters previously.
1 had completed it three semesters previously.
3 had completed it four semesters previously.
1 had completed it five semesters previously.

The difficulty index was calculated by the following formula:

$$\text{Persent of Difficulty} = \frac{\text{number correct in upper (U) third plus number correct in lower (L) third}}{\text{total number of responses possible in both upper and lower third}}$$

$$\text{or} \qquad \text{Difficulty} = \frac{U + L}{46}$$

The discrimination index was calculated by the following formula:

$$\text{Discrimination} = \frac{\text{number correct in the upper (U) third minus number correct in the lower (L) third}}{\text{number in one third}}$$

$$\text{or} \qquad \text{Discrimination} = \frac{U - L}{23}$$

The difficulty and discrimination indices for the seventeen items are reported in Table III.

The seventeen item test was administered to S's involved in the experiment immediately following the audio-tape on work and the interim activity. The experiment was conducted during a regularly scheduled class period on a Monday afternoon from 4:30 to 5:30. A copy of the instrument is located in the Appendix G.

The Kuder-Richardson (1939) Formula 20 was used to determine test reliability; it was reported by Guilford and Fruchter (1973) to be "The most accurate of the practical Kuder-Richardson formulas..." (p. 416). The KR_{20} reliability ($R_{\tau\tau}$) formula is:

$$R_{\tau\tau} = \frac{n}{n-1} \qquad \frac{\sigma_\tau{}^2 - \Sigma pq}{\sigma_\tau{}^2}$$

where: n = number of items in the test

p = proportion passing an item

$q = 1 - p$

$\sigma_\tau{}^2$ = total test variance

Σpq = the sum of the variance of all items

An analysis of the data yielded a reliability of .39 (N = 70), a total test variance of 4.504 and a total item variance of 2.77. The low reliability derived may be accounted for in a number of ways elaborated in the following paragraphs.

It was suggested that any internal consistency formula which was utilized for only one administration of a test would probably result in an underestimate of reliability. Guilford and Fruchter also pointed out that "Even the KR_{20} formula gives an underestimate when there is wide dispersion of item difficulties" (p. 418).

Reliability may also be affected by the range of ability in the population sample. The wider the range of abilities, the greater the reliability and conversely the narrower the range, the smaller the reliability tends to be. The range of a given trait in the sample population will also demonstrate the same tendencies. It was thus possible that some unidentified ability or trait was interacting.

It was suggested in the preceding chapter that attrition and transfers had, in effect, resulted in a screening process. This process as described seemed to indicate a narrowing in the range of abilities. Although not supported empirically, there was reason to believe such traits had developed among the engineering students involved in this study.

The test instrument contained only seventeen items and may have contributed to the low reliability score. The Spearman-Brown Prophecy formula was applied to the data and indicated that a reliability of .61 (N = 70) could be achieved if the number of test items was increased 2.5 times to forty-three items. It was not, however, practical to lengthen the instrument due to the narrowness of the tapes content and professor Robinson's determination that the test items provided thorough coverage of the tape content.

An additional source which may have influenced the results is the tendency of the KR_{20} to underestimate reliability when there is a wide dispersion of item difficulties. Table III showed that there was a rather wide range in item difficulty. The average item difficulty was calculated and an index of 48.7 was derived.

A final influence which was considered as a potential cause of the low reliability was the test itself. There was the possibility that the test was not adequately difficult and failed to discriminate between students of differing abilities. There were a few items (Table III) which indicated a weakness; in light of the test length, they may have adversely affected the test reliability.

Recommendations have been included in the final chapter of this study which should be considered in subsequent research of this nature.

TABLE III

ITEM DIFFICULTY INDEX AND ITEM DISCRIMINATION INDEX

Item Number	Difficulty Index	Discrimination Index
1	62.9	.06
2	34.3	.11
3	61.4	.83
4	17.5	.15
5	70.0	.10
6	62.9	.56
7	10.0	.00
8	20.0	.11
9	100.0	.00
10	18.6	.11
11	61.4	.67
12	50.0	.67
13	22.9	.39
14	91.5	.00
15	34.3	.50
16	50.0	.39
17	60.0	.50

CHAPTER IV

RESULTS OF THE STUDY

Introduction

The goals of this study were: (1) to contribute to the improvement of instruction of engineering students using the audio-tutorial materials in Engineering Science 3213; (2) to investigate the effect on comprehension which could be related to the utilization of a lecture compressed by varying amounts; (3) to investigate the effect on comprehension which could be related to an interim activity utilized in conjunction with a lecture compressed by varying amounts; and (4) to detect if the varying rates of compression and the interim activity interact to effect comprehension of a taped lecture.

Sixty students who were enrolled in Engineering Science 3213 participated in the experimental listening sessions. The participants completed an evaluation instrument at the conclusion of their respective listening session. The scores on this post-test represented the participants' performance or comprehension of the material presented in the taped lecture. The scores were used to test the hypotheses of the experiment by means of the analysis of variance. Each of the hypotheses has been repeated with the results of the statistical analysis.

Statistical Analysis

<u>Hypothesis</u> 1: Varying rates of compression will not differentially effect comprehension of taped material.

The raw data for the participants' performance on the instrument are presented in Table IV for the three groups which listened to the audio-tape and took the test. The total mean scores for G-1, G-3 and G-5, respectively were 13, 11.8 and 12.

the analysis of variance yielded an F ratio of 1.47 (Table VI). Rejection of the null hypothesis at the .05 level of confidence with 2 and 54 degrees of freedom called for an F ratio of 3.17. Hence the experimenter failed to reject the null hypothesis; the groups did not differ significantly due to varying rates of compression.

> Hypothesis 2: An interim activity will not differentially effect comprehension of taped material.

Presented in Table IV are the raw data for the participants' performance on the instrument. The three groups which listened to the audio-tape, participated in the interim activity and took the test were G-2, G-4 and G-6. The total mean scores for these groups, respectively, were 12.1, 11.4 and 12.3.

The analysis of variance yielded an F ratio of 0.54 (Table VI). Rejection of the null hypothesis at the .05 level of confidence with 1 and 54 degrees of freedom called for an F ratio of 4.02. Hence the experimenter failed to reject the null hypothesis; again, the groups did not differ significantly due to the interim activity.

> Hypothesis 3: Varying rates of compression and an interim activity will not interact to effect comprehension of taped material.

TABLE IV

RAW SCORES FOR GROUPS G-1, G-3 AND G-5
(LISTENING ONLY)

100 Percent		80 Percent		60 Percent	
Subject Number	Test Score	Subject Number	Test Score	Subject Number	Test Score
5	16	22	14	48	15
9	15	24	13	41	14
6	14	26	13	47	13
4	13	28	13	46	13
1	13	30	13	42	12
2	13	25	11	43	12
10	12	23	11	50	12
8	12	21	11	49	11
3	11	27	10	44	10
7	11	29	9	45	8
s.d.	1.63		1.62		2.0
ΣX	130		118		120
ΣX^2	1714		1416		1476
$\bar{X}$	13		11.8		12

TABLE V

RAW SCORES FOR GROUPS G-2, G-4 AND G-6
(LISTENING AND INTERIM ACTIVITY)

100 Percent		80 Percent		60 Percent	
Subject Number	Test Score	Subject Number	Test Score	Subject Number	Test Score
15	14	40	15	54	15
12	13	33	13	59	14
13	13	31	12	53	14
14	13	39	12	52	13
16	13	35	12	55	13
17	12	36	11	57	12
18	12	37	11	58	12
20	12	38	10	56	11
11	10	32	9	51	10
19	9	34	9	60	9
s.d.	1.52		1.83		1.89
ΣX	121		114		123
ΣX^2	1485		1330		1545
$\bar{X}$	12		11.4		12.3

TABLE VI

ANALYSIS OF VARIANCE TABLE FOR TOTAL SCORES

Source	SS	DF	MS	F Ratio	P .05
Rate	9.1	2	4.55	1.47	NS
Interim Activity	1.67	1	1.67	0.54	NS
Interaction	3.64	2	1.82	0.59	NS
Error	166.86	54	3.09		
Total	181.27	59			

The raw data for the participants' performance on the instrument are presented in Table IV and Table V for all groups which were subjected to one of the control or experimental treatments (G-1, G-2, G-3, G-4, G-5 and G-6). The total mean scores for these groups were reported following Hypotheses 1 and 2.

The analysis of variance for interaction effects yielded an F ratio of 0.59 (Table VI). Rejection of the null hypothesis at the .05 level of confidence with 1 and 54 degrees of freedom called for an F ratio of 3.17. Hence the experimenter failed to reject the null hypothesis; again, the groups did not differ significantly due to interaction.

Summary

The sixty students in this study were divided into six groups for an experimental listening arrangement to a taped Engineering Science 3213 lecture. The subjects were administered a multiple choice instrument which yielded total scores used in testing the three hypotheses. The data generated were treated statistically through the analysis of variance tests and yielded less than sifnificant F ratios in all three cases, which caused the experimenter to fail to reject the null hypotheses. Rate, an interim activity and the interaction of rate and activity did not significantly effect comprehension of a taped lecture.

CHAPTER V

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Introduction

The preceding chapter reported the raw data, the statistical treatment of that data and the inferences which were justified as a result of the statistical analysis. The experimenter attempted to interpret the data with the caution which characterizes a carefully developed research report.

The summary of the study has followed the conservative approach of the preceding chapter and was an endeavor to state concisely how the experimental design was carried out. The conclusions and recommendations were somewhat less conservative as they reflected, to a degree, the experimenter's concerns, questions, interpretations and suggestions.

Summary of the Study

This study has examined the effect on comprehension which could be related to the utilization of a lecture compressed by varying rates. The study also investigated the effect on comprehension which was related to an interim activity utilized in conjunction with a lecture compressed by varying rates. Finally, the study sought to determine if the varying rates of compression and the interim activity effected comprehension, due to an interaction between the independent variables.

The audio-tutorial lecture and the evaluation instruments were developed by Robert Robinson, Professor of Chemical Engineering, for use with students enrolled in the spring (1974) semester of Engineering Science 3213. Sixty students were randomly selected to participate and randomly assigned to one of six treatments. All participants were introduced to compressed speech and a practice listening session prior to their involvement in the experiment.

The introduction to compressed speech, the practice listening session, and the controlled experimental session were conducted in the foreign language laboratory at Oklahoma State University during regularly scheduled class periods. S's were assigned to individual booths where they listened to all taped materials, participated in the interim activity and were tested. The booths were accoustically shielded, provided individual headsets, microphones and tape recorders. The tape content was distributed through pre-set listening channels from a teacher's console.

The participants' scores on a post-test were subjected to an analysis of variance. The F ratios derived were utilized to test the three hypotheses. In each case the F ratio failed to reach a level which would allow the rejection of the null hypothesis at the .05 level. There were no significant differences in performance scores within or between groups due to treatment nor as the result of interaction of treatments and groups.

Conclusions

Subject to the limitations of this study, the following inferences and conclusions may be drawn. It seemed that the conclusions were drawn objectively from the available data.

1. Students who listened to the compressed audio-tape [80 percent (174 w.p.m.) and 60 percent (223 w.p.m.) of normal] did statistically no better and no worse on the comprehension test than those who listened to the tape at the normal rate.

2. Students who listened to the compressed audio-tape (rates above) and participated in an interim activity did statistically no better and no worse than students who listened to the tape at the normal rate.

3. A summary conclusion was that, on the basis of the findings of the research, listening time could be saved through the use of compressed speech without significant loss of comprehension. This conclusion was a tentative one due to certain limitations which may have influenced the results.

Recommendations

The recommendations which follow have been categorized under two headings. Some of the recommendations had implication for both categories but were listed only one time. The headings are: (1) Recommendations for Oklahoma State University and (2) Recommendations for Future Research.

Recommendations for Oklahoma State University

1. The volume of oral communication to which youth and adults are subjected throughout their schooling and life highlights

the need to teach listening skills and to develop the ability to translate, interpret and extrapolate oral messages. The implication of this recommendation extends beyond the university to include elementary and secondary education which shares a major burden in the development of oral communication skills. Such specific means might include:

a) A pilot program for entering freshmen which would screen and identify students for "remedial listening." Such a program should provide diagnosis of listening deficiencies, prescribe and carry out remediation. Students involved in the program could be observed through the remainder of their university career in a longitudinal study.

b) An elective course added to the curricular offerings.

c) An inclusion in teacher preparation (elementary-secondary) programs providing a major and systematic emphasis to the development of listening skills.

2. It is recommended that courses using the audio-tutorial method and materials consider providing audio-tapes at varying rates of compression. One advantage of the audio-turorial method of instruction is the potential for self pacing and individual options; this advantage could thus be enhanced.

3. Oklahoma State University has allocated considerable resources to the development of facilities, materials and staffing for a center providing individually paced instruction (IPI Center). Courses offered through IPI represent a number of disciplines e.g. mathematics, education and engineering. The use of audio

visual media are a significant part of the courses offered. The IPI approach and existing facilities provide a viable location for the use of compressed speech tapes. It is thus recommended that a study be made of possible uses of compressed speech in the IPI courses offered. It is also recommended that consideration be given to the purchase of speech compression equipment which permits the individual to vary the rate according to his needs. Availability of such equipment would eliminate the need to develop numerous copies of each tape at various rates. In addition the individual's control of rate is in keeping with the philosophy of the IPI approach. It is anticipated that Panasonic and Sony will soon have low cost models of speech compression equipment on the market. If the equipment is found to produce a good quality of compressed speech, then feasibility for the IPI Center would be enhanced.

Recommendations for Future Research in the Area of Compressed Speech

1. This study should be replicated under conditions which allow a higher degree of control than existed in this study. It would be desirable to extend the time period during which the participants could be exposed to additional practice and experimental listening to compressed speech. The added time would also permit coverage of a wider range of content and thus development of more reliable test instruments with a larger number of items. Attention should also be directed to

the development of items which discriminate more adequately.

2. The conceptualization which supported the use of an interim activity was neither confirmed nor rejected. It is, therefore, recommended that additional research be conducted into this aspect. There are questions which suggest potential areas of research and a few are listed below:

    a) What are the most productive uses to be made of the time saved by compressing audio-tapes? Are there educational activities which will significantly improve instruction when used in conjunction with compressed audio-tutorial tapes?

    b) What is the relationship of the participant's recorded comments to comprehension? Do the students with the higher test scores make better verbal comments? If there is a correlation, will content analysis yield an insight to the type of responses associated with superior comprehension? Can students be taught to verbally translate, interpret or extrapolate a communication?

As illustrated in Table I, studies to determine the effectiveness of a method of instruction vary in many aspects and the generalizations to be made are limited to that particular population. This study was subject to similar limitations and direct generalization to other populations cannot be stated. Indirect generalizations by the reader may, however, lead to the improvement of instruction in areas which may or may not be similar to the situation examined in this study.

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APPENDIX A

GLOSSARY OF TERMS

GLOSSARY OF TERMS

Comprehension. "Those objectives, behaviors or responses which represent an understanding of the literal message contained in a communication" (Bloom et al., 1956, p. 89). The three types of comprehension behaviors are:

a) Translation. The individual puts a communication into other terms.

b) Interpretation. The individual mentally or verbally re-orders a communication into a new configuration.

c) Extrapolation. The individual makes inferences from a communication which are in accordance with the conditions described in that communication.

Compressed Speech (Time-compressed speech). Recorded speech which is reproduced in less than the regular time. Antonym - expanded speech.

Frequency Shifting. A type of speech compression which increased the rate of information flow through an increase in the speed of the recording device. This is done without a correction for the increase in pitch which results in the "donald duck" effect.

Intelligibility. The ability of a listener to recognize a word or short phrase and to repeat it immediately. No consideration is given to understanding a message.

Interim Activity. In this study it referred to the five minute (interim) period immediately following the audio tape. The participant was required to record comments (activity) which he felt were salient aspects of the Audio tape.

Pause. "Syntactical cues in which the reader renders his own perceptions of the syntactic organization of the material" (Miron and Brown, 1974, p. 564). The period of silence between words, phrases and sentences in a connected discourse.

Phoneme. The smallest segments of speech sound which are used as the building block of spoken language.

Reinforcement. The strengthening by adding to or that which strengthens when added. The interim activity was added to strengthen the comprehension of the audio tape.

Selective Deletion. The process of speech compression whereby pauses are removed from a recorded discourse.

Systematic Deletion. The technique of speech compression which discards extremely small fragments of a recording at regular intervals.

APPENDIX B

DESCRIPTION OF COMPRESSION EQUIPMENT

AND THE LISTENING LABORATORY

EQUIPMENT

Modes of Compression

For this research only three of the available modes or mechanisms of compression were considered. The decision to limit evaluation to only three compression devices was the result of practical considerations. A major consideration was the anticipated availability of one or more of the three machines in the Audio-Visual Department of Oklahoma State University.

The three speech compressors evaluated for possible use in this research were VOCOM-I, Varispeech-I and the Copycorder Model CC-103. The titles above are trade names for the compressors manufactured by P.K.M. Corporation, Lexicon Incorporated and Magnetic Video Corporation, respectively. The literature was reviewed and an evaluation was conducted as described in the following paragraphs.

Three audio-tutorial courses were being taught in the Division of Engineering; included as part of their material were sets of taped lectures. Tapes had been prepared by Dr. Thomas Dean, Dr. Ron Rhoten and Dr. Robert Robinson. From existing tapes for each course a tape was selected and compressed for evaluation. A section of each tape was compressed to 70%, 60% and 50% of the original time on VOCOM-I, Varispeech-I and Copycorder CC-103 by the Oklahoma State University Audio-Visual Department.

A panel of individuals including two of the above professors listened to the compressed tapes and were requested to evaluate the different modes and rates of comprssion. No standard evaluation form was employed, however, it was the general opinion of the listeners that the VOCOM-I compressor was the most intelligible and least disrupted by splice noises at 70% and 60% compression. At 50% the Varispeech-I was slightly favored by the panel.

Before describing briefly each of the machines, it would be pertinent to discuss types of deletion which may be utilized to affect compression.

The types were "systematic" and "selective" deletion. Their differences raised additional questions regarding theoretical and practical considerations of importance in choosing a particular mode of compression. The following explanation of the two techniques of deletion and the subsequent description of machines is not technical in nature; however, technical references were included when available.

Systematic deletion via an automatic electrical and mechanical process was the first mode developed to compress speech. It was a technique developed and refined by Fairbanks, Everitt and Jaeger (1953), and as was mentioned in the portion of the chapter dealing with the "Giants" or "Major Contributors", it was a great technological breakthrough. The reference cited above provides a good description in semitechnical language of the underlying theory and method of systematic deletions. For a complete description including a full technical explanation of the recording device the reader is referred to the patent. A copy of the patent is included in volume two of the anthology by Duker (1974).

In their patent Fairbanks, Everitt and Jaeger explained that the function of the recording device was

> ... to take information, such as connected speech or sounds and reproduce them by leaving out small fragments or portions occurring during very short time intervals. These are so small in time duration that they do not include a whole sound unit, or in other words, a whole syllable or even a sound in a syllable. What remains after the fragments are discarded is in effect, squeezed together. The final recording is thus made a continuous one from which the original speech or sounds

> may be played back in a shorter time than required for the original delivery. The shortened material may sound much faster in delivery, but the pitch is unchanged and comprehension is still easily possible.... The purpose of the device of this invention is to sample discrete portions of a recording of connected speech and discard some of the portions so as to record less than the total number of portions. It is important that each discarded portion be so small that a sound unit could not be lost if that portion is discarded. The term 'sound unit' as used herein, means any portion of an expression if missing, would interfere with the intelligibility of the whole expression. In case of human speech, the discarded portions or intervals are so short that words and syllables are not lost in the shortening effect. Each sound is reproduced in sufficient length to make it as intelligible as the original sound, but enough of the sounds are ommitted to greatly shorten the time of delivery (Duker, 1974, p. 1040).

The key factor in systematic deletion is that the portions are discarded at regular intervals indiscriminantly. The compression was a result of the machine's capacity to abut the modified sounds. The Fairbanks recorder is not on the market, but numerous machines have been developed which utilize the Fairbanks principle. The most common machine of this type currently in use is the Whirling Dervish manufactured by Discerned Sound. The Whirling Dervish solved some of the problems of abutting noise and distortion which occurred at sample boundaries by the addition of switching circuitry and electronic components. The major problem with this piece of equipment was its cost which was in excess of $3500.00.

The second type of deletion to be considered was "selective deletion" which involved the technique of shortening or removing pauses from a recorded message. Additional compression was made possible through the removal of selected vowel sounds. Systematic deletion has been discussed further in the section describing the VOCOM-I compressor.

One of the problems encountered was the paucity of objective descriptions of the modes of compression considered for use in this study.

Most of the literature was of a commercial origin or a superficial restatement of the commercial material minus some of the glowing phrases. The three modes considered for use in this study were the VOCOM-I Speech Compressor/Expander, the Varispeech-I and the Copycorder.

The CRCR Newsletter has periodically published descriptions of the speech compressors that are commercially available at the time of publication or which are being developed. The newsletter provided the most adequate and concise descriptions of the various modes. It has been referred to extensively in developing the following descriptions of compression equipment.

VOCOM-I

The PKM Corporation has made available a speech compression/expansion device which utilizes the technique of selective deletion to accomplish compression. VOCOM-I permits the operator to adjust the amount of pause retained from 30 milliseconds to 1.0 second. It has thus become possible via pause removal to compress a recorded message for playback in 60% of the original time. The exact amount of compression possible is dependent on the speech rate and pattern of the individual recording the message. Additional compression is possible through the machines capacity to sense and compress vowels using a sampling method. During pause compression a high speed start-stop clutch is activated based upon information obtained from the signal being copied. The duration of vowel sounds is reduced by repeated stopping and starting of the transport which drives the cassette on which the signal is being copied thus sampling the vowels while they are occurring.

The removal of pauses reaised some important questions regarding its effect on the syntactic organization of a message and the listener's ability to understand the intentions of the speaker and the intended stress of important content. In one of the earliest studies on the effect of pause alteration Diehl, White and Burk (1959) found that "The relationship between pause time and phonation time in connected speech can, apparently be altered with no appreciable loss in comprehension" (p. 232).

In a recent study Miron and Brown (1974) examined the effect of pauses, as syntactical cues on comprehension. They indicated that

> ... when durational distortion (compression) is accomplished through reduction in the physical markers of syntactic organization (pause deletion), which preserves the proportionate distribution of the encoders intentions, the process of understanding those intentions suffers little or no disturbance (p. 230). (Emphasis Added)

The CRCR Newsletter reported the findings of a masters thesis by James Wilson (1969) in which he examined the comparative effects of the two types of deletion: selective and systematic. The study also examined the effects of rate on the immediate oral recall of word sequences. At each rate the two methods of compression were utilized. Wilson reported finding no significant differences as a result of rate or method of compression.

The research identified has demonstrated that the type of compresion possible via VOCOM-I is a viable technique of compressing speech. There were, however, some problems related to the use of VOCOM-I. Research studies examining the effect of word rate require tapes compressed to rather exact standards. It is difficult and time consuming to compress an original tape to an exact rate on VOCOM-I. This problem was related to the nature of selective deletion and the variations of pause duration in connected discourse. If all pauses in a discourse were of the same duration, it would be possible to compress to an exact rate on the first pass through VOCOM-I. Such uniformity of pause duration is not realistically possible. At a given moment the VOCOM compressor will vary in the amount of compression being accomplished.

A second limitation was that VOCOM-I could not be used for listening to compressed speech without first making a compressed tape. It was not possible to monitor an original tape at varying rates prior to making a compressed copy.

Varispeech-I

Lexicon Incorporated manufactures and distributes the compressor/expander developed by Francis Lee, a member of the faculty of the Department of Electrical Engineering at Massachusetts Institute of Technology. The Varispeech-I is an electronic device whereas VOCOM-I is electro-mechanical and it utilizes systematic sampling with discard intervals of under 60 milliseconds in range.

Compression is accomplished through a built-in pitch correction processor which employs digital integrated circuits similar to those used in digital computers. The pitch correcting processor is constructed with modular printed circuit cards which facilitate servicing when required. When a tape is being compressed the Varispeech-I electronically adjusts the "exact amount" of discard thus making possible a one time recording process. It was also possible to use Varispeech-I for compressed speech listening without first making a compressed copy of the tape.

Copycorder CC-103

The Magnetic Video Corporation has marketed a speech compressor which utilized two integrated circuit chips which were developed by the Cambridge Research and Development Group. These tiny chips are marketed under the trademark of Variable Speech Control or VSC.

The VSC is about the size of a sugar cube and is made up of the two chips stacked together. One chip contains the control circuit and the other is the processor. The VSC, according to its developers, can be incorporated into tape recorders, phonographs, dictating machines, audio visual devices and other sound-reproducing equipment. The VSC was developed by Murray Schiffman, the director of electronic research for the Cambridge firm.

The Copycorder was the first truly portable cassette speech compressor to become available. It is only slightly larger than the typical cassette player/recorder. The additional size is due to its additional cassette transport. One cassette transport handles the original while the second accommodates the compressed version. The listener may monitor an original at varying rates without making a compressed copy.

The major problem associated with the Copycorder proved to be the splicing noise which was a regular clicking sound throughout compression. The noise, however, was not judged to be so severe as to impede comprehension. Its advantages were its size and cost.

At the time of this study none of the available speech compressors were in the price range which would make them desirable to a large number of individuals. The three modes described above were less expensive than most of the earlier speech compressors but were still too expensive for most college students. The advertised prices were as follows: VOCOM-I, $1195.00; Varispeech-I, $995.00; and Copycorder CC-103, $495.00.

Listening Lab Facilities

The practice listening sessions and the experimental sessions were conducted in the foreign language laboratory of Oklahoma State University. The lab was ideally suited to meet the needs of this experiment and a description of the equipment and facilities follows, excerpted from the Rheem Califone (n.d) Laboratory Instruction Manual, Section II.

The Rheem Califone language lab is a complete system designed to augment traditional teaching methods. The convenience and flexibility of this system allow the simultaneous teaching of several languages (or subjects) to different groups of students. It consisted of a teacher's console which had the capacity to play ten master tapes simultaneously. There were sixty-four student positions in the laboratory and each was equipped with headset and microphone. Half of the listening booths were equipped with a transistor amplifier for their microphone. This enabled the student to hear his own voice and to be monitored by or communicate with the instructor. The remaining thirty-two student booths were equipped with tape recorders. It was also possible to monitor or communicate with students located in these booths.

Each student had access to ten listening channels via an individual control knob, each booth was also equipped with a loudness control for the headset, loudness control for the microphone and a teacher call button which activated a signal light on the teacher's console.

APPENDIX C

INSTRUCTIONS AND INTRODUCTION TO COMPRESSED SPEECH LISTENING PRACTICE

PART I AND PART II

INSTRUCTIONS AND INTRODUCTION TO COMPRESSED SPEECH LISTENING PRACTICE

PART I

"A large portion of your formal education has been communicated to you by the spoken word and has thus demanded that you spend a considerable amount of time as a listener, a recorder and an interpreter of lectures and discussions. Listening will also be a significant part of the activity in this thermodynamics class. In order to make maximum progress in this course it is necessary to utilize the audio-tutorial tapes prepared for each section of the course.

One of the problems with listening is that the spoken word is one of the slowest means of communicating information. You are able to read at a much faster rate than I am recording this message. You are also able to think much faster than you read. The problem then is that a speaker can't talk as fast as you can listen. The limitation is not yours it is the speaker's since he can only talk or read to you at a rather slow rate. Recent technological developments have made it possible to deal with this limitation, that is, it is now possible to speed up the rate of speaking with no loss of intelligibility.

In a few moments you will be listening to me as I speak at a much faster rate. It is important that you accept the fact that you <u>can listen</u> and comprehend at this accelerated rate. There will be no distortion and no words will have been taken out to make the message more rapid.

There are three important suggestions which could help you gain the most from a message compressed to less than the normal listening time.

First - concentrate on the message content and attempt to ignore all other influences or considerations. Second - do not let the rapidity with which the words are coming to you be a distraction. The words will be coming at a rate considerably slower than you read and think. For some listeners, however, there is a "shock affect" which causes them not to hear the message because of the mere phenomenon of words coming at a much faster rate than is customary to them. The final suggestion was referred to previously and that is the importance of your attitude. Despite the rapid pace at which the words flow you can comprehend the message. Numerous studies have already proven that people are able to listen to and comprehend speech which is accelerated by considerable amounts.

As an introduction to accelerated or compressed speech you will now hear my introductory comments accelerated by 40%, or stated another way, you will hear the comments in just 60% of the original time. Ready".

(Preceding instructions repeated)

"Now you see that you can in fact listen to and understand a spoken message accelerated by a significant amount. The comments originally took 180 seconds or three minutes while the accelerated version took only 108 seconds. If this had been a 30 minute lecture, you would have saved 12 minutes of listening time."

LISTENING PRACTICE

PART II

"The next selection to which you will listen is taken from the first unit in thermodynamics which reviews some crucial definitions and concepts on which all additional units will build.

In addition to listening you will be given the opportunity at the end of the selection to verbally summarize the contents of the tape. You will find that the technique of immediately verbalizing an important term, definition or concpet in your own words will improve your comprehension. As you listen to the tape attempt to concentrate on grasping the major concepts and as many related details as possible so that your verbal comments will reflect a thorough coverage of the topic. The tape notes may help visualize or grasp a concept but you will not be able to use them extensively at this time. Ready".

(S's listen to practice tape 1 compressed to 80%)

"This concludes the first selection. You will have only two minutes to verbally summarize the preceding tape. You should state in your own words those terms, concepts, definition, formulas and applications which you feel to be most important. Do not be overly concerned with the order or sequence of your comments. Do not worry if your terminology is not exactly the same as that of the tape. The most important thing is to fill the two minutes with personal and meaningful narrative comments.

If you are in a booth numbered 5, 6, 7 or 8, it is equipped with a tape recorder turn it on by depressing the red button and turning the left hand lever all the way to the record position before beginning your comments.

If you are in a booth without a recorder, position the microphone close enough to your mouth so that your comments feedback clearly through your earphones.

You will have two minutes after my signal to start talking. Get Ready. Begin recording your comments."

(2 minutes of silence on master tape)

"Stop. Turn off your tape recorder by turning the lever to the (off) position.

You will now hear a second selection from unit one of thermodynamics at a slightly faster rate. At the conclusion of this selection you will again attempt to verbally summarize its contents. No additional instructions will be given at the conclusion of this tape _except_ to tell you to begin talking."

(S's listen to practice tape 2 compressed to 60%)

"This concludes the second selection. You will have two minutes to make your comments. Turn on your recorder, adjust your microphone and begin."

(2 minutes silence on master tape)

"Stop. This concludes the listening exercise today. You are reminded that the class will meet in this room again next Monday at 4:30. You are dismissed upon turning in your completed attendance information card."

APPENDIX D

RECORDED INSTRUCTIONS FOR

EXPERIMENTAL SESSION

RECORDED INSTRUCTIONS

FOR

EXPERIMENTAL SESSION

"During this listening excercise, you may wish to adjust the volume of the sound if so, turn the round volume knob on the extreme left of your console.

This afternoon you will be listening to a tape dealing with the topic of work. You will also be requred to take a 30 minute examination over its contents.

Everyone in a booth numbered 5, 6, 7 or 8 should be familiar with the procedure of turning on their recorder so those instructions will be given at this time. DO NOT, I REPEAT, DO NOT turn on your recorder at this time. Merely familiarize yourself with the procedure as you will be required to use the recorder at a later time. To turn on the recorder you must press down the red button and turn the left hand lever all the way to the record position. In addition the power toggle switch should already be in the on position.

(Stop all master tapes - questions answered)

Non-Recorded Directions

"Put your headsets back on".

(Start all master tapes)

Recorded Instructions for G-2, G-4 and G-6

(After listening to the tape on work)

"At this time you will be given five minutes to restate in your own words as much of the tape contents as possible. Include in your comments those portions which seem crucial or of extreme importance in understanding the concept of work and its application. This may include definitions, formulas, rules to remember, important relationships or any statement that helps you clarify that to which you have just listened.

Now turn on your recorder by depressing the red button, turning the left hand lever all the way to the "Record" position and begin recording your comments."

(5 minutes silence on tape)

"Stop. Turn off your recorder by returning the left hand lever to the off position. Please hold up your "tape notes" as an indication that you are ready to begin the test. A class monitor will pick up your notes and give you a test booklet. When you receive the test booklet be sure that you put your name and the booth, letter and number on the cover. This is a timed test. You will have 30 minutes in which to complete the test and thus it is important that you not spend too much time on any one question. If you experience difficulty with an item, you may wish to go on to the next question and return to the item omitted as time permits. If you complete your test in less time than allotted, please remain in your booth and review your test answers. Your test booklet will be picked up in 30 minutes."

Recorded Instructions for G-1, G-3 and G-5

(After listening to the tape in work)

"This concludes the listening exercise. Please hold up your "tape notes" as an indication that you are ready to begin the test. A class monitor will pick up your notes and give you a test booklet. When you receive the test booklet, be sure that you put your name and the booth letter and number on the front cover. This is a timed test. You will have 30 minutes in which to complete the test and it is thus important that you not spend too much time on any one question. If you experience difficulty with an item, you may wish to go on to the next question and return to the item omitted as time permits. If you complete your test in less time than allotted, please remain in your booth and review your test answers. Your test booklet will be picked up in 30 minutes."

APPENDIX E

SELECTED SAMPLES FROM AUDIO-TAPE

SELECTED SAMPLES FROM AUDIO-TAPE

This audio tape for Engineering Scinece 3213 Thermodynamics, deals with the calculation of work. As we begin to deal with work, we really have our first introduction into energy. Because as we have learned in elementary Physics couses, work is a form of energy and a particular form of energy. It is energy in motion or energy in transit across system boundaries. We shall in this tape carefully focus our attention on the work done by the particular system we have chosen to study as that system undergoes a specified process. We will calculate work by its regorous definition and we will see that in thermodynamics we must take very special care to evaluate the work and make use of certain sign conventions regarding the magnitude of work, that is, when work is negative and when work is positive as it refers to our system. In the study notes accompanying this tape the very first item of business is the definition of work. The first equation in the handout material presents the classical definition of mechanical work. Work being defined as a force acting thru a distance. This first equation is a rigorous definition of work in vector notation where we have the dot product of the force and the vector distance DX integrated from some initial to some final position X_1 to X_2. Well, for those that haven't had vector' calculus and don't know how to handle vectors this equation doesn't look very promising....

For our purposes in thermodynamics, we must be more specific regarding the definitions of force and of boundary movement F and dX. The force F is not defined completely until we very specifically say what the force F is acting upon. For our purposes we will define F to be the force exerted on the system by the surroundings, that force being applied at the system boundaries. So F then is the force exerted on the system at the system boundaries by the surroundings. The surroundings of course being every thing outside the system. For example, if we have one pound of iron as our system then every thing in the world other than that one pound of iron is the surroundings. We now define dX as the distance of movement of the system boundary. So to repeat now, F in our thermodynamic notation is the force exerted upon the system by the surroundings that force being applied at the system boundaries. DX is the motion of the system boundary. If you reflect on F and dX for a moment you see that both the definition of F and dX apply to conditions at boundary of the system. We must train ourselves in calculations of work to always focus our attentions strictly on the system boundaries.

APPENDIX F

AUDIO-TAPE NOTES

SPECIAL TAPE

WORK

Definition of Mechanical Work

$$W \equiv \int_{\vec{x}_1}^{\vec{x}_2} \vec{F} \cdot d\vec{x}$$

or

$$W = \int_{x_1}^{x_2} F dx$$

F = force exerted on the system, at the system boundary, by the surroundings
dx = distance of movement of system boundary

$$W = \begin{cases} (+) \text{ if F and dx are in opposite directions} \\ (-) \text{ if F and dx are in same direction} \end{cases}$$

Examples of Sign Convention for Work

Extension of a Spring:

Figure 1

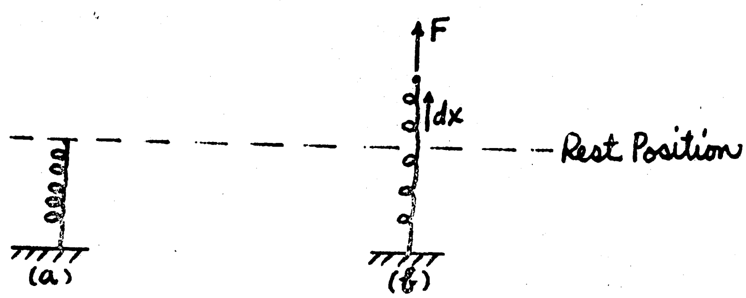


Figure 2

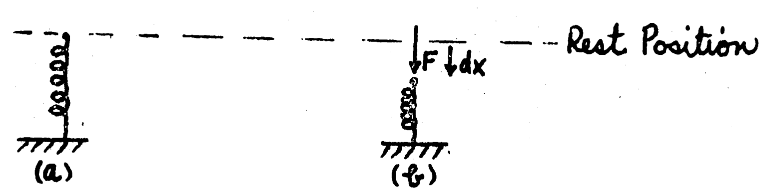
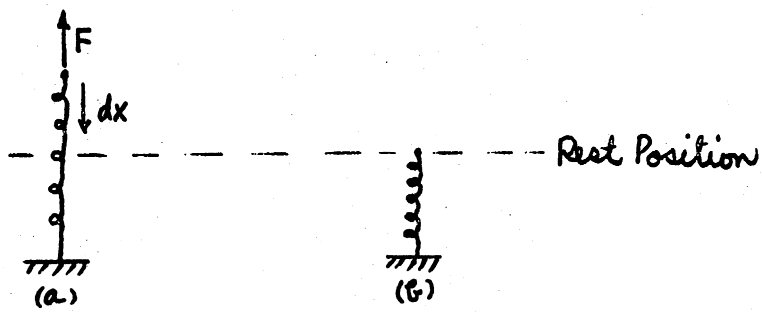


Figure 3



Expansion of a Gas:

Figure 4

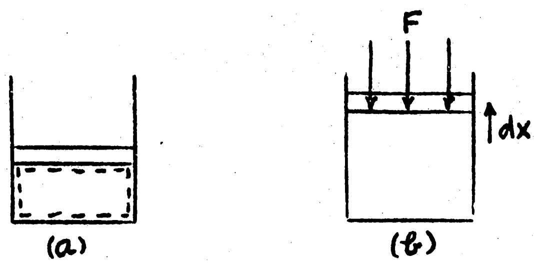
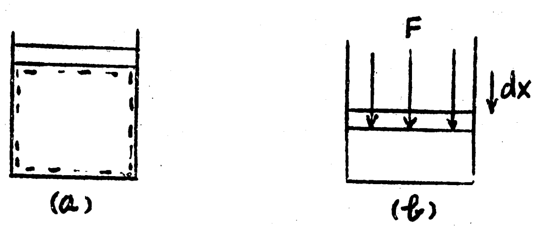


Figure 5

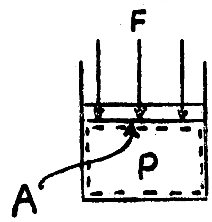


Thus, work is (+) when work is done by the system; work is (-) when work is done on the system.

Pressure-Volume (p-v) Work

Consider a process which occurs sufficiently slowly that the system pressure remains uniform

Figure 6



$$W = \int_{x_1}^{x_2} F dx$$

but $F = pA$

$$W = \int_{x_1}^{x_2} pA dx$$

but

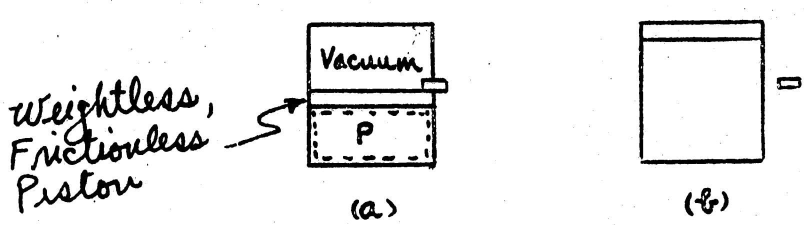
$$A dx = dV$$

$$W = \int_{V_1}^{V_2} p dV$$

To use this relation we must know some relation between p and V.

When does $\int p dV$ not apply?

Figure 7



$$W = \int F dx$$

but $F = 0$

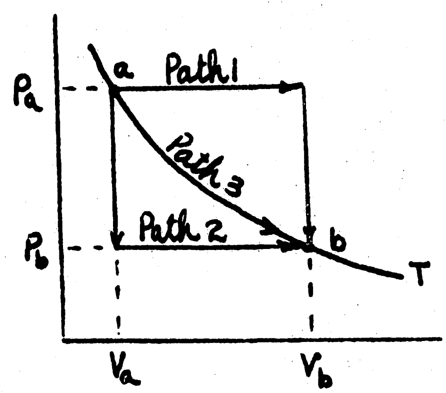
$$W = 0$$

Expansion of a gas into a vacuum results in no performance of work.

Work--A Path Function

Consider an ideal gas undergoing a change in state from state (a) to state (b) under such conditions that $W = \int pdV$ applies.

Figure 8



Path 1

$$_aW_b = \int_{V_a}^{V_b} pdV = p_a(V_b - V_a) + 0$$

Path 2

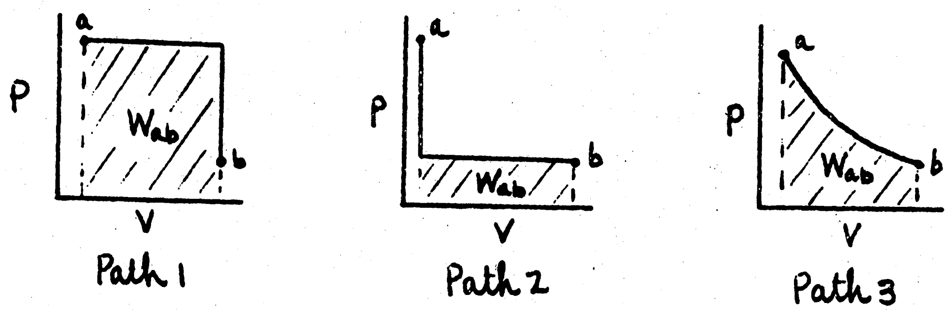
$$_aW_b = \int_{V_a}^{V_b} pdV = 0 + p_b(V_b - V_a)$$

Path 3

$$p = \frac{nRT}{V}$$

$$_aW_b = \int_{V_a}^{V_b} pdV = \int_{V_a}^{V_b} nRT \frac{dV}{V} = nRT \ln \frac{V_b}{V_a}$$

Figure 9



Note: Work depends on path taken between states (a) and (b).

Flow of Electricity:

If a current of electrons (amperage), i, flows through a potential difference (voltage drop), ε, the work is given by

$$W = \int_{o}^{t} - \varepsilon i dt$$

We are more familiar with the rate of work, $\frac{dW}{dt}$, which is the power (wattage).

$$\frac{dW}{dt} = -\varepsilon i$$

Determining if System Does Work

Ask these questions, concentrating on the system boundaries:

(1) Do the system boundaries move?

(2) Do shafts, belts, or chains cross the system boundaries?

(3) Do electrical leads cross the system boundaries?

If the answer to the above questions is

Yes (for any of 3 questions) - work is probably done

No (for all 3 questions) - work is unlikely

APPENDIX G

AUDIO-TAPE TEST

ENGINEERING SCIENCE

3213

TEST 1: WORK

____
NAME (Please Print)

BOOTH: ________ _ ________
Letter and Number

INSTRUCTIONS: Read each question carefully and circle the correct answer for each. You will have 30 minutes to complete the test.

QUESTIONS ON SPECIAL TAPE -- WORK

1. The defining equation for mechanical work, W, is

(a) $\int_{F_1}^{F_2} x\,dF$

(b) $F\Delta x$

(c) $\int_{x_1}^{x_2} F\,dx$

(d) $\Delta(Fx)$

2. In the equation for mechanical work, the force used in the calculation is the force exerted by

(a) the surroundings on the system

(b) the system on the surroundings

(c) the distance of boundary movement

(d) the center of mass of the system on the surroundings.

(e) none of the above

3. In our sign convention for work, work is <u>positive</u> when work is done

   (a) by the system

   (b) on the system

   (c) may be on or by the system, depending on direction of boundary movement

   (d) none of the above

   (e) all of the above (a), (b), (c)

4. Which assumption <u>must</u> apply for the relation $W = \int pdV$ to apply for total work done in a process?

   (a) constant pressure process

   (b) uniform temperature throughout the system

   (c) only expanison (or compression) work involved in the process.

   (d) all of the above

   (e) None of the above

5. For which case does $W = \int pdV$ apply?

   (a) constant volume heating of a gas

   (b) expansion of gas into a vacuum

   (c) extension of a spring

   (d) compression of a spring

   (e) all of the above

6. One lb_m of steam (the system) is heated from p = 100 psia to p = 500 psia at constant volume. How much work is done by the steam?

(a) 400 psia - ft^3

(b) -400 psia - ft^3

(c) zero

(d) none of the above.

7. For which of the process paths shown below does the system do the least work? (Process moves from state "1" to state "2.")

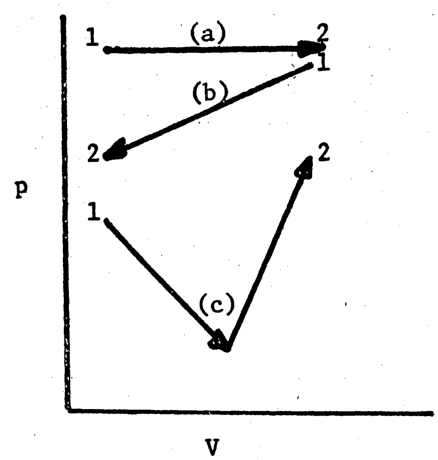
(a)______

(b)______

(c)______

(d) = insufficient information

(e) = all the same



8. Work is positive if the force and the boundary movement are

(a) in the same direction

(b) in the opposite direction

(c) both constant

(d) both varying

(e) none of the above

9. Which of the following questions is the least appropriate to help determine if work effects are present in a given process?

   (a) do the system boundaries move?

   (b) do any shafts, belts or chains cross the boundaries of the system?

   (c) is gravity acting on the system through its center of mass?

   (d) do electrical leads cross the system boundary?

10. Suppose a spring resists extension or compression by exerting a force $F = k(x - x_0)$ where k is a constant, x_0 is the unextended length and x the extended length of the spring. What is the equation for the work done in extending the spring from x_1 to x_2 ?

   (a) zero

   (b) $k(x_2 - x_1)$

   (c) $k(x - x_0)\ (x_2 - x_1)$

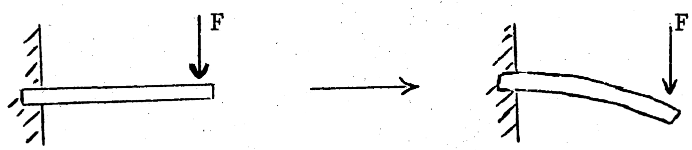
   (d) $\frac{1}{2}k \left[(x_2 - x_0)^2 - (x_1 - x_0)^2\right]$

   (e) $\frac{1}{2}k\ (x_2^{\ 2} - x_1^{\ 2})$

For each of the following processes, consider the beam as the system. For the process shown, tell whether work is positive (+), negative (-) or zero (0).

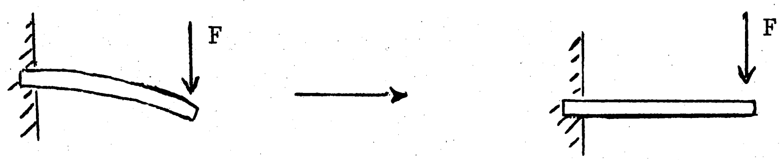
11. The beam, initially in its rest position, is deflected by application of a force, F.

Work =
(a) negative
(b) zero
(c) positive



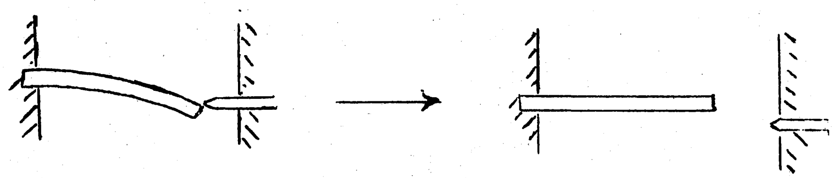
12. The beam, initially deflected by a force, F, is allowed to return to its rest position by gradual reduction of the magnitude of the force, F.

Work =
(a) negative
(b) zero
(c) positive



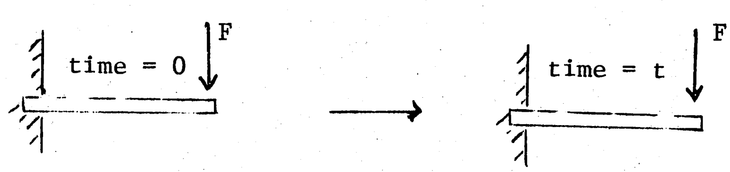
13. The beam, initially held in a deflected position by a pin, is allowed to return to its rest position by retracting the pin.

Work =
(a) negative
(b) zero
(c) positive



14. A rigid (inflexible) beam is subjected to a force, F, for a period of time, t, without bending.

Work =
(a) negative
(b) zero
(c) positive



15. One lb_m of an ideal gas ($pv = RT$) is expanded at constant temperature from an initial volume v_1 to $v_2 = 5v_1$. The work done by the gas is

(a) zero

(b) $P_1 (v_2 - v_1)$

(c) RT ln 5

(d) RT ln $4v_1$

(e) none of the above.

16. When evaluating work effects for a system, at what point in the system should your attention be focused?

(a) at the system boundaries

(b) at the system center of mass

(c) at all points in the system

(d) only at those boundaries where mass enters the system

(e) at all points where heat transfer occurs.

17. What is the magnitude of the work done by a gas when it expands into a vacuum?

(a) greater than zero

(b) zero

(c) less than zero

(d) May be any of the above, depending on the process.

(e) none of the above

VITA

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Thesis: THE EFFECT OF COMPRESSED SPEECH AND INTERIM ACTIVITY ON COMPREHENSION

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