1975

Effect of information reduction on certain aspects of operator's performance in a decision task.

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EFFECT OF INFORMATION REDUCTION ON CERTAIN ASPECTS OF OPERATOR'S PERFORMANCE IN A DECISION TASK

by

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A Thesis
Submitted to the Faculty of Graduate Studies
through the Department of Industrial Engineering
in Partial Fulfillment for the
Degree of Master of Applied Science
at the University of Windsor

Faculty of Graduate Studies

University of Windsor

September, 1975

I wish to dedicate this work
to my parents and sister.

ABSTRACT

To investigate the effect of information reduction on performance time and pulse rate while subjects performed combined manual and decision tasks (Type II), two sets of experiments were conducted. In the first set, five subjects performed a 3 x 2 x 2 completely randomized, factorial experiment in which three levels of information content in the stimuli (N_{Si}), two levels of information content in the response (N_{Rj}) and two levels of reach (R_k) were tested. The N_{Si} levels were 10, 8 and 6 alternatives in which the probability of occurrence of each alternative was equally likely. The two levels of N_{Rj} were 2 and 4 alternatives also occurring with equal probabilities. The response variable for this test was the performance time. The second set of experiments had three independent subsets. In each subset, information in the stimuli was as of 10, 8 and 6 alternatives. The stimuli information (N_{Si}) was not considered as a variable for these tasks. Ten subjects reduced this information (N_{Rj}) to 10, 8, 6, 4 and 2 alternatives in the first subset. Similarly, in other two subsets, the information was

decreased gradually by 2 alternatives till it was reduced to 2 alternatives. Under each condition subjects performed 7 inches and 14 inches of reach respectively. In addition to performance time, pulse rate of subjects while performing these tasks, was also used as a response variable. It has been found that information content in the stimuli (N_{Si}), information content in the response (N_{Rj}) and reach (R_k) are significant variables that effect performance time and pulse rate difference from its normal level. Both of these increase as the difference between N_{Si} and N_{Rj} decreases.

ACKNOWLEDGEMENTS

The author gratefully acknowledges the assistance of Prof. A. Raouf, who generously supported this project at every stage with encouragement and advice.

Sincere thanks go to all the Committee Members for their suggestions and help.

The author extends his appreciation to all his colleagues for their co-operation in this project.

The gratitude is also due to my brother whose moral support was a great source of inspiration.

This research project was financially supported by the National Research Council of Canada.

TABLE OF CONTENTS

		Page
APPENDIX H.	COMPUTER PROGRAMS	206
	(i) For Regression Analysis	207
	(ii) For Histograms and Frequency Distribution Charts	208
BIBLIOGRAPHY		213
VITA AUCTORIS		215

LIST OF FIGURES

LIST OF TABLES

CHAPTER I

INTRODUCTION

An industrial worker is potentially subjected to two types of 'uncertainty' that he might have to resolve while performing his task. One type of uncertainty could be related to time, i.e. the worker does not know in advance the time at which he is required to respond. The other type could be some form of uncertainty with respect to the selection of response from a finite set of response alternatives. In cases, when the uncertainty over time and uncertainty with respect to response alternatives are eliminated, the task becomes repetitive in nature. From a prediction point of view, such tasks have been termed as Type I tasks (Raouf, 1974). For performing tasks in which either type of uncertainty is to be resolved, workers are required to use both of their psycho-motor and decision making abilities. These types of tasks have been termed as 'Combined Manual and Decision Making Tasks' or Type II tasks (Sadosky 1968; Raouf 1974; Thomas 1974).

Well tested techniques for predicting and evaluating human performance for such tasks are not available to the practitioners of work study. Adding the decision time, obtained by using the concept of choice-reaction time, to the manual time had been suggested in the past. It has been shown that manual times and decision times obtained by using the concepts of information theory are not additive for a given informational load as the magnitudes of motions increase. For these experiments, each signal had 1:1 mapping information conserving tasks. Some of the industrial tasks are of the nature in which each signal does not necessarily have an explicit response and the worker may be required to make one response for a given subset of stimuli. Such tasks have been termed as Information Reduction Tasks (Posner, 1964). Figure 1.1 represents the various information processing models (Posner, 1964). If N_S is the information content in the stimuli and N_R is the information content in the response that the subject has to make, then for error-free performance in the information reduction task, $N_S > N_R$. If $N_S = N_R$, it becomes information conserving task and if $N_S < N_R$, then it is an information creation task.

The experiments used for the investigations pertaining to Type II tasks had the following factors in common:

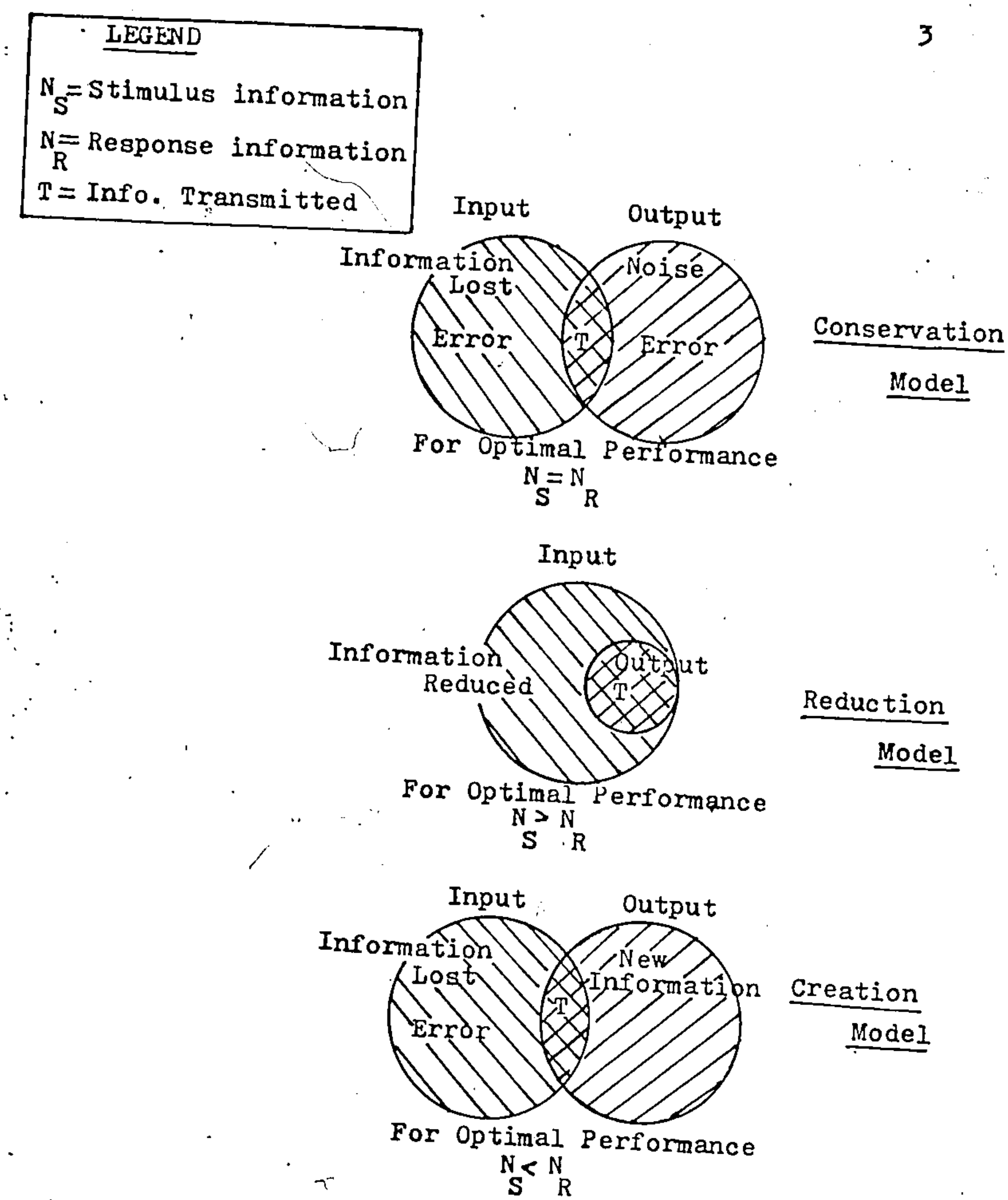


Figure 1.1 Illustration of Information Processing Models (After Posner, 1964).

(i) the subjects were to resolve choice uncertainty only

(ii) tasks were of information conserving type (Pew, 1965).

In some other studies it has been shown that heart rate of persons under mental load stabilizes (Kalsbeek, 1967). This stability also known as Sinus Arrhythmia has been suggested as a measure of mental load. The effect of informational load on heart rate while a subject is performing a combined manual and decision task of information conserving type, has already been investigated (Raouf, 1975).

Before a methodology for developing standards for combined manual and decision tasks including information reduction can be developed it was considered essential that our understanding of human performance while performing such tasks be increased. Consequently, the following study was undertaken to find out the effect of stimulus information (N_{Si}), information reduction (N_{Rj}) and two levels of reach (R_k) on;

(i) Performance Time

(ii) Pulse Rate Difference.

CHAPTER II

LITERATURE SURVEY

A brief survey of the existing literature pertaining to combined manual and decision tasks, which forms the basis of this study, is provided.

Sadosky (1968) developed a methodology for predicting cycle times for Type II tasks. He estimated manual times using the concept of Information Processing Rate (IPR) based on choice-reaction task. He, for his investigations, used a task in which the probability of occurrence of each alternative from a set of four alternatives was the same.

Raouf (1973) studied IPR and reports that it varies considerably amongst the subjects when the experimental conditions which are known to effect choice-reaction time are kept invariant.

Thomas (1974) explored the interrelationship among various components of Type II task by various types of probability distributions which governed the occurrence of each alternative from a set of four alternatives.

Raouf (1974) has shown that the effect of choice-uncertainty or information load on reach of different magnitudes following the decision in a Type II task, is not the same. For his experiments he used eight, four and two alternative tasks and the different magnitudes of element reach tested were 7 inches, 10 inches and 14 inches.

Some of the psychologists who studied human performance strongly emphasize that information reduction is a predominant situation for the human to work. As regards any theoretical relationship, Posner (1962, 1964), Fits et al (1975, 1967) and Bricker (1955) suggest that a linear relationship should exist between information reduced and various measures of performance. However, the results of their studies cannot be put into use for evaluating worker's performance in the industry because stimulus characteristics of their experiments could not be related to industrial tasks in which decision making and manual motions take place.

Heart Rate

Heart Rate (H.R.) variations due to physiological changes in the human body has been used to measure fatigue, physical work load (Brouha, 1954) operator's performance in industrial tasks (Young 1956). Apart from these studies H.R. variability has also been suggested as a measure of mental load. It has been shown that H.R. pattern of normal healthy subjects sitting at rest is irregular. Momentary irregularity of up to ten or fifteen beats per minute can occur. If one is doing a mental work, this irregularity decreases and the H.R. variability from the resting level of the heart also becomes stable. In medical terms this phenomenon is known as Sinus Arrhythmia. Sinus Arrhythmia occurring alone can be used as a measure of mental load. Kalsbeek and others (Kalsbeek and Ettema 1963, Kalsbeek 1967, Kalsbeek 1971) found that for the situations where physical load is low, Sinus Arrhythmia is monotonically related to the level of the mental load. Boyce (1974) showed that the H.R. and Sinus Arrhythmia change with change in physical load.

While investigating H.R. Variability, Raouf and Khare (1975) found that the H.R. Variability from rest increases as the magnitude of informational load and reach is increased. This was an information conserving type of combined manual and decision task .

CHAPTER III

EQUIPMENT DESCRIPTION

This chapter explains in detail the equipment used for the study and underlines the functions of the various units.

3.1 Methodology

This study was conducted in the Industrial Engineering Laboratory at the University of Windsor. The experiment consisted of recording of performance time and pulse rate of subjects while performing combined manual and decision tasks.

3.2 Performance Time

This is the elapsed time between appearance of a visual stimulus and the completion of response. This time can be divided into the following elements:

(1) occurrence of stimulus

(2) detection of stimulus

(3) decision time

(4) selection of response

(5) movement of hands

(6) completion of response.

Figure 3.1 represents the block diagram of combined manual and decision tasks when the task is repetitive in nature and the manual motions are discrete.

3.3 Experimental Set-Up

The experiment consists of two main units:

(1) Multi-choice (10 Channel) Reaction Time Apparatus

(2) Pulse Rate Recorder.

1. Multi-choice Reaction Time Apparatus

The experiment has been conducted on the multi-choice reaction time apparatus. Detailed description of this experiment is given in reference 16. This equipment consists of the following three units:

(i) Signal Response (S-R) Unit

(ii) Tape-Reader

(iii) Time Measuring and Recording Unit.

(i) Signal Response Unit (For details see figures 1 - 4, Appendix A)

S-R unit houses the decoding circuits, error and total trial indicators, 'scramble' matrix and other control circuitry. The front panel has ten lights (source of stimuli) about 3/8 inches diameter and ten response switches (R.S.) mounted on it below the lights. Also, it has an initiate button (I.B.)

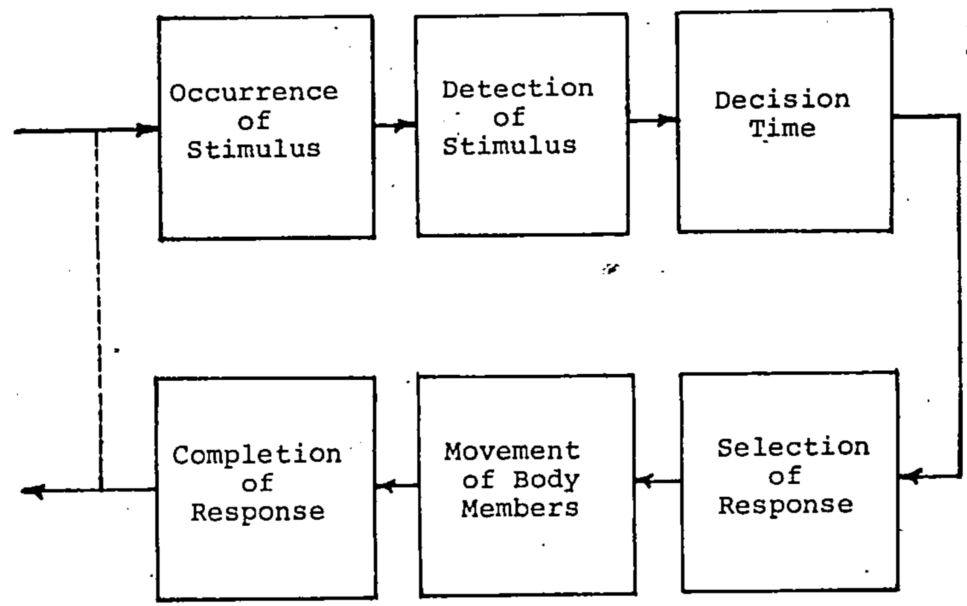


Figure 3.1. Block Diagram Showing Various Activities While Subject Performs a Combined Manual and Decision Task.

which can slide in the guide. The I.B. is used to activate the stimulus lights. The distance of I.B. from R.S. #5 and #6 can be adjusted from 7 inches in position I and 14 inches in position II. The rear panel houses an error indicator, a total trial indicator with counter re-set push button switches.

<u>The Error Counter</u>

The stimulus lights can be turned on by pressing the I.B. and turned off only by pressing the R.S. associated with that stimulus. The timer-counter keeps running till the proper response has been made. Due to error in selection of response button, the counter advances by one. The error counter thus keeps a record of the number of incorrect responses made by the operator under test. The performance time for these response cycles is unusually high and can be detected and eliminated for the purpose of analysis.

<u>Total Trial Indicator</u>

This registers the total number of cycles including the cycles in which the wrong R.S. was pressed. The trial indicator as well as the error counter can be set to zero by pressing the reset buttons. Both are of electro-mechanical types. Thus this indicator helps to keep a record of total performance cycles performed under any experimental condition.

Scramble Matrix

Through this matrix any of the signal lights can be connected to any of the R.S. This matrix has (10 x 10) plug holes in which plugs can be inserted to connect different lights to a R.S. In other words, the scramble matrix (encoder) allows the experimenter to program any R.S. and light or lights combination he so chooses.

Response Switch Sliding Covers

Any of the R.S. which is not in the scheme of connections is covered by an aluminum slide attached with lever used for sliding it. See Appendix A, Figure 1 for details.

(ii) Tape Reader

Tape reader is used as a random display generator. The tape is programmed so that any of the lights on the S-R unit will light up in a random pattern. Depending on the hole pattern in the tape, the tape reader sends out a combination of electrical signals (BCD) which are decoded in the S-R unit and the result displayed on the front panel signal lights. The tape can be so programmed that the pattern of display of lights can be made to obey any of the probabilities law. Therefore, it controls (i) the size of the set of N_{Si} and, (ii) the sequence of occurrence of N_{Si}.

A SLO-SYN tape reader has been used for the present study.

Preparation of Punch Tape

This is a standard computer paper tape which can be punched on any of the teletype punching machines using an IBM code. The sequence of punching of characters has to be such that when I.B. is pressed any of the light comes on and when the R.S. is pressed, the light is switched off. Tapes were prepared for 10, 8 and 6 alternatives tasks with equal probabilities of occurrences in a set.

(iii) Time Measuring and Recording Unit

This consists of a Hewlett-Packard 5326 A Timer Counter and a paper tape punch unit. It records in milliseconds the time elapsed between the coming of the signal and making of the response. The DIGITEC punching equipment comprised of a tape punch controller and a paper tape punch models 625 and 672. The performance time and light number for each cycle is punched on the tape. This tape is converted into data cards for the analysis.

2. Pulse Rate Recorder

It is a portable pulse monitoring equipment with a sensor-clip which is attached to the left-hand index finger of the operator. It continuously computes and averages every four consecutive pulses of the operator and displays digitally on the screen. These averages are recorded manually by the attendant on the paper while the operator performs. This instrument is accurate to within ± 1% between the rate of 30 and 130 beats/min.

An Electronic/Medical System, Pulse Trac Unit has been used for this study.

3.4 Procedure

Figure 3.2 shows the diagram representing block layout of the equipment.

This experimental unit was placed in one of the laboratories of Industrial Engineering having proper air-conditioning and lighting arrangements. Before the commencement of testing of each subject, a trial was held to check the equipment. The subject performed after this. His task comprised of the following steps:

(i) Press the I.B. (preset to a certain 'Reach') with right hand index finger. The associated light was switched on.

(ii) Reach for the corresponding R.S. and press it. The light is switched off.

If the R.S. is one associated with the signal, the light went off and the recording unit punched out the time elapsed and the corresponding light number. And if the R.S. is not the one associated

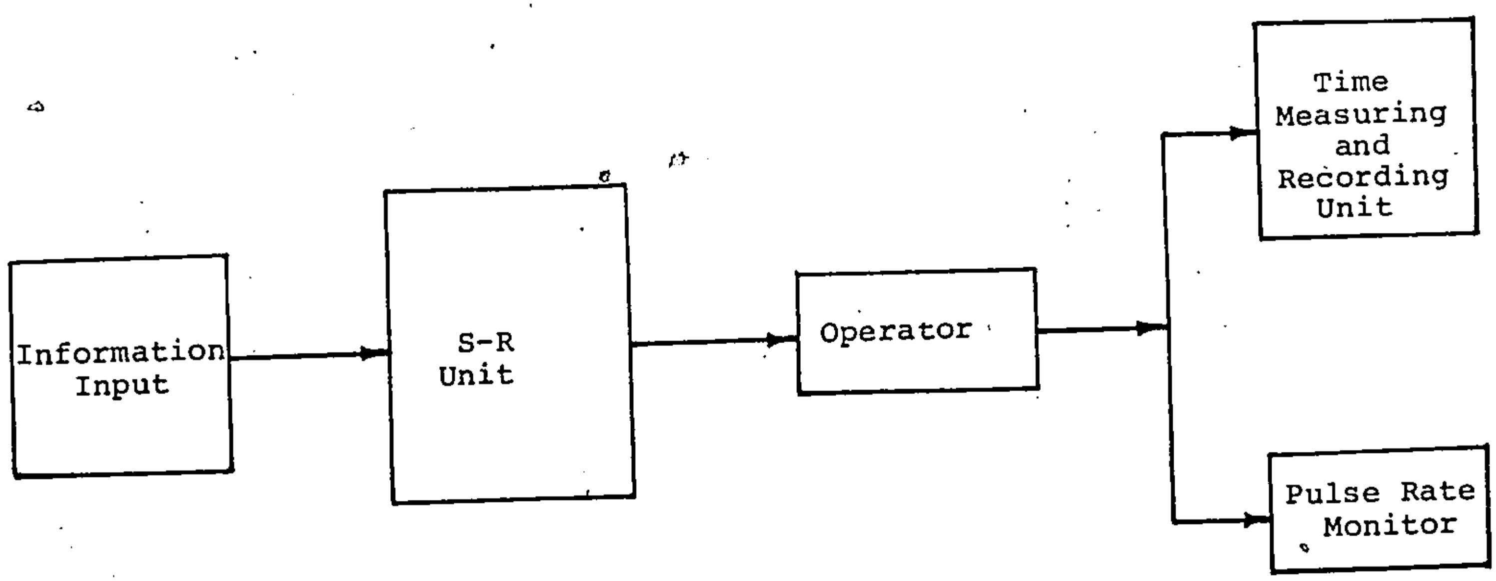


Figure 3.2. Diagram Showing the Block Layout of the Equipment.

with the signal, time elapsed is not recorded till the correct response is performed.

3.5 Instructions to the Subjects

Before the start of the above test, there was a set of instructions given to each subject in order to minimize experimental errors particularly with regards to reach so that the subject does not make unnecessary hand movements while searching for the R.S. The following instructions were given to each subject:

(i) He was instructed to move his right hand index finger from the I.B. till he determined the corresponding R.S.

(ii) He was to feel free to ask for more rest if feeling tired.

(iii) Task was performed in short sleeve shirts.

The two studies conducted are described in detail in the next chapters.

CHAPTER IV

THE STUDY

4.1 Objectives

The following were the objectives of this investigation:

(i) to find out if for given information levels in the responses (N_{Rj}) and for different information levels contained in stimulus (N_{Si}) and for different magnitudes of reach (R_k), the performance time is significantly affected or not. This study has been named as the Pilot Study.

(ii) to study the effect of information reduction (N_{Si} - N_{Rj}) for different levels of R_k in terms of performance times and pulse rate difference. This part comprises the Major Study.

4.2 The Pilot Study

This study has been done by taking three sets of stimuli with different information contents. The information in the stimuli (N_{Si}) is the same as in

6, 8 and 10 alternatives tasks in which the occurrence of stimulus is equally likely. Under each set of stimulus, the information in the response (N_{Rj}) was kept at two levels of 2 and 4 alternative task. The effect of above two variables and two levels of reach of 7 inches and 14 inches was tested on performance time of subjects.

4.21 Validity for N_{Si}, N_{Rj} and R_k for the Study

In the research being done on decide action, it has been established that if there are more than 16 alternatives in the stimulus which are presented to the operator, mental overload occurs and the efficiency of the operator falls in repetitive kind of work. For such cases it has been suggested that there is need for more than one operator to do the same job (Bayha, Hancock)*. Keeping this in view, the design of the work place which is the signal-response unit is kept at a maximum of 10 alternatives.

Commonly, it has been seen that the number of responses associated with the number of signals or stimulus are less than the number of stimulus. Examples of such situations can be manual sorting, monitoring and sensing devices.

The 'Reach' distances of 7 inches and 14 inches are chosen because there is no body assistance for the

*Application Guidelines on Decide Action Research published by MTM Association, Fairlane, New Jersey.

moves corresponding to those reach distances and the above distances are most frequently used in work design.

4.22 Validity for the Occurrence of Stimuli and Response and Information Measurement

Researchers studying the decision component performance in an isolated form through choice-reaction time studies empirically arrived at a linear relationship between performance time and the "uncertainty" of the stimulus set using Shannon's information metric (Shannon 1969). This uncertainty according to information theory is termed as entropy and is given by:

$$H(P) = -\Sigma_i \, p_i \Sigma_j \, p_{ij} \log_2 p_{ij} \text{ bits,} \qquad (1)$$

where p_i is the probability that stimulus i occurring from the finite set of alternatives {1, ..., N}, and p_{ij} is the conditional probability of j occurring given that i occurred on the previous cycle. If there are no sequential dependencies, i.e. $p_{ij} = p_j$ for all i, eqn. (1) reduces

$$H(P) = -\Sigma_j \, p_j \log_2 p_j \text{ bits,} \qquad (2)$$

In real industrial tasks involving combined manual and decision tasks, the probabilistic conditions for occurrence of stimuli can obey different discrete probability laws depending on the nature of the job. In an investigation done by Satsangi (1974) on a fabric sorting operation, the occurrence of different choices was observed to follow a poisson process. Similarly, for different situations one can expect arrival patterns for the occurrences of stimuli to obey different probabilistic laws. Keeping this thing in view, for the present study, it has been taken that among number of choices, the probability of occurrence of each stimulus and the response is the same as that of the rest.

In the above case, if there are 'n' alternatives present in the stimuli, then $p_j = \frac{1}{n}$, the eqn. (2) reduces to;

$$H(P) = - \sum_{j=1}^{n} \frac{1}{n} \log_2 \frac{1}{n} \text{ bits}$$

$$= -n \frac{1}{n} (-\log_2 n) \text{ bits}$$

$$= \log_2 n \text{ bits} \qquad (3)$$

The same expressions hold good for the information content in the response which the operator has to make in order to conserve or reduce information.

4.23 Experimental Conditions

Denoting stimulus information as N_{Si}, response information as N_{Rj} and reach as R_k, where i, j, and k represent the levels of these effects. Figure 4.1 shows the graphical representation of experimental conditions for the Pilot Study.

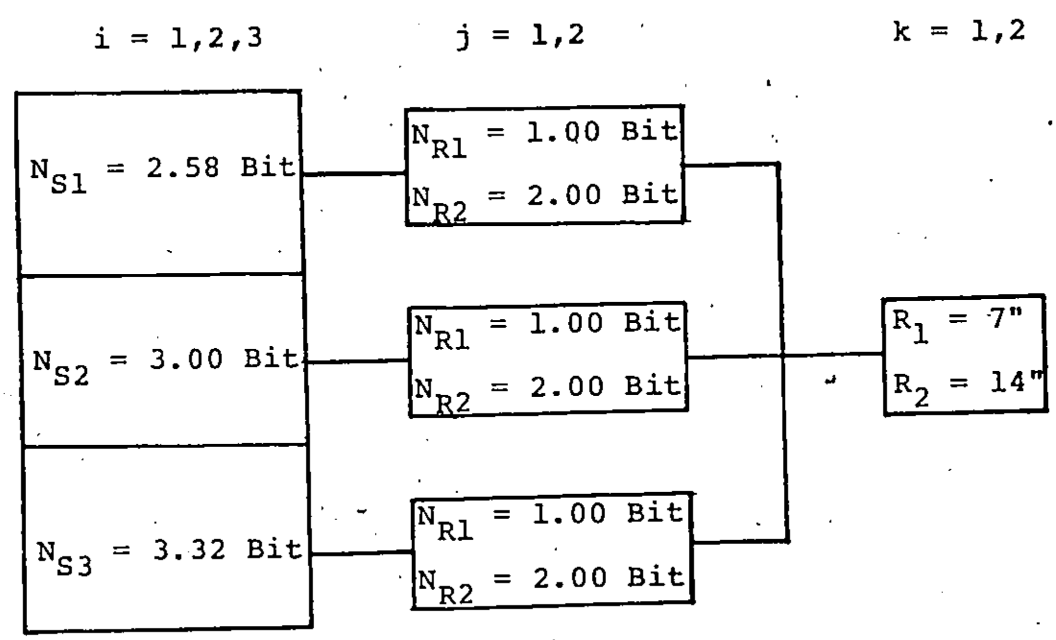


Figure 4.1. Graphical Representation of Experimental Conditions for the Pilot Study.

4.3 The Major Study

Based on the results of Pilot Study, the stimulus information has not been taken as a variable but instead three independent experiments under 3.32 bits, 3.00 bits and 2.58 bits of stimulus information (N_{Si}) have been undertaken. The effect of different N_{Rj} levels and reach (R_k) of 7 inches and 14 inches was tested on performance time and pulse rate difference of subjects. The pulse rate difference (P.R.D.) of subjects is defined as -

$$\text{P.R.D.} = \left[\text{Pulse Rate at Rest} - \text{Pulse Rate at Work}\right]$$

4.31 Experimental Conditions

Total experimental conditions for this set of three experiments can be put as follows -

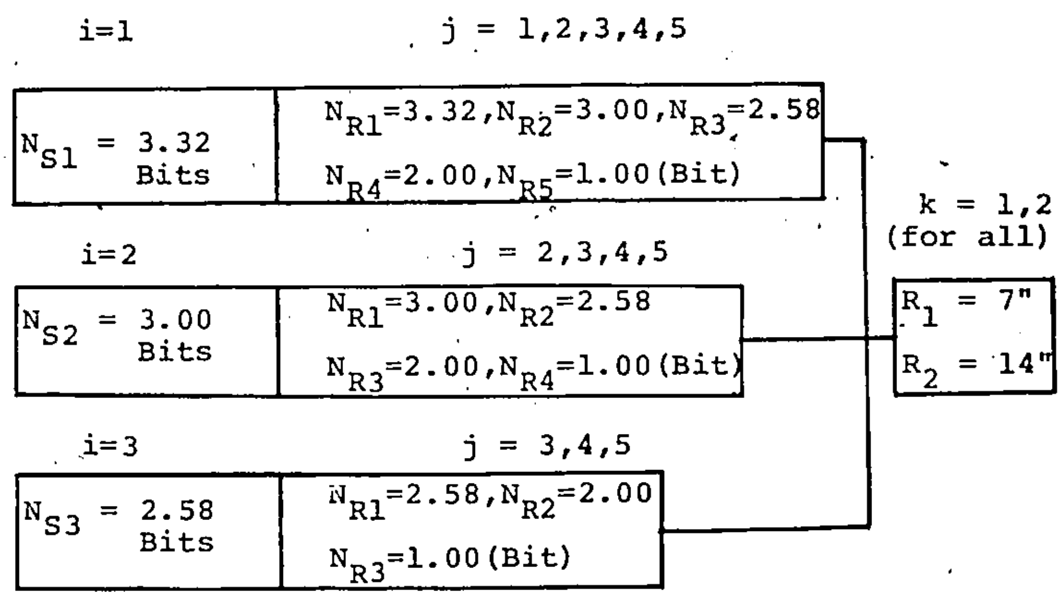


Figure 4.2. Graphical Representation of Experimental Conditions for the Major Study.

4.4 Methodology

As explained, three sets of stimuli information have been taken for this study. If the occurrence of stimuli is equally likely, then 6, 8 and 10 alternatives represent 2.58, 3.00 and 3.32 bits of information. Light numbers 3 to 8, 2 to 9 and 1 to 10 of S-R unit are chosen to form the sources of stimuli (see appendix A for S-R details). As the information is being reduced from these sets, it is obvious that less number of responses are associated with the same stimulus, i.e., $N_{Si} > N_{Rj}$, the occurrence of response is also kept equally probable by programming the tapes for lights accordingly. Appendix B explains in detail the S-R connections, number of performance cycles taken for each condition. It also describes the steps taken in preparation and programming the tapes for the tape reader.

Pulse rate of each subject was recorded before the start of the experiment while he was at rest. This was done by putting the sensor clip of the pulse recorder to the forefinger of any hand (see Appendix A).

4.5 Deviations in Response Information (N_{Rj})

In some experimental conditions when signal to response (S/R) ratio is not a whole number, the information in the response (N_{Rj}) changes because occurrence of response cannot be kept equally likely. The following table gives the combination of signal and responses in terms of alternatives in which these deviations from N_{Rj} occur and the corresponding percentages of error involved. Appendix B gives these calculations.

S/R Ratio	% age Deviation in N_{Rj}
10/8	2.29
10/6	2.30
10/4	1.50
8/6	3.10
6/4	4.20

Table 4.1. S/R Ratios and the Corresponding Deviations in N_{Rj}.

4.6 The Subjects

Fifteen male graduate research students in the Faculty of Engineering were selected as subjects for this study. Five subjects were taken for the pilot study and the rest for the major study. Table 4.2 and 4.3 give the details of the students. These subjects were paid at the university wage rate. All were in good physical condition and were interested in the studies being undertaken. The equipment was shown to the subjects and the function of each unit was explained to them and all were given 400 practice cycles before the start of the experiment.

The pilot study lasted for three hours per subject while the major study took around six hours per subject. Each experimental condition took approximately 10 minutes with 3 minutes of rest in between. The subjects were given 50 practice cycles before each condition to adapt themselves to the changed conditions.* One subject was tested each day.

Name (Initials)	Age (Years)	Profession
G.A.	23	Grad. Student
K.A.	22	Grad. Student
M.W.	23	Grad. Student
S.H.	24	Grad. Student
T.J.	24	Grad. Student

Table 4.2. Details of the Subjects for Pilot Study.

*See Appendix B for explanation of Signal Response Compatibility.

Name (Initials)	Age (Years)	Profession
G.A.	23	Grad. Student
J.S.C.	23	Grad. Student
M.V.R.	26	Grad. Student
M.W.	23	Grad. Student
S.E.	26	Grad. Student
A.M.	24	Grad. Student
E.B.	22	Grad. Student
M.A.	20	Undergraduate
M.Y.	24	Grad. Student
[illegible]J.	24	Grad. Student

Table 4.3 Details of the Subjects for Major Study.

4.7 Experimental Design

For the pilot study each subject has been tested under (3 x 2 x 2) completely randomized, full factorial experiment. The order of set information (N_{si}), information reduced (N_{Rj}) and reach (R_k) levels were selected at random and it varied for each subject. The order of randomization for this study is given in table 4.4.

In the three experiments carried out in the major study, the designs are (5 x 2), (4 x 2) and (3 x 2) completely randomized, full factorial experiments. The order of three subsets has also

N_{Si}	$N_{S1}=2.58$ Bits				$N_{S2}=3.00$ Bits				$N_{S3}=3.32$ Bits			
N_{Rj}	$N_{R1}=1.00$		$N_{R2}=2.00$		$N_{R1}=1.00$		$N_{R2}=2.00$		$N_{R1}=1.00$		$N_{R2}=2.00$	
R_k	R_1	R_2	R_1	R_2	R_1	R_2	R_1	R_2	R_1	R_2	R_1	R_2
G.A.	5	4	6	1	11	9	3	2	7	12	10	8
K.A.	6	2	5	8	3	11	7	10	9	4	12	1
M.W.	8	9	6	10	7	1	4	3	12	5	2	11
S.H.	1	11	3	5	9	6	2	10	4	7	8	12
T.J.	7	1	8	9	2	10	6	11	4	12	5	3

Table 4.4. Order of Randomization of Experimental Conditions of Pilot Study for Each Subject.

Note: The entries denote the sequence in which each condition was tested.

been randomized. Tables 4.5 to 4.8 represent the scheme of randomization for these subsets and their experimental conditions.

Subjects \ Subsets	1	2	3
G.A.	2	1	3
J.S.C.	3	2	1
M.V.R.	1	2	3
M.W.	2	3	1
S.E.	3	1	2
A.M.	2	1	3
E.B.	1	3	2
M.A.	2	3	1
M.Y.	1	2	3
T.J.	3	1	2

Table 4.5. Order of Randomization of Subsets of Major Study for Each Subject.

Note: The entries denote the sequence in which each set was tested.

N_{S1}=3.32 Bits

N_{Rj} (Bits)	N_{R1}=3.32		N_{R2}=3.00		N_{R3}=2.58		N_{R4}=2.00		N_{R5}=1.00	
R_k (Ins.)	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2
G.A.	8	3	5	4	2	10	6	9	7	1
J.S.C.	4	1	7	8	9	3	10	2	5	6
M.V.R.	3	9	6	1	10	2	8	7	4	5
M.W.	10	2	5	4	3	7	6	1	8	9
S.E.	5	7	8	2	6	1	9	4	10	3
A.M.	7	9	1	6	5	4	3	10	2	8
E.B.	5	10	9	4	8	3	7	2	1	6
M.A.	1	8	2	5	4	7	9	6	3	10
M.Y.	6	5	3	7	1	10	4	8	9	2
T.J.	2	6	9	3	10	8	1	5	7	4

Table 4.6. Order of Randomization of Experimental Conditions for Subset 1 for Each Subject when N_{S1}=3.32 Bits.

Note: The entries denote the sequence in which each condition was tested.

N_{S2}=3.00 Bits

N_{Rj}(Bits)	N_{R1}=3.00		N_{R2}=2.58		N_{R3}=2.00		N_{R4}=1.00	
R_k(Ins.)	R1	R2	R1	R2	R1	R2	R1	R2
G.A.	7	2	4	3	8	6	1	5
J.S.C.	1	7	6	2	5	4	8	3
M.V.R.	2	6	8	1	3	5	4	7
M.W.	3	4	1	5	7	8	2	6
S.E.	8	6	3	7	2	1	5	4
A.M.	5	1	2	6	4	7	3	8
E.B.	2	3	8	4	1	5	6	7
M.A.	4	5	3	7	6	2	8	1
M.Y.	6	4	1	8	7	3	5	2
T.J.	3	7	2	5	8	6	1	4

Table 4.7. Order of Randomization of Experimental Conditions for Subset 2 for Each Subject when N_{S2} = 3.00 Bits.

N_{S3}=2.58 Bits

N_{Rj}(Bits)	N_{R1}=2.58		N_{R2}=2.00		N_{R3}=1.00	
R_k(Ins.)	R1	R2	R1	R2	R1	R2
G.A.	4	1	5	3	2	6
J.S.C.	3	5	1	5	4	2
M.V.R.	2	6	5	4	1	3
M.W.	6	1	3	2	5	4
S.E.	1	4	2	6	3	5
A.M.	3	2	4	1	5	6
E.B.	5	3	6	4	2	1
M.A.	1	6	2	5	3	4
M.Y.	4	2	6	1	5	3
T.J.	2	3	4	6	1	5

Table 4.8. Order of Randomization of Experimental Conditions for Subset 3 for Each Subset when N_{S3}=2.58 Bits.

Note: The entries denote the sequence in which each set was tested.

The conditions under which each subject was tested for the major study can be summed up in the following Table 4.9.

	R_1=7"			R_2=14"		
	N_{Si} (Bits)			N_{Si} (Bits)		
	3.32	3.00	2.58	3.32	3.00	2.58
	3.00	2.58	2.00	3.00	2.58	2.00
N_{Rj} (Bits)	2.58	2.00	1.00	2.58	2.00	1.00
	2.00	1.00	-	2.00	1.00	-
	1.00	-	-	1.00	-	-

Table 4.9. Total Experimental Condition for the Major Study.

4.8 Data Collection

The performance time associated with every response switch was collected but the performance time for R.S. #5 and R.S. #6 which are at the required distances from I.B. has to be analyzed. The data associated with other response switches has not been taken for the purpose of analysis. For the pilot study, 70 observations associated with R.S. #5 or R.S. #6 and the mean taken for each condition. But for the major study, mean of 35 observations associated with R.S. #5 and R.S. #6 per condition has been taken. Less number of observations for the experimental conditions of major study has been taken because it was observed that there is no significant difference in the mean values for one particular condition if more than 25 observations for such type of tasks are taken. Moreover, by taking 35 observations per condition of the major study there is a considerable saving in time and labor including boredom to the subjects is reduced.

Pulse rate of each subject was taken and recorded in the beginning of the experiment of major study while they were at rest.

Nine observations per experimental condition were taken for the pulse rate. These observations were recorded after every minute from the commencement of each experimental condition. But for this purpose of analysis, mean of last six observations has been taken because in doing so pulse rate of the subjects has very little effect of the previous condition and moreover the subject is adjusted to that condition.

The errors made by the subjects for each experimental condition in terms of pressing the wrong R.S. were less than 1%.

CHAPTER V

DATA ANALYSIS AND RESULTS

5.1 Technique Employed

Tables 1 to 7, Appendix C give the mean values of performance times and pulse rate differences (P.R.D.) for individual subjects. Histograms for only performance time has been plotted by a standard computer program (see Appendix H). The computer outputs beside means has given standard deviation, minimum and maximum values of performance times. It also gives the total observations taken for each condition, their ranges, frequency of occurrences and their expected values. Appendix F gives these histogram plots and the related information.

Analysis of variances (ANOVA) has been used to analyse the data. This is taken because the overall differences among the means of several experimental groups can be evaluated.

The following mixed model has been used to analyse the performance time data for the pilot study:

$$X_{ijk\ell} = \mu + \alpha_i + \beta_j + \gamma_k + \delta_\ell + \alpha\beta_{ij} + \alpha\gamma_{ik}$$

$$+ \alpha\beta\gamma_{ijk} + \ldots\ldots + \alpha\beta\gamma\delta_{ijk\ell}$$

where $\alpha_i = N_{Si}$, $i = 1,2,3$; $B_j = N_{Rj}$. $k = ;.2$

$N_{S1} = 3.32$ bits, $N_{R1} = 1.00$ bit

$N_{S2} = 3.00$ bits, $N_{R2} = 2.00$ bit

$N_{S3} = 2.58$ bits,

$\gamma_k = R_k$, $k = 1,2$; δ_ℓ = subjects

$R_1 = 7"$, Response Variable = Performance Time

$R_2 = 14"$.

$X_{ijk\ell}$ is the mean performance time for the i^{th} stimulus information level, j^{th} information reduction level, k^{th} reach and ℓ^{th} subject.

In the above model δ, β and γ are taken as fixed factors while δ is considered as a random factor.

For the major study, the stimulus information (N_{Si}) is not considered independent variable, therefore, the mixed model used for each subset (N_{Si}) of the major study is

$$X_{ijk} = \mu + \alpha_i + \beta_j + \gamma_k + \alpha\beta_{ij} + \alpha\gamma_{ik} + \beta\gamma_{jk} + \alpha\beta\gamma_{ijk}.$$

where $\alpha_i = N_{Rj}$, for Subset 1, j = 1,2,...,5.

$$\left.\begin{aligned} N_{R1} &= 3.32 \text{ bits} \\ N_{R2} &= 3.00 \text{ bits} \\ N_{R3} &= 2.58 \text{ bits} \\ N_{R4} &= 2.00 \text{ bits} \\ N_{R5} &= 1.00 \text{ bit} \end{aligned}\right\} \begin{array}{l} \text{tested under} \\ N_{S1} = 3.32 \text{ bits} \end{array}$$

for Subset 2, j = 1,2,...,4

$$\left.\begin{aligned} N_{R1} &= 3.00 \text{ bits} \\ N_{R2} &= 2.58 \text{ bits} \\ N_{R3} &= 2.00 \text{ bits} \\ N_{R4} &= 1.00 \text{ bit} \end{aligned}\right\} \begin{array}{l} \text{tested under} \\ N_{S2} = 3.00 \text{ bits} \end{array}$$

for Subset 3, j = 1,2,3,

$$\left.\begin{aligned} N_{R1} &= 2.58 \text{ bits} \\ N_{R2} &= 2.00 \text{ bits} \\ N_{R3} &= 1.00 \text{ bit} \end{aligned}\right\} \begin{array}{l} \text{tested under} \\ N_{S3} = 2.58 \text{ bits} \end{array}$$

$\beta_k = R_k$, k = 1,2 ; γ_k = Subjects

R_1 = 7", Response Variables -

R_2 = 14", (i) Performance Time

(ii) Pulse Rate Difference (P.R.D.)

A standard computer package known as Statistical Analysis System (Barr and Goodnight) has been used to compute sums of squares of various effects (see Appendix G).

Tables 5.1 to 5.7 show the findings of pilot and major studies showing only the main effects. F-ratios are compared with standard tables for $\alpha = 0.05$ (Hicks, 1973). Results indicate that all the main effects are significant. Complete details of ANOVA are given from Tables 9 to 15, Appendix C.

Source	DF	MS	F	Findings
N_{Si}	2	27609.267	79.83	Significant ($P < 0.05$)
N_{Rj}	1	138712.723	34.47	Significant ($P < 0.05$)
R_k	1	19175.943	20.32	Significant ($P < 0.05$)

Table 5.1. Analysis of Variance for Performance Time of Pilot Study (Main Sources of Variation Only).

Source	DF	MS	F	Findings
N_{Rj}	4	23166.5335	13.17	Significant ($P < 0.05$)
R_k	1	16467.5623	30.29	Significant ($P < 0.05$)

Table 5.2. Analysis of Variance for Performance Time of Subset-Set I of Major Study (Main Sources of Variation Only).

Source	DF	MS	F	Findings
N_{Rj}	3	27312.1934	14.20	Significant ($P < 0.05$)
R_k	1	11265.8175	45.18	Significant ($P < 0.05$)

Table 5.3. Analysis of Variance for Performance Time of Subset-II of Major Study (Main Sources of Variation Only).

Source	DF	MS	F	Findings
N_{Rj}	2	8593.9845	9.55	Significant ($P < 0.05$)
R_k	1	10284.8134	3.16	Significant ($P < 0.12$)

Table 5.4. Analysis of Variance for Performance Time of Subset-III of Major Study (Main Sources of Variation Only).

Source	DF	MS	F	Findings
N_{Rj}	4	52.10	3.71	Significant ($P < 0.05$)
R_k	1	190.67	46.50	Significant ($P < 0.05$)

Table 5.5. Analysis of Variance for P.R.D. of Subset-I of Major Study (Main Sources of Variation Only).

Source	DF	MS	F	Findings
N_{Rj}	3	56.79	3.21	Significant (P < 0.05)
R_k	1	138.88	56.68	Significant (P < 0.05

Table 5.6. Analysis of Variance for P.R.D. of Subset-II of Major Study (Main Sources of Variation Only).

Source	DF	MS	F	Findings
N_{Rj}	2	91.12	6.18	Significant (P < 0.05)
R_k	1	106.96	23.61	Significant (P < 0.05)

Table 5.7. Analysis of Variance for P.R.D. of Subset-III of Major Study (Main Sources of Variation Only).

5.2 Test on Means After Experimentation

Having concluded that there is a significant difference in treatment means, the next step would be to find out which means are different. As we are investigating the effect of different stimuli and responses on performance time and pulse rate difference, a test called Newman-Keuls Range Test (Hicks, 1973) has been put to evaluate these differences.

Appendix C (calculations) show that for the pilot study, stimulus information level means are significantly different from each other ($\alpha = 0.05$).

For the major study, reach level means are also significantly different for all the subsets of performance time as well as for pulse rate differences.

5.3 Computation of Variances for Various Effects

The variances for the main effects has been calculated in order to see what percentages are attributable to N_{Rj} and R_k levels for each set of N_{Si}. Also, the variances for individual N_{Rj} has been calculated. These variances are listed in the following tables from 5.8 to 5.11 (for calculations see Appendix C).

N_{Si} (Bits)	N_{Rj} %	R_k %
3.32	26.00	7.76
3.00	26.83	5.82
2.58	6.82	4.15

Table 5.8. Percentages of Variances Attributable to N_{Rj} and R_k Levels for Performance Times.

N_{Si} (Bits)	N_{Rj} %	R_k %
3.32	20	40
3.00	19	56
2.58	39	35

Table 5.9. Percentages of Variances Attributable to N_{Rj} and R_k for P.R.D.

N_{Si} (Bits) \ N_{Rj} (Bits)	3.32	3.00	2.58	2.00	1.00
3.32	7.60	13.25	5.78	0.01	73.00
3.00	--	15.16	13.28	0.70	70.76
2.58	--	--	15.55	17.81	66.59

Table 5.10. Percentages of Variances Attributable to Individual N_{Rj} Means of Different Sets for Performance Times.

N_{Si} (Bits) \ N_{Rj} (Bits)	3.32	3.00	2.58	2.00	1.00
3.32	60.50	3.60	2.00	10.67	23.26
3.00	--	58.75	1.37	15.18	24.68
2.58	--	--	50.00	2.00	48.00

Table 5.11. Percentages of Variances Attributable to Individual N_{Rj} Means of Different Sets for P.R.D.

5.4 Graph Plotting

The graphs are plotted (Appendix D) for both the studies between N_{Rj}, performance times and pulse rate differences for different N_{Si} and R_k. The graphs are also plotted between $(N_{Si} - N_{Rj})$, performance time and pulse rate differences.

These graphs indicate that performance time and pulse rate difference increase as $(N_{Si} - N_{Rj})$ decreases.

5.5 Regression Analysis

In order to find prediction models for performance time and pulse rate difference for combined manual and decision tasks of this nature, polynomial regression analysis has been done. A computer program (see Appendix H) is put to fit a least square curve to the data of all the subsets of major study.

Appendix E (computer outputs) shows that for any subset of stimulus information (N_{Si}) and response information (N_{Rj}), performance time and pulse rate difference can be predicted for both reaches of R_1 and R_2. For the subset when N_{S1} = 3.32 bits, 1st to 4th degree polynomial can be inserted to the data for each of the reaches. Similarly, a maximum of 3rd and 2nd degree polynomials can be inserted to subsets 2 and 3 respectively. For example, for the first subset of performance, the first degree polynomial for R_1 (see computer outputs) is -

$$\text{Performance Time (ms)} = 500.68 + 31.80\ N_R$$

where N_R = stimulus information in bits.
The % age average error involved in prediction by the above equation is 1.64.

There is a gradual decrease in % age average errors as the degrees of polynomial increase till it is 0.00 at the maximum level. The 4th degree polynomial for the above equation is -

$$\text{Performance Time (ms)} = 1388.00 - 1925.15\ N_R + 1467.00\ N_R^2 - 451.21\ N_R^3 + 49.01\ N_R^4$$

The % age error involved in prediction by the above equation is 0.00.

The following tables summarize the percentages of average errors involved in each degree of polynomials for all the subsets.

	$R_1 = 7"$				$R_2 = 14"$			
	Degree of Polynomial				Degree of Polynomial			
N_{Si} (Bits)	1	2	3	4	1	2	3	4
3.32	1.64	0.59	0.56	0.00	2.28	0.53	0.50	0.00
3.00	1.09	0.37	0.00	--	1.87	0.34	0.00	--
2.58	1.38	0.00	--	--	0.85	0.00	--	--

Table 5.12. Percentages of errors involved in each degree of polynomials for the performance times.

	$R_1 = 7"$				$R_2 = 14"$			
	Degree of Polynomial				Degree of Polynomial			
N_{Si} (Bits)	1	2	3	4	1	2	3	4
3.32	5.47	1.69	1.08	0.00	6.22	2.70	0.08	0.00
3.00	8.93	0.89	0.00	--	4.73	0.30	0.00	--
2.58	2.76	0.00	--	--	2.21	0.00	--	--

Table 5.13. Percentages of errors involved in each degree of polynomials for the pulse rate differences.

Owing to large number of equations involved for prediction, it was thought to develop general equations for prediction of performance times and pulse rate differences and for the easiness of formulation, a linear relationship has been assumed between N_{Rj} and both the response variables. These equations can be used when the information in the stimuli and response has been ascertained. The equations are -

$$\text{Performance Time (ms)} = RAD'' + CD'' + 33.33\ N_R$$

where RAD" = time taken in ms by reach distance of class A*

N_R = information in the response in bits

CD" = experimentally determined constants (ms) based on N_{Si} and R_k levels). (These values are given in Appendix E).

The average error involved in this prediction equation is approximately 15%.

The P.R.D. in beats/min. can also be predicted by the equation;

$$\text{P.R.D. (beats/min.)} = KD'' + 2.10\ N_R$$

---

*The MTM data card describes class A reach: Reach to an object in fixed location, or to object in other hand or on which other hand rests. (Published by The Maynard Foundation, Pittsburgh, Pa.).

where N_R = information in the response in bits

KD" = experimentally determined constants (ms) based on N_{Si} and R_k levels. (These values are given in Appendix E).

The average error involved in this prediction equation is approximately 20%.

The practitioners of work study can use the above equations for approximate estimation but if a precise estimation is required, the highest order polynomial for a given N_{Si}, N_{Rj} and R_k can be used.

Further validation of the above findings is suggested before they are used by the work designers.

CHAPTER VI

CONCLUSIONS AND SUGGESTIONS FOR FURTHER STUDY

For a Typle II task where subjects are required to resolve uncertainty related to choice alternatives and information reduction is involved ($N_{Si} > N_{Rj}$) and the cycles are discrete and repetitive, the following conclusions can be made:

1. For $N_{Rj} = 1.00$ bit and $N_{Rj} = 2.00$ bits, N_{Si} is a significant variable affecting performance time.

2. For a given N_{Si}, N_{Rj} and R_k are significant variables affecting performance time.

3. Also, for a given N_{Si}, N_{Rj} and R_k are significant variables affecting pulse rate difference.

4. Performance time increase as ($N_{Si} - N_{Rj}$) decreases. This is shown in Figures 7 and 8, Appendix D.

5. Pulse rate difference also increases as ($N_{Si} - N_{Rj}$) decreases. Figures 9 and 10, Appendix D.

6. Tests on means of N_{Rj} levels of performance time show that all the means are significantly different from only one level when $N_{Rj} = 1.00$ bit where the performance time is minimum. This is true for all the subsets.

7. Means of N_{Rj} levels of pulse rate difference indicate that for all subsets means of N_{Rj} = 1.00 bit and $N_{Rj} = N_{Si}$ are significantly different from each other. The means in between do not differ.

8. Breakdown of variances for individual N_{Rj} levels for the pulse rate difference for all N_{Si} levels indicate that extreme levels, i.e. N_{Rj} = 1.00 bit and $N_{Rj} = N_{Si}$ contribute more towards variation than any other level in all the subsets (Chapter IV).

6.1. Suggestions for Further Studies

A function relating N_{Si}, N_{Rj} and R_k for the performance time has been formulated in this study. But further validation is suggested before it is put in use because of the accuracy and the assumptions involved.

The effects of information creation for Type II tasks have not been looked into yet. A study in this direction is suggested before the study for such tests is regarded as complete.

APPENDICES

APPENDIX A

EQUIPMENT DESCRIPTION

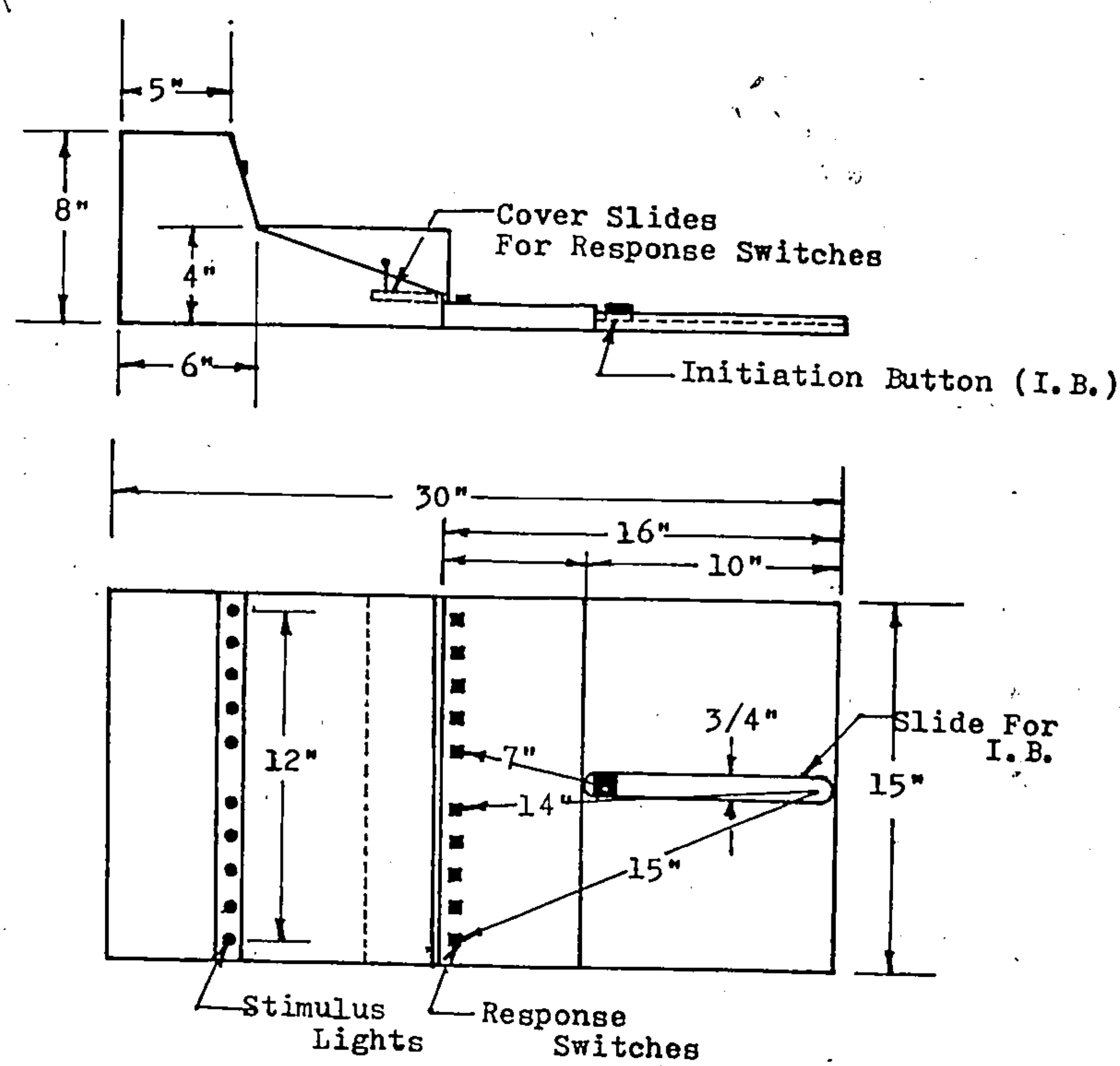
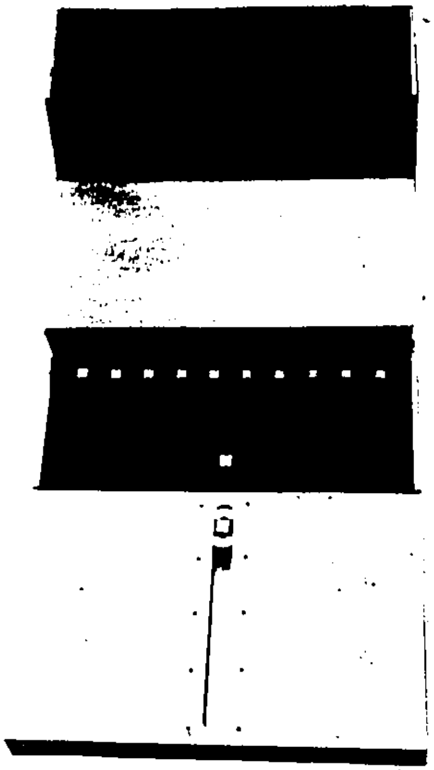
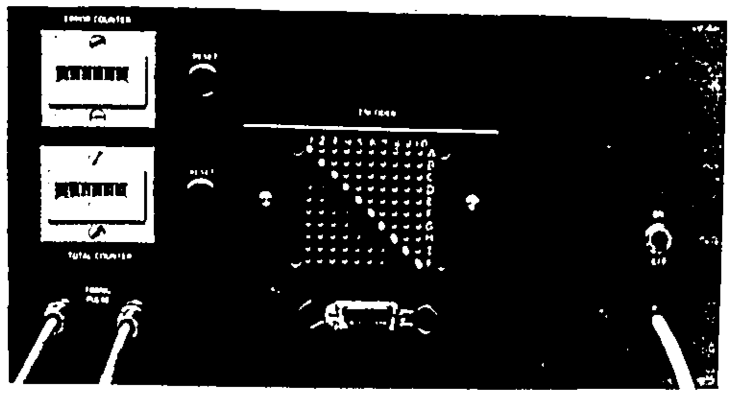


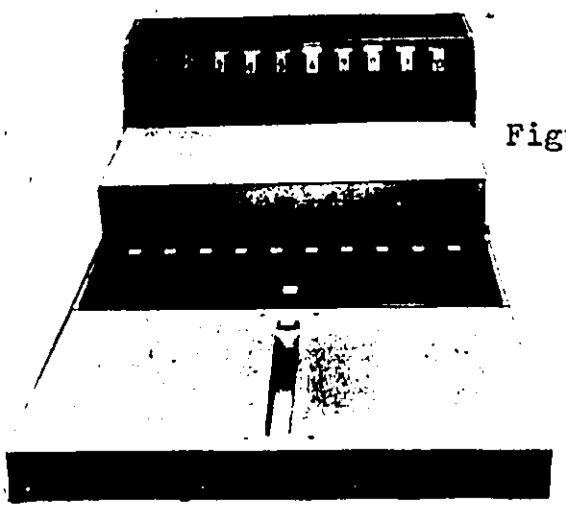
Figure 1. Details of Signal - Response Unit.



Top-View



Rear-View



Front-View

Figure 2. Pictorial Views of the Signal-Response Unit.

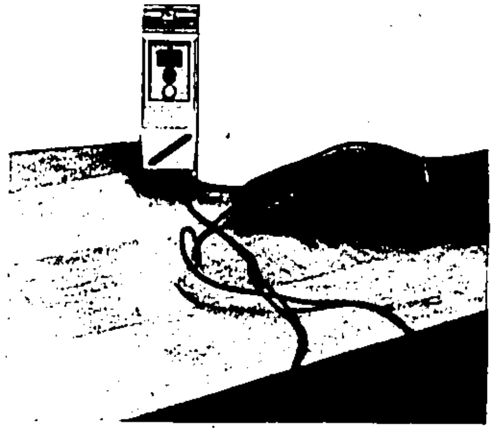


Figure 3. Pulse Rate Monitor with Sensor-Clip attached to the Forefinger.

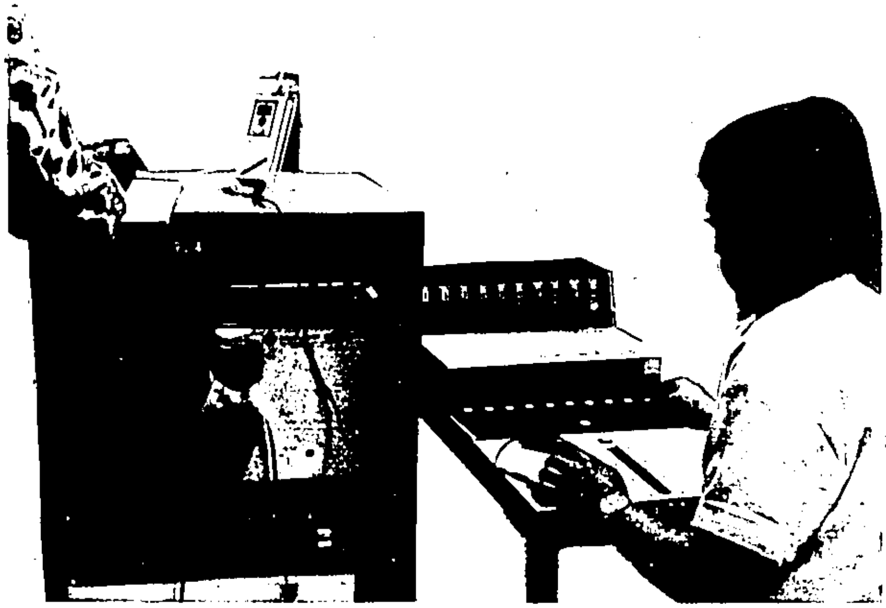


Figure 4. A subject under test.

APPENDIX B

1. Schematic Layout of S-R Connections.
2. Signal-Response Compatibility.
3. Why this Scheme of Connections.
4. Number of Performance Cycles.
5. Tape Preparation.
6. Calculations of Deviations in N_{Rj}.

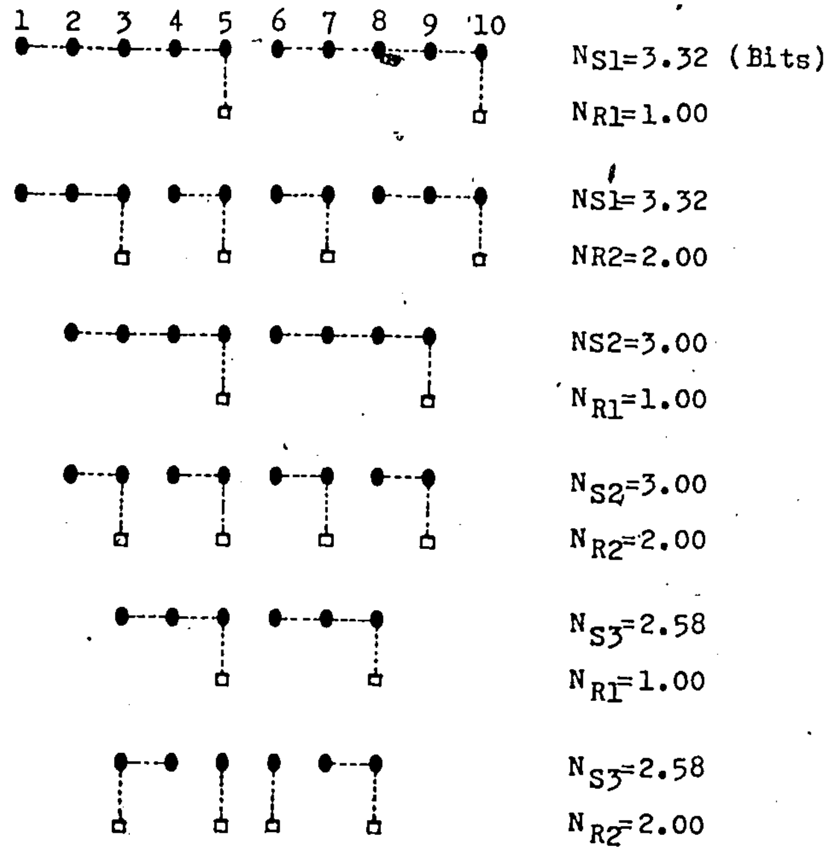


Figure 1. Schematic Layout of S-R connections representing various experimental conditions of the Pilot-Study.

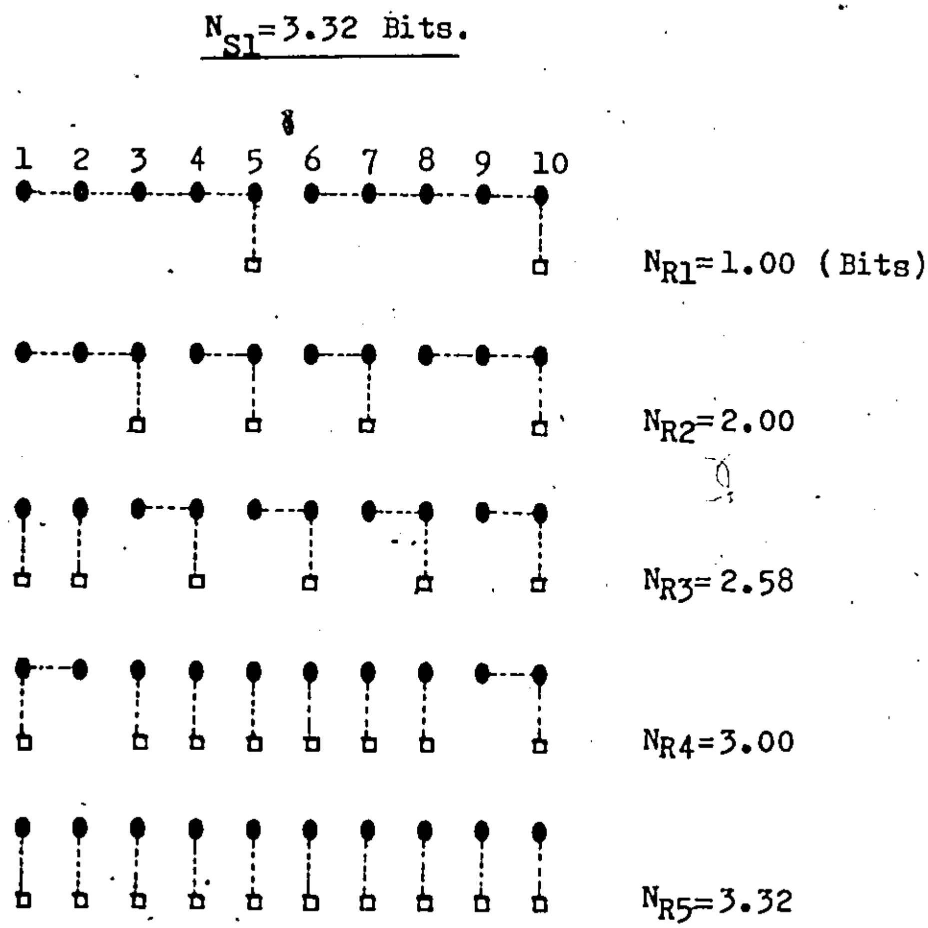


Figure 2. Schematic Layout of connections for set-1 of Major-Study.

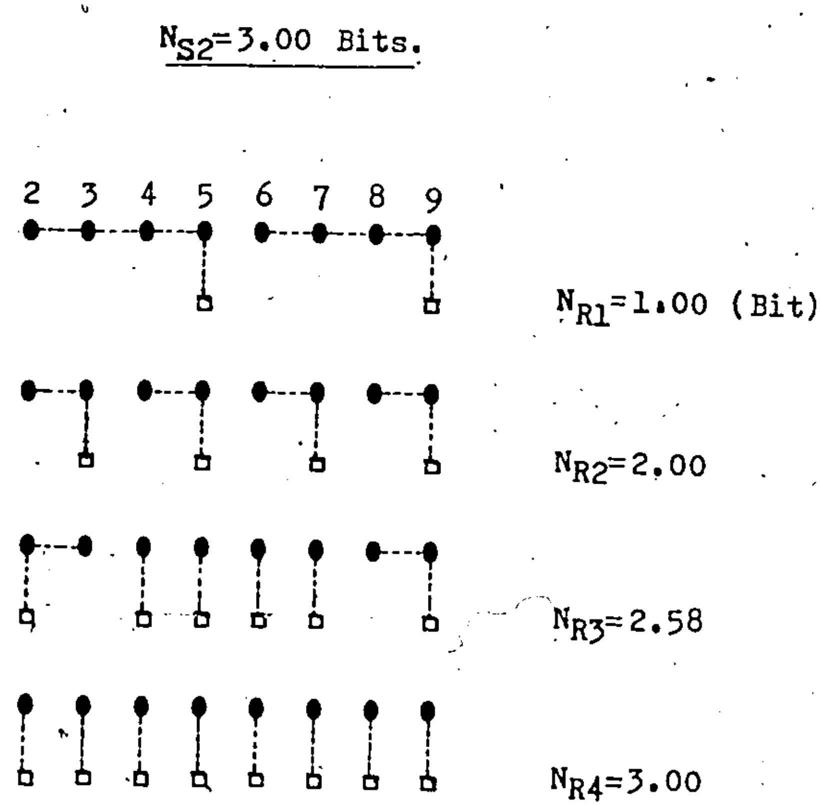


Figure 3. Schematic Layout of connections for set-2 of Major-Study.

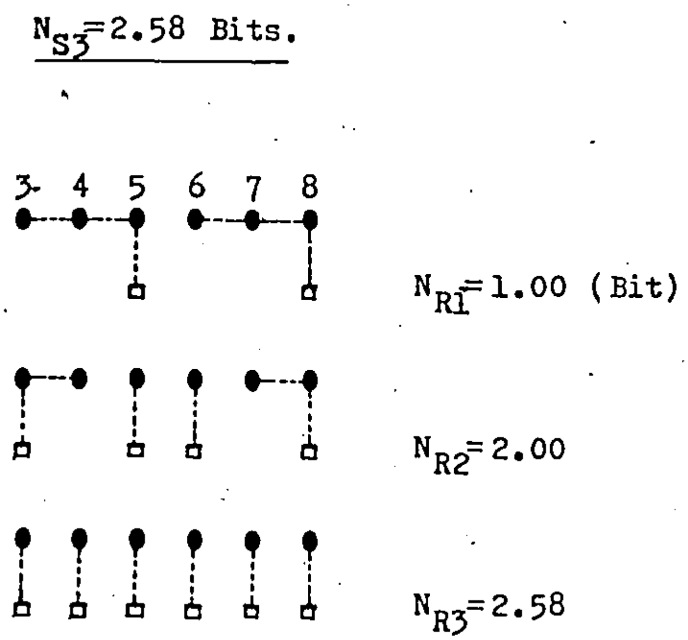


Figure 4. Schematic Layout of connections for set-3 of Major-Study.

Signal-Response (S-R') Compatibility

Signal to response compatibility plays an important role in human performance. It is obvious that if signal and response relationship is very simple, the number of errors made by the operator would be less and consequently, his efficiency in terms of performance time would be good. If this S-R' compatibility or relationship is changed, the operator is liable to commit more errors till he gets some experience on the new arrangement and the effect of compatibility with respect to any performance measure is nullified.

In the present study, this effect of compatibility was nullified by asking each subject to work on the new arrangement of each experimental condition till the experimenter felt satisfied that the effect of compatibility is no longer there.

The subject learned within 50 cycles.

Why This Scheme of Connections?

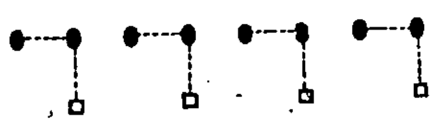
The question arises that why the scheme of signal and response connections has been like this while there can be so many other combinations. To answer this the following reasons are given:

(i) R.S. #5 or R.S. #6 is always in the scheme of connections. The distance of both these switches is the same from I.B. Before the start of the experiment it was proven in a 2 x 2 randomized, factorial experiment employing 2 subjects that the mean performance time for reach for both switches from I.B. is the same. The following table gives the mean performance times for both R.S.

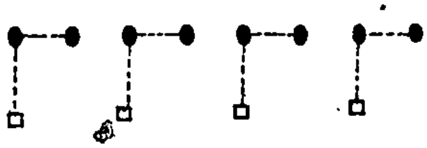
Reach	Time for R.S. #5 (ms)	Time for R.S. #6 (ms)
7"	270	272
14"	380	376

TABLE 1.

(ii) In another experiment with the given arrangements of S-R' unit, the mean performance times for reaches of 7 inches and 14 inches were also found to be the same. It was also 2 x 2 factorial experiment in which 2 subjects were employed.



Arrangement 1.



Arrangement 2.

Reach	Time for Arrangement 1	Time for Arrangement 2
7"	574(ms)	577
14"	605	606

Table 2.

Similarly, other combinations with the same information content in the response but different stimuli information were also tried. From these experiments, it was concluded that selection of any combination of response switches did not make any significant difference in the performance times as long as the probability of occurrence of stimuli and responses remain the same.

No. of Performance Cycles

To keep the performance cycles associated with different subsets of lights in a set in a manner that R.S. #5 or #6 is used equally, number of performance cycles were selected for each experimental condition such that the cycles pertaining to R.S. #5 or #6 were 70 for all the conditions of Pilot Study.

Similarly, for the Major Study 35 observations have been taken for each experimental condition for the purpose of analysis.

Tape Preparation

For all experimental conditions, the tapes were prepared. The probability of occurrence of stimuli in each set was kept invariant.

Calculation of Deviations in N_{Rj}

When S/R Ratio is 10/8 (see Appendix B for Connections)

Probabilities of occurrence of response no. 1 and 10

$= 0.2$ each.

Probabilities of occurrence of response from 2 to 8

$= 0.1$ each.

Therefore, information in the response, N_{Rj}

$= -\Sigma p_i \log_2 p_i$

$= 2 \times 0.4643 + 6 \times 0.3321$

$= 2.9212$ bits

Thus, % age deviation $= 100 - 100 \times \frac{2.9212}{3.00} = 2.29$

When S/R Ratio is 10/6

Prob. of occurrence of responses no. 1 and 2

$= 0.1$ each.

Prob. of occurrence of responses nos. 4,6,8,10

$= 0.2$ each.

Therefore, $N_{Rj} = 2 \times 0.3321 + 4 \times 0.4643$

$= 2.5214$ bits

Thus, % age deviation $= 100 - \frac{100 \times 2.5214}{2.58} = 2.30$

<u>When S/R′ Ratio is 10/4</u>

Prob. of occurrence of responses nos. 3 and 10

= 0.3 each.

Prob. of occurrence of response nos. 5 and 7

= 0.2 each.

Therefore, N_{Rj} = 2 x 0.5210 + 2 x 0.4643

= 1.9706 bits

Thus, % age deviation = 100 - 100 x $\frac{1.9706}{2.00}$ = 1.50

<u>When S/R′ Ratio is 8/6</u>

Prob. of occurrence of response nos. 2 and 9

= 0.25 each.

Prob. of occurrence of response nos. 4 to 7

= 0.125 each.

Therefore, N_{Rj} = 2 x 0.5 + 4 x 0.3749 = 2.50 bits

Thus, % age deviation = 100 - 100 x $\frac{2.50}{2.58}$ = 3.10

<u>When S/R′ Ratio is 6/4</u>

Prob. of occurrence of response nos. 3 and 8

= 0.333 each.

Prob. of occurrence of response nos. 5 and 6

= 0.166 each.

Therefore N_{Rj} = 2 x 0.5282 + 2 x 0.4300

= 1.9164 bits

Thus, % age deviation = 100 - 100 x $\frac{1.9164}{2.00}$ = 4.2

APPENDIX C

1. Tables for mean values.
2. Calculation of E.M.S. values.
3. ANOVA tables.
4. Tests on means after experimentation.
5. Calculation of variances attributable to main Aspects.
6. Calculation of individual variances.

TABLE 1

PILOT STUDY - MEANS OF PERFORMANCE TIMES (MS) FOR EACH SUBJECT FOR EACH EXPERIMENTAL CONDITION

	N_{S1} = 3.32				N_{S2} = 3.00				N_{S3} = 2.58			
	N_{R1} = 1.00		N_{R2} = 2.00		N_{R1} = 1.00		N_{R1} = 2.00		N_{R1} =1.00		N_{R1} = 2.00	
	R_1	R_2	R_1	R_2	R_1	R_2	R_1	R_2	R_1	R_2	R_1	R_2
M.W.	578.29	577.15	627.04	656.41	477.11	561.97	644.79	626.57	485.35	518.22	555.17	547.37
T.J.	368.44	396.04	490.38	499.87	365.02	398.17	452.87	485.57	342.00	344.62	430.47	420.39
G.A.	448.32	508.42	564.44	613.05	435.42	498.47	540.00	552.35	405.41	520.37	487.57	493.58
S.H.	600.67	623.28	620.83	704.84	503.71	617.92	654.24	643.80	493.44	513.72	560.67	661.04
K.A.	413.62	493.34	712.08	653.70	438.48	482.25	573.50	618.72	392.94	446.21	482.24	580.72
Means	481.86	519.63	602.96	625.57	443.95	511.75	573.00	585.20	423.83	466.63	503.22	540.60

TABLE 2

MAJOR STUDY - MEANS OF PERFORMANCE TIMES (MS) FOR N_{S1} = 3.32 BITS FOR EACH SUBJECT AND FOR EACH EXPERIMENTAL CONDITION

	N_{R1} = 3.32		N_{R2} = 3.00		N_{R3} = 2.58		N_{R4} = 2.00		N_{R5} = 1.00	
	R_1	R_2	R_1	R_2	R_1	R_2	R_1	R_2	R_1	R_2
G.A.	565.59	563.97	546.82	553.05	563.34	635.77	471.11	481.51	415.54	441.94
J.S.C.	651.17	695.25	676.74	683.62	628.34	654.08	597.68	678.39	500.91	548.62
M.V.R.	534.97	579.62	551.02	611.02	579.59	631.57	582.34	587.00	494.22	583.20
M.W.	565.34	566.85	565.14	574.91	593.39	603.82	569.25	596.14	538.22	542.74
S.E.	573.31	611.34	579.79	615.25	612.28	644.77	622.88	605.22	553.34	520.82
M.A.	587.42	574.97	568.39	578.31	627.79	657.42	550.25	617.28	521.51	487.59
E.B.	671.17	638.11	647.48	677.74	623.91	651.97	602.77	680.28	553.25	618.00
M.A.K.	679.97	743.54	602.77	633.68	609.48	653.51	613.97	603.94	567.22	645.97
M.Y.	634.65	679.08	663.25	693.94	666.88	626.02	619.45	680.31	560.85	528.59
T.J.	500.02	545.14	510.25	579.02	480.45	537.97	492.14	491.22	531.08	466.88
Means	596.36	619.79	591.07	620.06	598.55	629.69	572.19	602.12	523.62	538.44

TABLE 3

MAJOR STUDY - MEANS OF PERFORMANCE TIMES (MS) FOR N_{S2} = 3.00 BITS FOR EACH SUBJECT AND FOR EACH EXPERIMENTAL CONDITION

	N_{R1} = 3.00		N_{R2} = 2.58		N_{R3} = 2.00		N_{R4} = 1.00	
	R_1	R_2	R_1	R_2	R_1	R_2	R_1	R_2
G.A.	547.54	607.00	578.17	571.88	560.68	588.54	385.94	453.48
J.S.C.	653.20	688.97	654.37	666.28	596.17	602.00	566.51	583.65
M.V.R.	548.34	587.91	545.48	579.05	552.39	591.71	485.31	520.22
M.W.	553.94	547.94	577.48	587.77	549.42	575.02	542.59	528.51
S.E.	558.00	563.57	534.82	600.39	557.42	614.39	502.11	508.65
M.A.	629.85	637.82	653.51	615.48	436.04	552.94	541.97	532.68
E.B.	669.45	685.34	636.85	697.71	654.48	679.42	565.42	595.71
M.A.K.	622.11	637.14	589.59	630.68	606.00	631.02	575.42	585.57
M.Y.	675.42	624.82	656.37	640.91	629.25	650.20	513.74	539.88
T.J.	466.66	479.97	467.54	469.00	483.05	488.39	426.45	455.79
Means	592.45	606.00	589.41	602.92	563.40	597.36	510.55	530.41

TABLE 4

MAJOR STUDY - MEANS OF PERFORMANCE TIMES (MS) FOR N_{S3} = 2.58 BITS FOR EACH SUBJECT AND FOR EACH EXPERIMENTAL CONDITION

	N_{S1} = 2.58		N_{S2} = 2.00		N_{S3} = 1.00	
	R_1	R_2	R_1	R_2	R_1	R_2
G.A.	446.14	501.20	430.31	445.08	393.02	414.45
J.S.C.	554.82	706.65	552.20	674.28	535.82	584.05
M.V.R.	518.85	524.68	528.34	542.25	548.62	535.28
M.W.	509.05	521.82	519.54	525.17	522.88	511.57
S.E.	524.57	512.17	526.54	573.65	434.57	495.59
M.A.	565.11	516.00	577.08	485.08	562.91	506.85
E.B.	643.77	708.91	599.51	684.59	570.51	627.85
M.A.K.	600.82	603.25	595.71	594.11	536.11	591.20
M.Y.	550.57	607.79	574.85	647.02	526.62	570.71
T.J.	416.08	437.79	475.57	435.54	375.11	416.57
Means	532.98	564.02	537.97	560.67	500.61	525.41

TABLE 5

MAJOR STUDY - MEANS OF PULSE RATE DIFFERENCES (BEAT/MIN.) FOR N_{S1} = 3.32 BITS AND FOR EACH SUBJECT FOR EACH EXPERIMENTAL CONDITION

PULSE RATE DIFFERENCE = [PULSE RATE AT REST - PULSE RATE AT WORK]

		N_{R1} = 3.32		N_{R2} = 3.00		N_{R3} = 2.58		N_{R4} = 2.00		N_{R5} = 1.00	
		R_1	R_2	R_1	R_2	R_1	R_2	R_1	R_2	R_1	R_2
M.W.	60	10	16	8	12	9	13	8	10	4	8
S.E.	70	14	20	8	13	12	15	10	15	14	16
J.S.C.	75	10	15	7	13	7	8	11	12	11	12
G.A.	84	16	18	9	11	9	8	7	9	8	7
M.V.	72	9	11	10	12	8	15	9	11	10	11
M.A.	100	16	19	16	20	10	10	9	16	33	10
M.A.K.	76	18	19	12	11	8	12	10	13	11	12
M.Y.	75	8	13	13	16	12	16	5	8	5	10
T.J.	95	7	13	10	15	12	12	11	10	12	11
Means		12.00	16.00	10.33	13.66	9.66	12.11	8.88	11.55	8.55	10.77

TABLE 6

MAJOR STUDY - MEANS OF PULSE RATE DIFFERENCE (BEATS/MIN.) FOR N_{S2} = 3.00 BITS FOR EACH SUBJECT AND FOR EACH EXPERIMENTAL CONDITION

		N_{R1} = 3.00		N_{R2} = 2.58		N_{R3} = 2.00		N_{R4} = 1.00	
	Rest	R_1	R_2	R_1	R_2	R_1	R_2	R_1	R_2
M.W.	60	16	17	9	16	7	10	8	10
S.E.	70	13	15	13	13	5	9	12	16
J.S.C.	75	18	21	9	10	8	13	7	8
G.A.	84	16	21	11	14	10	13	9	11
M.V.	72	13	14	8	10	9	11	8	10
M.A.	100	9	14	10	15	15	16	10	16
M.A.K.	76	11	12	12	14	8	14	10	13
M.Y.	75	15	16	9	14	7	8	4	8
T.J.	95	8	10	15	16	12	15	10	10
Means		13.22	15.55	10.66	13.55	9.00	11.90	8.99	11.11

TABLE 7

MAJOR STUDY - MEANS OF PULSE RATE DIFFERENCES (BEATS/MIN.) FOR N_{S3} = 2.58 BITS FOR EACH SUBJECT AND FOR EACH EXPERIMENTAL CONDITION

		N_{R1} = 2.58		N_{R2} = 2.00		N_{R3} = 1.00	
	Rest	R_1	R_2	R_1	R_2	R_1	R_2
M.W.	60	13	15	8	12	2	6
S.E.	70	12	18	12	15	8	5
J.S.C.	75	13	16	10	13	11	18
G.A.	84	13	16	15	17	9	11
M.V.	72	11	13	10	14	8	8
M.A.	100	15	18	10	13	10	8
M.A.K.	76	8	11	9	14	9	11
M.Y.	75	11	15	10	14	11	16
T.J.	95	20	20	13	10	10	8
Means		12.90	16.00	10.77	13.55	8.99	11.22

CALCULATION OF E.M.S. VALUES

For the proper F-test to be put in ANOVA and for the computation of variances, the calculation of expected mean squares of all the main and other interaction effects becomes essential. As a sample E.M.S. values for the experiment set N_{S1} = 3.32 bits are calculated (Hicks, 1973);

Effects	Symbols	Levels	Type
Subjects	S	10	Random
I-Reduction	N	5	Fixed
Reach	R	2	Fixed

	R S	F N	F R	
Source	10	5	2	E.M.S.
S	1	5	2	$\sigma_\varepsilon^2 + 10\ \phi_S$
N	10	0	2	$\sigma_\varepsilon^2 + 2\sigma_{SN}^2 + 20\ \phi_N$
SXN	1	0	2	$\sigma_\varepsilon^2 + 2\sigma_{SN}^2$
R	10	5	0	$\sigma_\varepsilon^2 + 5\sigma_{SR}^2 + 50\ \phi_R$
SXR	1	5	0	$\sigma_\varepsilon^2 + 5\sigma_{SR}^2$
NXR	10	0	0	$\sigma_\varepsilon^2 + 10\ \phi_{NR}$
NXRXS	1	0	0	σ_ε^2

TABLE 8. CALCULATION OF E.M.S. VALUES

For sets 2 and 3, the levels of N_{Rj} are 4 and 3. Also, these E.M.S. values change for the Pulse Rate Difference Analysis because 9 subjects have been taken in all three sets of Major Study.

TABLE 9

PILOT STUDY - ANOVA FOR PERFORMANCE TIME

Source	D.F.		F_R	F_{CR}	E.M.S.	Findings
P	4	60658.914			$\sigma_\varepsilon^2 + 12\sigma_P^2$	
S	2	27609.267	79.83	4.46	$\sigma_\varepsilon^2 + 4\sigma^2_{PS} + 20\ \phi_S$	Significant (P < 0.05)
PXS	8	345.837			$\sigma_\varepsilon^2 + 4\sigma^2_{PS}$	
N	1	1318712.723	34.47	7.71	$\sigma_\varepsilon^2 + 6\sigma^2_{PN} + 30\ \phi_N$	Significant (P < 0.05)
PXN	4	4024.072			$\sigma_\varepsilon^2 + 6\sigma^2_{PN}$	
SXN	2	1711.114	1.12	4.46	$\sigma_\varepsilon^2 + 2\sigma^2_{PSN} + 10\ \phi_{SN}$	Not Significant (P < 0.05)
PXSXN	8	1528.359			$\sigma_\varepsilon^2 + 2\sigma^2_{PSN}$	
R	1	19175.943	20.32	7.71	$\sigma_\varepsilon^2 + 6\sigma^2_{PR} + 30\ \phi_R$	Significant (P < 0.05)
PXR	4	943.529			$\sigma_\varepsilon^2 + 6\sigma^2_{PR}$	
PXNXRXS	8	1537.207			σ_ε^2	

<u>Terminology</u>: P - Subjects; S - Sets; N - Information Reduction; R - Reach.

TABLE 10

MAJOR STUDY - ANOVA FOR PERFORMANCE TIME FOR N_{S1} = 3.32 BITS

Source	D.F.	M.S.	F_R	F_{CR}	E.M.S.	Findings
S	9	21138.4285			$\sigma_\varepsilon^2 + 10\ \phi_S$	
N	4	23166.5335	13.17	2.65	$\sigma_\varepsilon^2 + 2\sigma^2_{SN} + 20\ \phi_N$	Significant (P < 0.05)
SXN	36	1758.3396			$\sigma_\varepsilon^2 + 2\sigma^2_{SN}$	
R	1	16467.5623	30.29	5.12	$\sigma_\varepsilon^2 + 5\sigma^2_{SR} + 50\ \phi_R$	Significant (P < 0.05)
SXR	9	543.5248			$\sigma_\varepsilon^2 + 5\ \sigma_{SR}$	
NXR	4	227.5040	0.31	2.65	$\sigma_\varepsilon^2 + 10\ \phi_{NR}$	Not Significant (P < 0.05)
NXRXS	36	720.3643			σ_ε^2	

<u>Terminology (for Tables 10 - 15)</u>

S - Subject

N - Information Reduction

R - Reach

TABLE 11

MAJOR STUDY - ANOVA FOR PERFORMANCE TIME FOR N_{S2} = 3.00 BITS

Source	D.F.	M.S.	F_R	F_{CR}	E.M.S.	Findings
S	9	22447.1920			$\sigma_\varepsilon^2 + 8\ \phi_S$	
N	3	27312.1934	14.20	2.96	$\sigma_\varepsilon^2 + 2\sigma^2_{SN} + 20\ \phi_N$	Significant (P < 0.05)
SXN	27	1923.22			$\sigma_\varepsilon^2 + 2\sigma^2_{SN}$	
R	1	11265.8178	45.18	5.12	$\sigma_\varepsilon^2 + 4\sigma^2_{SR} + 40\ \phi_R$	Significant (P < 0.05)
SXR	9	249.3152			$\sigma_\varepsilon^2 + 4\sigma^2_{SR}$	
NXR	3	318.2543	0.71	2.96	$\sigma_\varepsilon^2 + 10\ \phi_{NR}$	Not Significant (P < 0.05)
NXRXSX	27	447.8706			σ_ε^2	

TABLE 12

MAJOR STUDY - ANOVA FOR PERFORMANCE TIME FOR N_{S3} = 2.58 BITS

Source	D.F.	M.S.	F_R	F_{CR}	E.M.S.	Findings
S	9	27957.8273			$\sigma_\varepsilon^2 + 6\ \phi_S$	
N	2	8593.9845	9.55	3.55	$\sigma_\varepsilon^2 + 2\sigma^2_{SN} + 20\ \phi_N$	Significant (P < 0.05)
SXN	18	899.1107			$\sigma_\varepsilon^2 + 2\sigma^2_{SN}$	
R	1	10284.8134	3.16	5.12	$\sigma_\varepsilon^2 + 2\ \sigma_{SR} + 30\ \phi_R$	Not Significant (P < 0.05)
SXR	9	3247.4838			$\sigma_\varepsilon^2 + 3\ \sigma_{SR}$	
NXR	2	94.1065	0.19	3.55	$\sigma_\varepsilon^2 + 10\ \phi_{NR}$	Not Significant (P > 0.05)
NXRXS	18	485.1592			σ_ε^2	

TABLE 13

MAJOR STUDY - ANOVA FOR P.R.D. FOR N_{S1} = 3.32 BITS

Source	D.F.	M.S.	F_R	F_{CR}	E.M.S.	Findings
S*	8	18.62			$\sigma_\varepsilon^2 + 10\ \phi_S$	
N	4	52.10	3.71	2.65	$\sigma_\varepsilon^2 + 2\sigma^2_{SN} + 18\ \phi_N$	Significant (P < 0.05)
SXN	32	14.03			$\sigma_\varepsilon^2 + 2\sigma^2_{SN}$	
R	1	190.67	46.50	4.46	$\sigma_\varepsilon^2 + 3\sigma^2_{SR} + 45\ \phi_R$	Significant (P < 0.05)
RXS	8	4.10			$\sigma_\varepsilon^2 + 5\sigma^2_{SR}$	
NXR	4	2.56	1.04	2.65	$\sigma_\varepsilon^2 + 9\ \phi_{NR}$	Not Significant (P > 0.05)
NXRXS	32	2.46			σ_ε^2	

*Nine Subjects have been taken for the purpose of analysis.

TABLE 14

MAJOR STUDY - ANOVA FOR P.R.D. NOR N_{S2} = 3.00 BITS

Source	D.F.	M.S.	F_R	F_{CR}	E.M.S.	Findings
S	8	7.62			$\sigma_\varepsilon^2 + 8\ \phi_S$	
N	3	56.79	3.21	3.01	$\sigma_\varepsilon^2 + 2\sigma^2_{SN} + 18\ \phi_N$	Significant (P < 0.05)
SXN	24	17.69			$\sigma_\varepsilon^2 + 2\sigma^2_{SN}$	
R	1	138.88	56.68	5.32	$\sigma_\varepsilon^2 + 4\sigma^2_{SR} + 36\ \phi_R$	Significant (P < 0.05)
RXS	8	2.45			$\sigma_\varepsilon^2 + 4\sigma^2_{SR}$	
NXR	3	0.66	0.25	3.01	$\sigma_\varepsilon^2 + 4\sigma^2_{SR}$	Not Significant (P > 0.05)
NXRXS	24	2.64			σ_ε^2	

TABLE 15

MAJOR STUDY - ANOVA FOR P.R.D. FOR N_{S3} - 2.58 BITS

Source	D.F.	M.S.	F_R	F_{CR}	E.M.S.	Findings
S	8	21.76			$\sigma_\varepsilon^2 + 6\ \phi_S$	
N	2	91.12	6.18	3.63	$\sigma_\varepsilon^2 + 2\sigma^2_{SN} + 18\ \sigma_N$	Significant (P < 0.05)
SXN	16	14.73			$\sigma_\varepsilon^2 + 2\sigma^2_{SN}$	
R	1	106.96	23.61	4.49	$\sigma_\varepsilon^2 + 3\sigma^2_{SR} + 27\ \phi_R$	Significant (P < 0.05)
RXS	16	4.53			$\sigma_\varepsilon^2 + 3\sigma^2_{SR}$	
NXR	2	0.35	0.02	3.63	$\sigma_\varepsilon^2 + 9\ \phi_{NR}$	Not Significant (P > 0.05)
NXRXS	16	14.83			σ_ε^2	

TEST ON MEANS

Putting Newman-Keuls Range Test (Hicks, 1973) on the means of both studies - (for computation of means see ANOVA computer outputs).

For N_{Si} Means of Pilot Study

The means in descending order are -

557.50	526.99	483.57
3	2	1

$$\text{Standard Error (S.E.)} = \sqrt{\frac{\text{error mean square}}{\text{number of observations}}}$$

For a mixed model then,

$$S.E. = \sqrt{\frac{1537.207}{20}} = 8.76$$

From standard tables, for d.f. = 8, the ranges are 3.26 and 4.04.

Therefore, the Least Significant Ranges are -

L.S.R. = S.E. x Range = 28.58 35.41

1 vs 3 = 73.93 > 35.41 Significant ($P < 0.05$)

1 vs 2 = 30.51 > 28.58 Significant ($P < 0.05$)

2 vs 3 = 43.42 > 35.41 Significant ($P < 0.05$)

Hence all the set means are significantly different from each other.

TEST ON MEANS OF MAJOR STUDY

(i) Performance Times

When N_{S1} = 3.32 bits

For N_{Rj} Levels

The means in descending order are -

5	4	3	2	1
614.11	608.07	605.55	587.15	531.02

$$\text{Standard Error (S.E.)} = \sqrt{\frac{\text{error mean square}}{\text{no. of observations}}}$$

$$= \sqrt{\frac{1758.3396}{20}} \doteqdot 9.38$$

From standard tables, for d.f. = 36, the ranges are -

	2.86	3.46	3.82	4.26
Least Significant Ranges =	26.82	32.45	35.83	39.95

Therefore,

1 vs 5 = 83.08 > 39.05 Significant ($P < 0.05$)

1 vs 4 = 77.05 > 39.05 Significant ($P < 0.05$)

1 vs 3 = 74.53 > 39.05 Significant ($P < 0.05$)

1 vs 2 = 56.13 > 39.05 Significant ($P < 0.05$)

2 vs 5 = 26.96 < 35.83 Not Significant ($P > 0.05$)

2 vs 4 = 20.92 < 35.83 Not Significant ($P > 0.05$)

2 vs 3 = 18.40 < 35.83 Not Significant ($P > 0.05$)

3 vs 5 = 8.56 < 32.45 Not Significant ($P > 0.05$)

3 vs 4 = 2.52 < 32.45 Not Significant ($P > 0.05$)

4 vs 5 = 6.04 < 26.82 Not Significant ($P > 0.05$)

The above results can be summed up as follows:

N_{Rj} 3.32 3.00 2.58 2.00 1.00

<u>For R_k Levels</u>

The means in descending order are -

2	1
576.35	602.01

$$S.E. = \sqrt{\frac{543.5248}{50}} = 3.30$$

for d.f. = 9, the range is - 3.20

L.S.R. = 10.56

1 vs 2 - 25.66 > 10.56 Significant ($P < 0.05$)

<u>When N_{S2} = 3.00 Bits</u>

<u>For N_{Rj} Levels</u>

The means in descending order are

4	3	2	1
599.24	597.66	579.93	520.48

$$S.E. = \sqrt{\frac{1923.22}{20}} = 9.81$$

for d.f. = 27, the ranges are -

2.90 3.50 3.87

L.S.R. = 28.45 34.33 37.96

1 vs 4 = 78.76 > 37.96 Significant ($P < 0.05$)

1 vs 3 = 77.18 > 37.96 Significant ($P < 0.05$)

1 vs 2 = 59.35 > 37.96 Significant ($P < 0.05$)

2 vs 4 - 19.31 < 34.33 Not Significant ($P > 0.05$)

2 vs 3 = 17.73 < 34.33 Not Significant ($P > 0.05$)

3 vs 4 = 1.58 < 28.45 Not Significant ($P > 0.05$)

The above results can be summed up as follows -

N_{Rj} 3.00 2.58 2.00 1.00

<u>For R_k Levels</u>

The means in descending order are -

2 1

562.46 586.20

$$S.E. = \sqrt{\frac{249.3152}{40}} = 2.49$$

for d.f. = 9, the range is - 3.20

L.S.R. = 7.96

1 vs 2 = 23.74 $>$ 7.96 Significant ($P < 0.05$)

When N_{S3} = 2.58

For N_{Rj} Levels

The means in descending order are -

3	2	1
549.32	548.50	513.01

$$S.E. = \sqrt{\frac{899.11}{20}} = 6.70$$

for d.f. = 18, the ranges are -

	2.97	3.61
L.S.R. =	19.90	24.18

1 vs 3 = 36.31 $>$ 24.18 Significant ($P < 0.05$)

1 vs 2 = 35.49 $>$ 24.18 Significant ($P < 0.05$)

2 vs 3 = 0.82 $<$ 19.90 Not Significant ($P > 0.05$)

The above results can be summed up as follows -

N_{Rj}	2.58	2.00	2.00

For R_k Levels

The means in descending order are -

2	1
550.03	523.85

$$S.E. = \sqrt{\frac{3247.4838}{30}} = 8.05$$

for d.f. = 9, the range is - 3.20

L.S.R. = 25.76

1 vs 2 = 26.18 > 25.76 Significant ($P < 0.05$)

(ii) Pulse Rate Differences

When N_{S1} = 3.32 bits

For N_{Rj} Levels

The means in descending order are -

5	4	3	2	1
14.00	12.00	10.88	10.22	9.72

$$S.E. = \sqrt{\frac{14.03}{18}} = 0.77$$

for d.f. = 32, the ranges are -

	2.88	3.47	3.83	4.10
L.S.R. =	2.21	2.67	2.94	3.15

1 vs 5 = 4.28 > 3.15 Significant ($P < 0.05$)

1 vs 4 = 3.78 > 3.15 Significant ($P < 0.05$)

1 vs 3 = 3.12 < 3.15 Not Significant ($P > 0.05$)

1 vs 2 = 2.00 < 3.15 Not Significant ($P > 0.05$)

2 vs 5 = 2.28 < 2.94 Not Significant ($P > 0.05$)

2 vs 4 = 1.78 < 2.94 Not Significant ($P > 0.05$)

2 vs 3 - 1.12 < 2.94 Not Significant ($P > 0.05$)

3 vs 5 = 1.16 < 2.67 Not Significant ($P > 0.05$)

3 vs 4 = 0.66 < 2.67 Not Significant ($P > 0.05$)

4 vs 5 = 0.50 < 2.21 Not Significant ($P > 0.05$)

The above results can be summed up as follows -

N_{Rj} 3.32 3.00 2.58 2.00 1.00

For R_k Levels

The means in descending order are -

2	1
12.82	9.91

$$S.E. = \sqrt{\frac{4.10}{45}} = 0.30$$

for d.f. = 8, the range is - 3.26

L.S.R. = 0.97

1 vs 2 = 2.91 > 0.97 Significant ($P < 0.05$)

When N_{S2} = 3.00 Bits

For R_k Levels

The means in descending order are -

4	3	2	1
13.94	12.11	10.55	10.22

$$S.E. = \sqrt{\frac{17.00}{18}} = 0.95$$

for d.f. = 24, the ranges are -

	2.92	3.53	3.90
L.S.R. =	2.80	3.38	3.70

1 vs 4 = 3.72 > 3.70 Significant ($P < 0.05$)

1 vs 3 = 3.39 < 3.70 Not Significant ($P > 0.05$)

1 vs 2 = 1.83 < 3.70 Not Significant ($P > 0.05$)

2 vs 4 = 1.89 < 3.38 Not Significant ($P > 0.05$)

2 vs 3 = 1.56 < 3.38 Not Significant ($P > 0.05$)

3 vs 4 = 0.33 < 2.80 Not Significant ($P > 0.05$)

The above results can be summed up as follows -

N_{Rj} 3.00 2.58 2.00 1.00

For R_k Levels

The means in descending order are -

2	1
13.13	10.27

$$S.E. = \sqrt{\frac{2.23}{36}} = 0.06$$

for d.f. = 8, the range is - 3.26

L.S.R. = 0.1936

1 vs 2 = 2.86 > 0.1936 Significant ($P < 0.05$)

When N_{S3} = 2.58 Bits

For N_{Rj} Levels

The means arranged in descending order are -

3	2	1
14.44	12.16	9.94

$$S.E. = \sqrt{\frac{14.73}{18}} = 0.90$$

for d.f. = 16, the ranges are -

	3.00	3.65
L.S.R. =	2.70	3.28

1 vs 3 = 4.50 > 3.28 Significant ($P < 0.05$)

1 vs 2 = 2.28 < 3.28 Not Significant ($P > 0.05$)

2 vs 3 = 2.78 > 2.70 Significant ($P < 0.05$)

The above results can be summed up as follows -

N_{Rj} 2.58 2.00 1.00

<u>For R_k Levels</u>

The means in descending order are -

2	1
13.59	10.77

$$S.E. = \sqrt{\frac{4.53}{27}} = 0.40$$

for d.f. = 16, the range is - 3.00

L.S.R. = 1.20

1 vs 2 = 2.82 > 1.20 Significant ($P < 0.05$)

COMPUTATION OF VARIANCES ATTRIBUTABLE TO DIFFERENT FACTORS OF MAJOR STUDY

(i) For Performance Times

When N_{S1} = 3.32 Bits

Using mixed model, from the ANOVA table, we have -

$$\sigma_\varepsilon^2 = 720.36$$

$$\sigma_\varepsilon^2 + 10\ \phi_{NR} = 227.50$$

$$\phi_{NR} = -49.28$$

$$\sigma_\varepsilon^2 + 5\ \sigma_{SR}^2 = 543.52$$

$$\sigma_\varepsilon^2 + 5\ \sigma_{SR}^2 + 50\ \phi_R = 16467.56$$

$$\phi_R = 318.48$$

$$\sigma_\varepsilon^2 + 2\ \sigma_{SN}^2 = 1758.34$$

$$\sigma_\varepsilon^2 + 2\ \sigma_{SN}^2 + 20\ \phi_N = 23166.53$$

$$\phi_N = 1070.40$$

$$^{2} + 10 \;\; _{S} = 21138.42$$

$$_{S} = 2041.80$$

$$\text{Total variance} = \sigma_{\varepsilon}^{2} + \phi_{N} + \phi_{R} + \phi_{S} + \phi_{NR}$$

$$= 4101.76$$

% age of variance attached with $N_{Rj} = \frac{1070.40}{4101.76} = 26.00$

% age of variance attached with $R_{k} = \frac{318.48}{4101.76} = 7.76$

<u>When N_{S2} = 3.00 Bits</u>

$$\sigma_{\varepsilon}^{2} = 447.87$$

$$\sigma_{\varepsilon}^{2} + 10 \; \phi_{NR} = 318.25$$

$$\phi_{NR} = -12.96$$

$$\sigma_{\varepsilon}^{2} + 4 \; \sigma_{SR}^{2} = 249.31$$

$$\sigma_{\varepsilon}^{2} + 4 \; \sigma_{SR}^{2} + 40 \; \phi_{R} = 11265.8178$$

$$\phi_{R} = 275.41$$

$$\sigma_\varepsilon^2 + 2\ \sigma_{SN}^2 = 1923.22$$

$$\sigma_\varepsilon^2 + 2\ \sigma_{SN}^2 + 20\ \phi_N = 27312.19$$

$$\phi_N = 1269.44$$

$$\sigma_\varepsilon^2 + 8\ \phi_S = 22447.19$$

$$\phi_S = 2749.91$$

$$\text{Total variance} = \sigma_\varepsilon^2 + \phi_N + \phi_R + \phi_S + \phi_{NR}$$

$$= 4729.76$$

$$\%\text{ age variance attached with } N_{Rj} = \frac{1269.44}{4729.76} = 26.83$$

$$\%\text{ age variance attached with } R_k = \frac{275.41}{4729.76} = 5.82$$

<u>When N_{S3} = 2.58 Bits</u>

$$\sigma_\varepsilon^2 = 485.16$$

$$\sigma_\varepsilon^2 + 10\ \phi_{NR} = 94.10$$

$$\phi_{NR} = -39.10$$

$$\sigma_\varepsilon^2 + 3\ \sigma_{SR}^2 = 3247.4838$$

$$\sigma_\varepsilon^2 + 3\ \sigma_{SR}^2 + 30\ \phi_R = 10284.81$$

$$\phi_R = 234.57$$

$$\sigma_\varepsilon^2 + 2\ \sigma_{SN}^2 = 899.11$$

$$\sigma_\varepsilon^2 + 2\ \sigma_{SN}^2 + 20\ \phi_N = 8593.98$$

$$\phi_N = 384.74$$

$$\sigma_\varepsilon^2 + 6\ \phi_S = 27957.82$$

$$\phi_S = 4578.77$$

$$\text{Total variance} = \sigma_\varepsilon^2 + \phi_N + \phi_R + \phi_S + \phi_{NR}$$

$$= 5644.14$$

% age of variance attached with $N_{Rj} = \frac{384.74}{5644.14} = 6.82$

% age of variance attached with $R_k = \frac{234.57}{5644.14} = 4.15$

(ii) For P.R.D.

When $N_{Si} = 3.32$

$$\sigma_\varepsilon^2 = 2.46$$

$$\sigma_\varepsilon^2 + 9\ \phi_{NR} = 0.10$$

Therefore

$$\phi_{NR} = 0.01$$

$$\sigma_\varepsilon^2 + 5\ \sigma_{SR}^2 = 4.10$$

$$\sigma_\varepsilon^2 + 5\ \sigma_{SR}^2 + 45\ \phi_R = 190.67$$

Therefore

$$\phi_R = 4.15$$

$$\sigma_\varepsilon^2 + 2\ \sigma_{SN}^2 = 14.03$$

$$\sigma_\varepsilon^2 + 2\ \sigma_{SN}^2 + 18\ \phi_N = 52.10$$

Therefore

$$\phi_N = 2.11$$

$$\sigma_\varepsilon^2 + 10\ \phi_S = 18.62$$

Therefore

$$\phi_S = 1.61$$

Therefore

$$\text{Total variance} = \sigma_\varepsilon^2 + \phi_N + \phi_R + \phi_S + \phi_{NR}$$

Therefore

$$\% \text{ of variance attached with } N_{Rj} = \frac{2.11}{10.34} = 20\%$$

$$\% \text{ of variance attached with } R_k = \frac{4.15}{10.34} = 40\%$$

<u>When N_{S2} = 3.00 Bits</u>

$$\phi_{NR} = \frac{0.66 - 2.64}{9} = -0.22$$

$$\phi_R = \frac{138.88 - 2.45}{36} = 3.78$$

$$\phi_N = \frac{56.79 - 17.69}{18} = 1.086$$

$$\phi_S = \frac{7.62 - 2.64}{8} = 0.62$$

Therefore

Total Variance = 5.706

Therefore

% variance attributed to $N_{Rj} = \frac{1.08}{5.70} = 19\%$

% variance attributed to $R_k = \frac{3.78}{6.74} = 56\%$

<u>When N_{S3} = 2.58 Bits</u>

$$\phi_{NR} = \frac{0.35 - 14.83}{9} = -1.60$$

$$\phi_R = \frac{91.12 - 14.73}{18} = 4.24$$

$$\phi_S = \frac{21.76 - 14.83}{6} = 1.15$$

Therefore

Total variance = 10.78

Therefore

% variance attributed to $N_{Rj} = \frac{4.24}{10.78} = 39\%$

% variance attributed to $R_k = 35\%$

COMPUTATION OF VARIANCES FOR INDIVIDUAL N_{Rj} MEANS

(i) For Performance Times

For N_{S1} = 3.32 Bits

Means in ascending order of N_{Rj} are -

608.07   614.11   605.55   587.15   531.02

$\bar{X}$ = 589.18

S_1^2 = 356.83

S_2^2 = 621.51

S_3^2 = 267.97

S_4^2 = 4.1209

S_5^2 = 3382.58, Total Variance = 4633.00

Therefore, % ages associated with the above means are -

7.60   13.25   5.78   0.01   73.00

For N_{S2} = 3.00 Bits

Means in ascending order of N_{Rj} are -

599.24   597.66   579.93   520.48

$\bar{X}$ = 574.32

S_1^2 = 621.00

S_2^2 = 544.75

S_3^2 = 31.47

S_4^2 = 2898.74, Total Variance = 4095.22

Therefore, % ages associated with above means are -

15.16   13.28   0.70   70.76

<u>For N_{S3} = 2.58 Bits</u>

548.50   549.32   513.01

$\overline{X}$ = 536.94

S_1^2 = 133.63

S_2^2 = 153.66

S_3^2 = 572.65, Total Variance - 859.54

Therefore, % ages associated with above means are -

15.55   17.81   66.59

(ii) <u>For P.R.D.</u>

<u>For N_{S1} = 3.32 Bits</u>

Means in ascending order of N_{Rj} are -

9.72   10.22   10.88   12.00   14.00

$\overline{X}$ = 11.36

S_1^2 = 2.68

S_2^2 = 1.23

$S_3^2 = 0.23$

$S_4^2 = 0.41$

$S_5^2 = 6.97$, Total Variance = 11.52

Therefore, % associated with the above means are -

23.26 10.67 2.00 3.60 60.50

<u>For N_{S2} = 3.00 Bits</u>

Means in ascending order of N_{Rj} are -

10.22 1.055 12.11 14.11

$\overline{X} = 11.75$

$S_1^2 = 2.34$

$S_2^2 = 1.44$

$S_3^2 = 0.13$

$S_4^2 = 5.57$, Total Variance = 9.48

Therefore, % associated with the above means are -

24.68 15.18 1.37 58.75

<u>For N_{S3} = 2.58 Bits</u>

Means in ascending order of N_{Rj} are -

9.94 12.16 14.44

$\overline{X} = 12.18$

$S_1^2 = 5.01$

$S_2^2 = 0.004$

$S_3^2 = 5.20$

Total Variance ≐ 10.30

Therefore, % associated with above means are -

48.00	2.00	50.00

APPENDIX D

GRAPHS

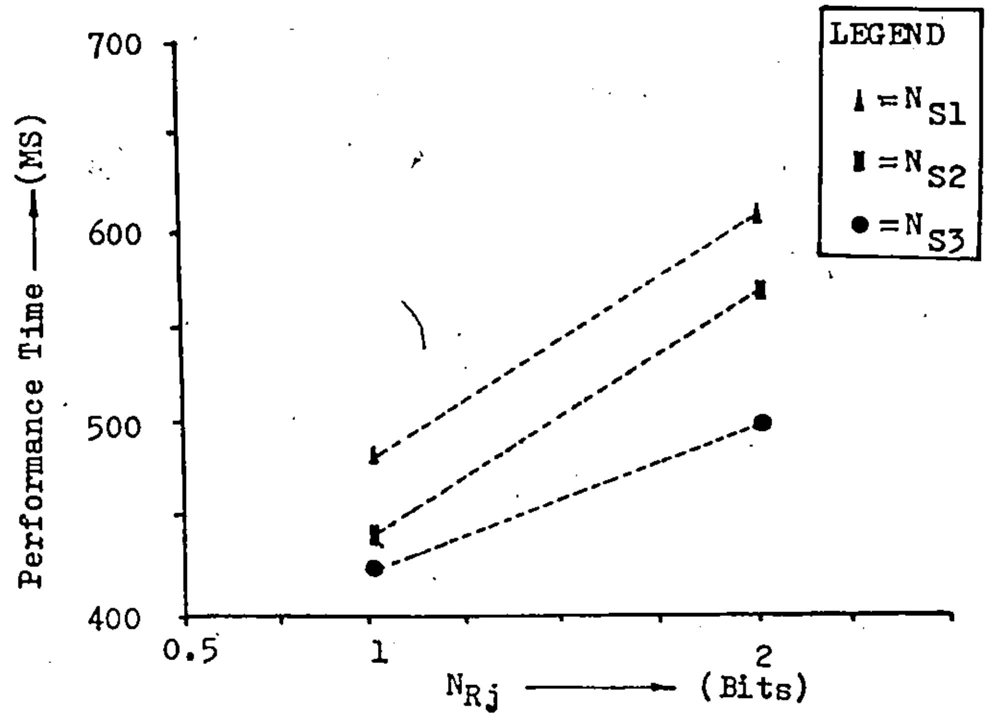


Figure 1. Results of Pilot-Study for R_1

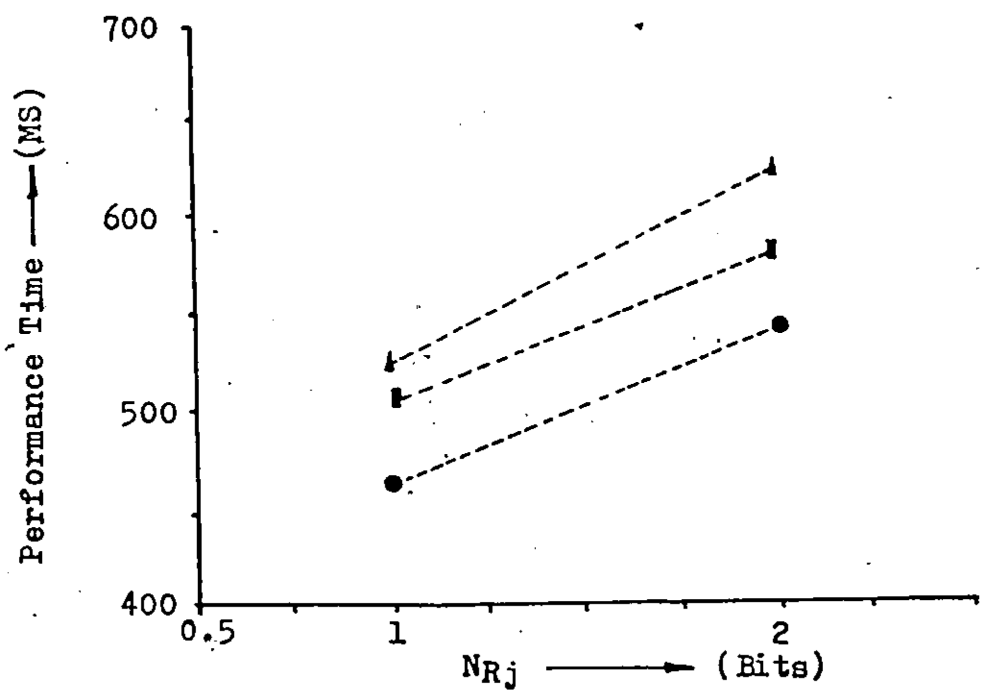


Figure 2. Results of Pilot-Study for R_2

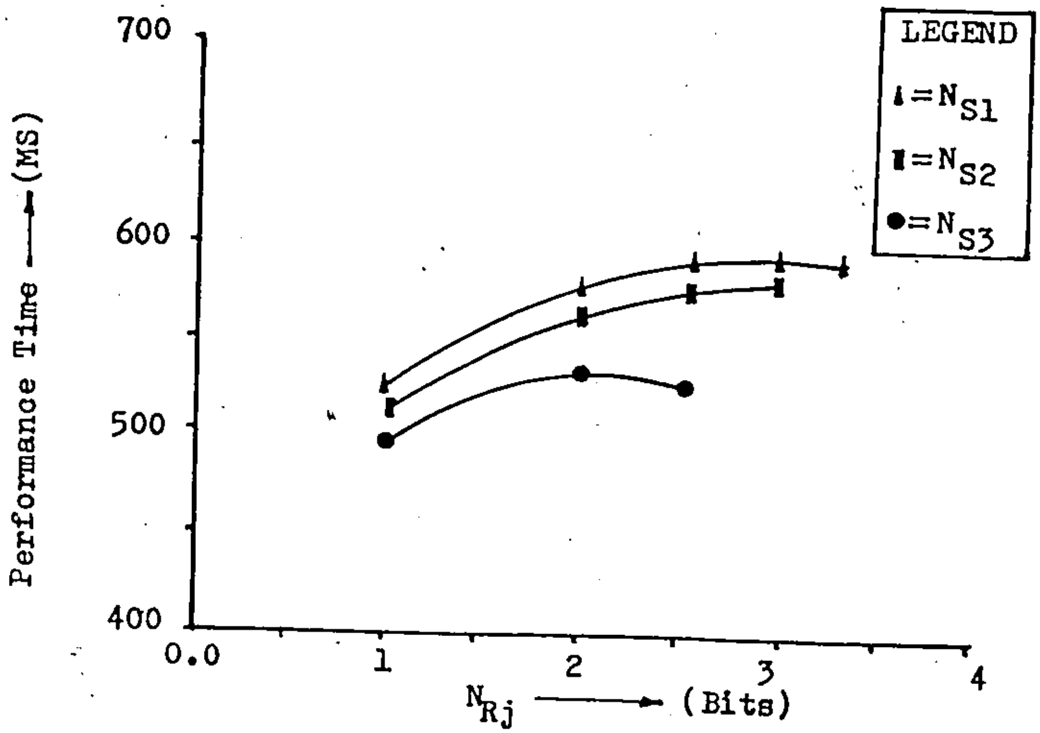


Figure 3. N_{Rj} vs. Performance Time for R_1

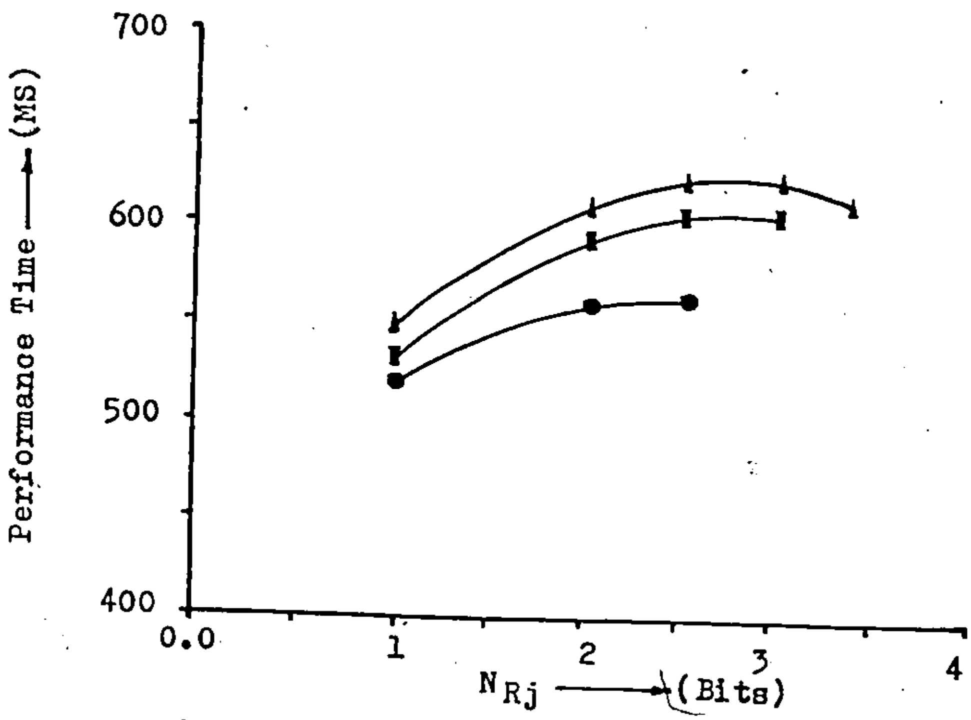


Figure 4. N_{Rj} vs. Performance Time for R_2

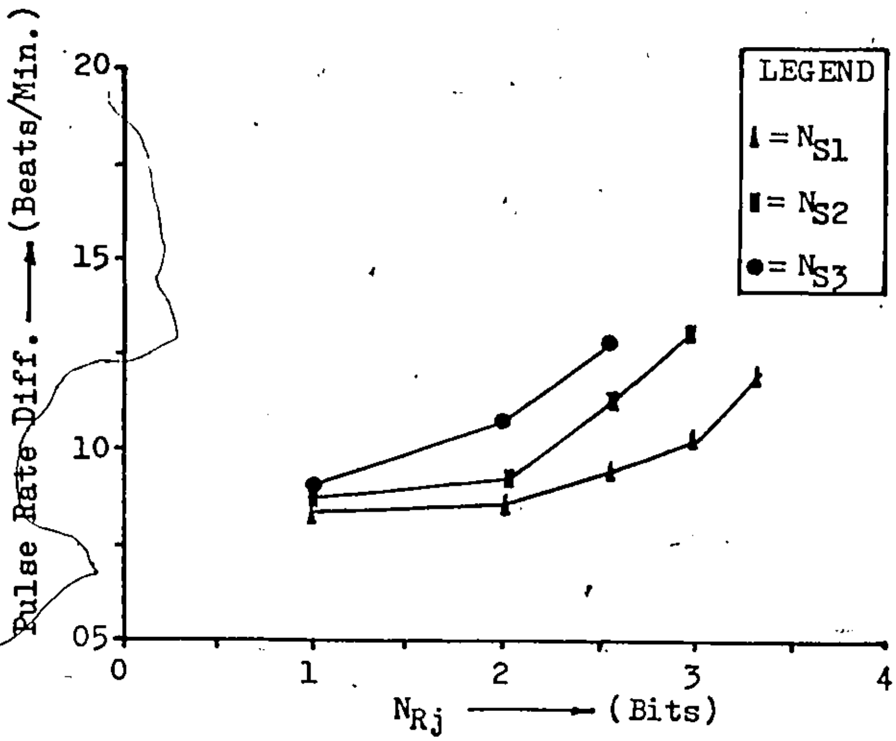


Figure 5. N_{Rj} vs. Pulse Rate Difference for R_1

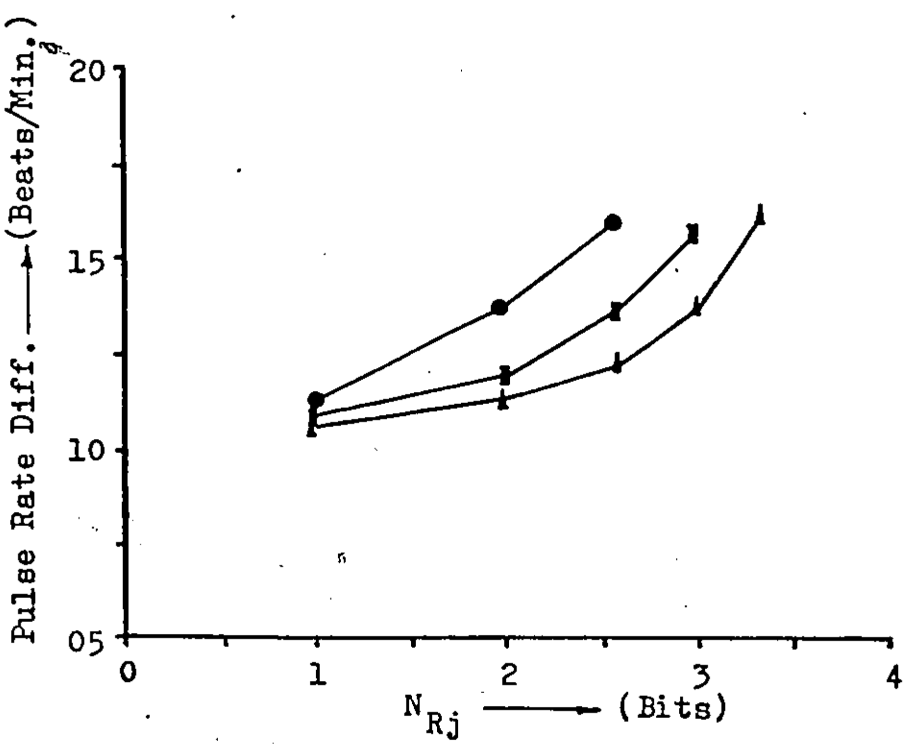


Figure 6. N_{Rj} vs. Pulse Rate Difference for R_2

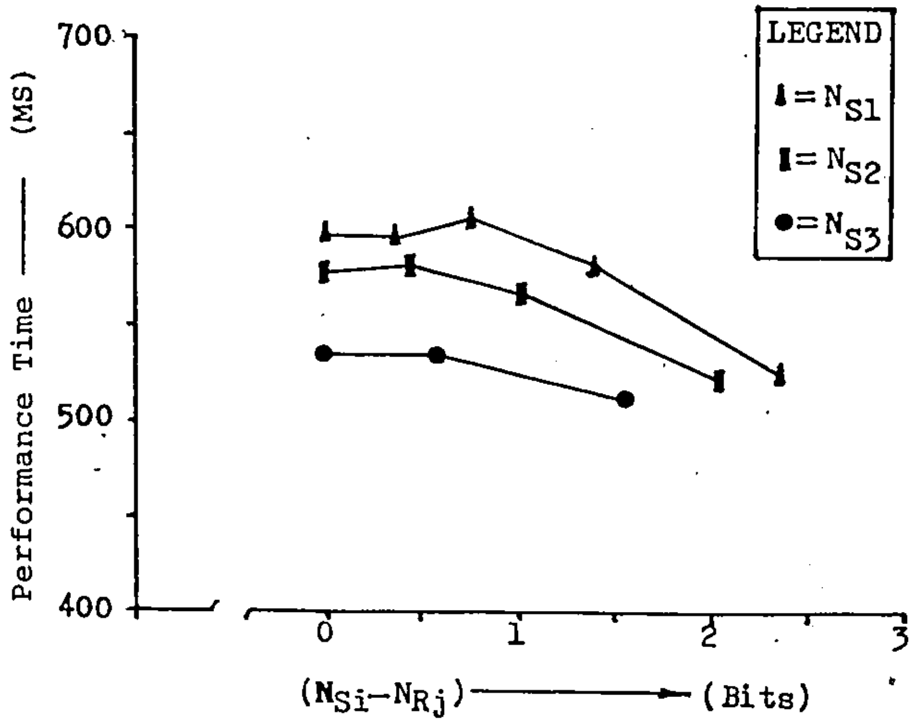


Figure 7. $(N_{Si}-N_{Rj})$ vs. Performance Time for R_1

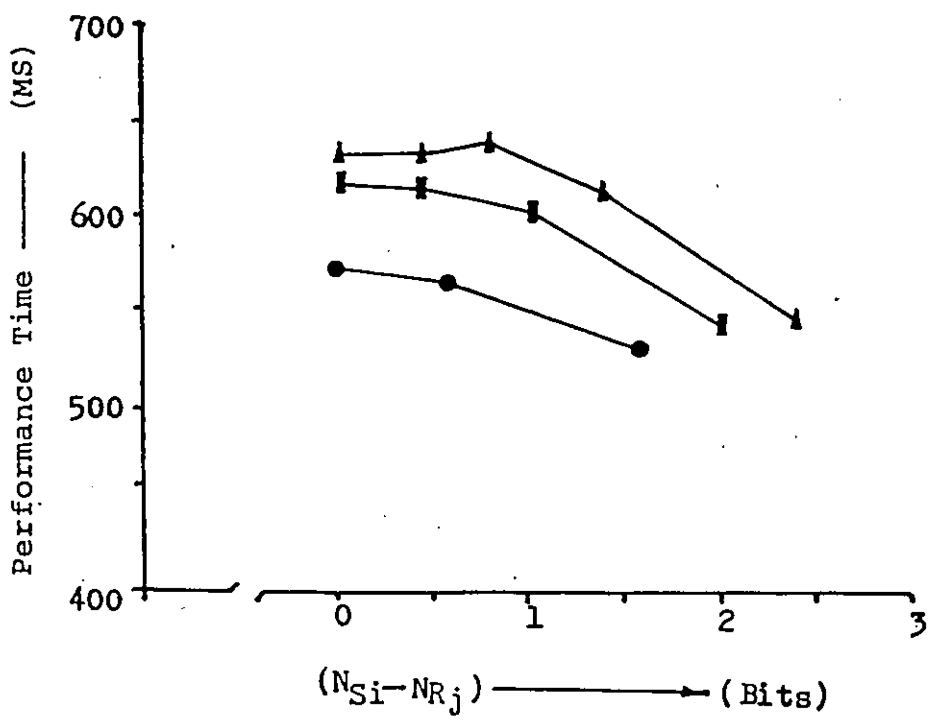


Figure 8. $(N_{Si}-N_{Rj})$ vs. Performance Time for R_2

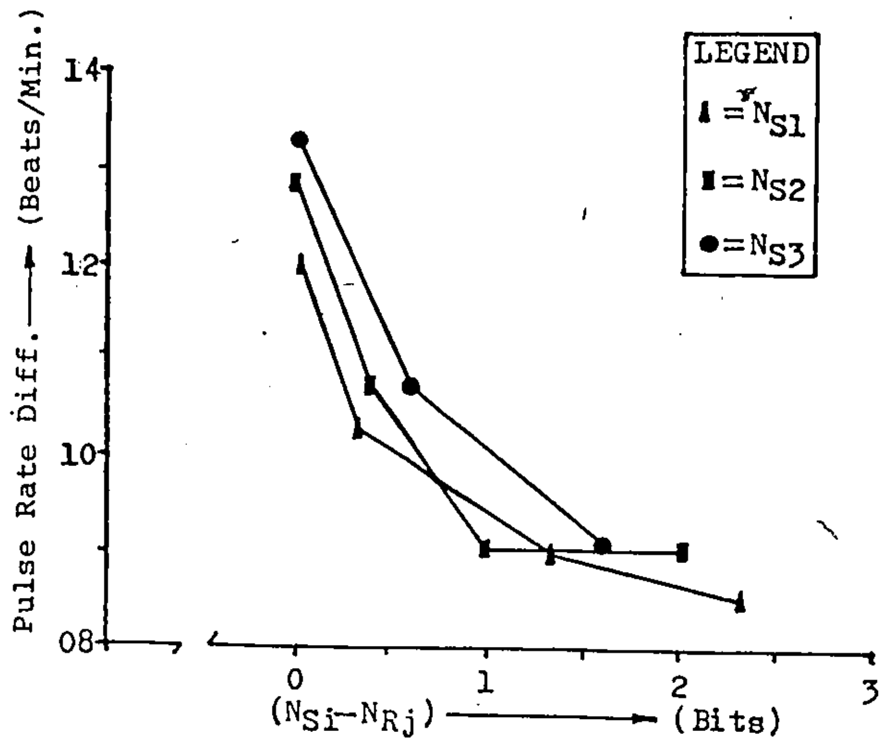


Figure 9. $(N_{Si}-N_{Rj})$ vs. Pulse Rate Diff. for R_1

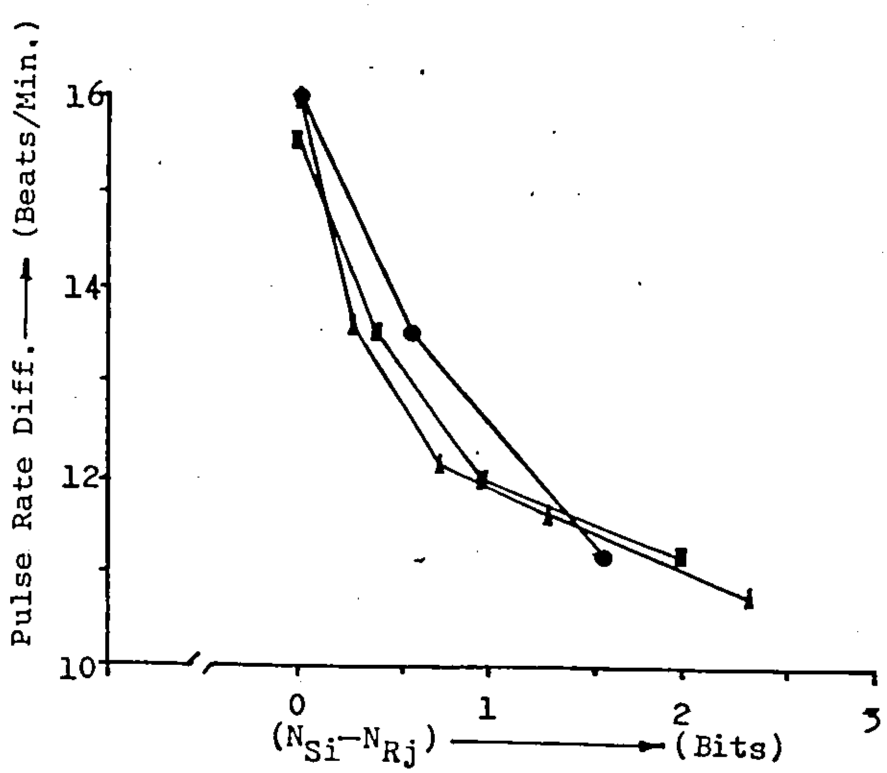


Figure 10. $(N_{Si}-N_{Rj})$ vs. Pulse Rate Diff. for R_2

APPENDIX E

REGRESSION ANALYSIS

Prediction Equations

The Regression Analysis Computer outputs indicate that the performance times for three sets of stimulus information (N_{Si}) can be given by first and second degree equations of the nature -

$$Y = a + mx$$

and

$$Y = a + bx - cx^2$$

The maximum percentages of error involved in both types of curves fitting is less than 7.65%. Based on all the first degree = ns for reach of 7 inches and 14 inches, the following equation has been developed. This = n can be used when the information in the stimulus and response has been ascertained. The = n is -

$$\text{Performance Time (MS)} = \text{RAD}" + \text{CD}" + 33.33\ N_R$$

Where, RAD" = time taken in MS by the reach distance of class A

RA7" = 266 MS

RA14" = 378 MS

N_R is the information in the response, and

CD' is experimentally determined constant (ms) based on stimulus information (bits) and reach distances (inches).

These constants are given by the following table:

N_{Si}	C7"	C14"
3.32	230.5 (MS)	144.0
3.00	225.0	134.0
2.58	195.0	113.0

TABLE 1. Constants Associated with Different N_{Si} and R_k for the Performance Time.

Similarly, the pulse rate difference (P.R.D.) in beats/min. can also be represented by first and second degree equations of the nature -

$$Y = a + mx$$

$$Y = a - bx + cx^2$$

The first degree = n developed from all the = ns representing all the sets of stimuli information is given by -

$$P.R.D.\ (beats/min.) = KD'' + 2.10\ N_R$$

Where, N_R is the information in the response in bits

KD" is the experimentally determined constants (MS) based on stimulus information (bits) and reach distances (inches).

These constants are given by the following table:

N_{Si}	K7"	K14"
3.32	5.07	7.56
3.00	5.97	8.51
2.58	6.97	9.10

TABLE 2. Constants Associated with Different N_{Si} and R_k for the P.R.D.

COMPUTER OUTPUTS

Performance Times

1. For N_{S1} = 3.32 bits R_1
   R_2

2. For N_{S2} = 3.00 bits R_1
   R_2

3. For N_{S3} = 2.58 bits R_1
   R_2

Pulse Rate Difference

1. For N_{S1} = 3.32 bits R_1
   R_2

2. For N_{S2} = 3.00 bits R_1
   R_2

3. For N_{S3} = 2.58 bits R_1
   R_2

```
LEAST SQUARES FIT COEFFICIENTS
  0.50[illegible]768350[illegible]D 03
  0.3179337464251676D 02

   X(I)        Y(I)        ACY(I)        R(I)       PERCENT ERROR
  3.32000    596.36000   606.24377     9.88377      1.65735
  3.00000    591.07000   596.06989     4.99989      0.84591
  2.50000    598.55000   582.71667   -15.83333     -2.64528
  2.00000    572.15000   564.27652    -7.91346     -1.38302
  1.00000    523.62000   532.4[illegible]314     8.86314      1.69267

CORRELATION COEFFICIENT =     0.931637     SIG =    11.341964     AVERAGE ERROR=  1.64 PERCENT

PERCENT STANDARD ERROR =  1.97

 LEAST SQUARES FIT COEFFICIENTS
  0.5687172736257840D 03
  0.1026[illegible]F91262[illegible]5C2D 02
 -0.1655740882960497D 02

   X(I)        Y(I)        ACY(I)        R(I)       PERCENT ERROR
  3.32000    596.36000   595.28318    -1.07682     -0.18056
  3.00000    591.07000   595.60572     4.53572      0.71881
  2.50000    598.55000   591.58601    -6.96399     -1.16348
  2.00000    572.15000   576.01117     3.82167      0.66794
  1.00000    523.62000   522.99921    -0.62079     -0.11856

CORRELATION COEFFICIENT =     0.911667     SIG =     4.692326     AVERAGE ERROR=  0.59 PERCENT

PERCENT STANDARD ERROR =  0.81

 LEAST SQUARES FIT COEFFICIENTS
  0.4717833860359075D 03
  0.42[illegible]5[illegible]419004542D 02
  0.1527697346940827D 02
 -0.[illegible]C4[illegible]7271316[illegible]5[illegible] 01

   X(I)        Y(I)        ACY(I)        R(I)       PERCENT ERROR
  3.32000    596.36000   594.09128    -2.26872     -0.38043
  3.00000    591.07000   597.19061     6.12061      1.03551
  2.50000    598.55000   592.77359    -5.77641     -0.96507
  2.00000    572.19000   574.33893     2.14893      0.37556
  1.00000    523.62000   523.39559    -0.22441     -0.04286

CORRELATION COEFFICIENT =     0.989628     SIG =     4.490105     AVERAGE ERROR=  0.56 PERCENT

PERCENT STANDARD ERROR =  0.76

 LEAST SQUARES FIT COEFFICIENTS
  0.[illegible]179979059732252D 04
 -0.1[illegible]21587506283990 04
  0.1[illegible]69775146258151 04
 -0.4[illegible]1205907339096 0D 03
  0.49[illegible]172371663151[illegible] 02

   X(I)        Y(I)        ACY(I)        R(I)       PERCENT ERROR
  3.32000    596.36000   596.36000    -0.00000     -0.00000
  3.00000    591.07000   591.07000     0.00000      0.00000
  2.50000    598.55000   598.55000    -0.00000     -0.00000
  2.00000    572.19000   572.19000     0.00000      0.00000
  1.00000    523.62000   523.62000    -0.00000     -0.00000

CORRELATION COEFFICIENT =     1.000000     SIG =     0.000000     AVERAGE ERRO =  0.00 PERCENT

PERCENT STANDARD ERROR =  0.00

CORE USAGE     OBJECT CODE=   4480 BYTES,ARRAY AREA=   5680 BYTES,TOTAL AREA AVAILABLE=   59272  BYTES
DIAGNOSTICS      NUMBER OF ERRORS=      0, NUMBER OF WARNINGS=      0, NUMBER OF EXTENSIONS=      0
COMPILE TIME=   1.87 SEC,EXECUTION TIME=    1.74 SEC,  WATFIV - JUL 1973 V1L4     10.07.01   WEDNESDAY    16 JUL 75
```

```
   LEAST SQUARES FIT COEFFICIENTS
    0.5161460300285988D 03
    0.3601234032411813D 02

    X(I)          Y(I)          ACY(I)          R(I)      PERCENT ERROR
   3.32000     619.79000     635.93940      16.14940      2.60562
   3.00000     620.06000     624.39305       4.33305      0.69881
   2.53000     629.69000     609.23847     -20.45153     -3.24791
   2.00000     602.13000     588.31071     -13.81929     -2.29507
   1.00000     538.44000     552.22837      13.78837      2.56080
 CORRELATION COEFFICIENT =    0.895547      SIG =    16.423577      AVERAGE ERROR=  2.28 PERCENT
 PERCENT STANDARD ERROR =  2.73
   LEAST SQUARES FIT COEFFICIENTS
    0.4115712327168312D 03
    0.1444643748954071D 03
   -0.2531368690857923D 02

    X(I)          Y(I)          ACY(I)          R(I)      PERCENT ERROR
   3.32000     619.79000     619.18237      -0.60763     -0.09804
   3.00000     620.06000     624.14818       4.08818      0.65932
   2.53000     629.69000     622.79829      -6.89171     -1.09446
   2.00000     602.13000     606.25223       4.12223      0.68461
   1.00000     538.44000     537.72892      -0.71108     -0.13206
 CORRELATION COEFFICIENT =    0.992440      SIG =     4.529803      AVERAGE ERROR=  0.53 PERCENT
 PERCENT STANDARD ERROR =  0.75
   LEAST SQUARES FIT COEFFICIENTS
    0.4627697820017292D 03
    0.6866864965336432D 02
    0.1257757294411925D 02
   -0.5785346146816064D 01

    X(I)          Y(I)          ACY(I)          R(I)      PERCENT ERROR
   3.32000     619.79000     617.67365      -2.11635     -0.34146
   3.00000     620.06000     625.76954       5.70954      0.92080
   2.53000     629.69000     624.30154      -5.38846     -0.85573
   2.00000     602.13000     604.13460       2.00460      0.33292
   1.00000     538.44000     538.23066      -0.20934     -0.03888
 CORRELATION COEFFICIENT =    0.993540      SIG =     4.188541      AVERAGE ERROR=  0.50 PERCENT
 PERCENT STANDARD ERROR =  0.70
   LEAST SQUARES FIT COEFFICIENTS
    0.1317444959419244D 04
   -0.1771154980107104D 04
    0.1368551587122607D 04
   -0.4274267144077959D 03
    0.4572514797300041D 02

    X(I)          Y(I)          ACY(I)          R(I)      PERCENT ERROR
   3.32000     619.79000     619.79000      -0.00000     -0.00000
   3.00000     620.06000     620.06000       0.00000      0.00000
   2.53000     629.69000     629.69000      -0.00000     -0.00000
   2.00000     602.13000     602.13000       0.00000      0.00000
   1.00000     538.44000     538.44000      -0.00000     -0.00000
 CORRELATION COEFFICIENT =    1.000000      SIG =     0.000000      AVERAGE ERROR=  0.00 PERCENT
 PERCENT STANDARD ERROR =  0.00
 CORE USAGE      OBJECT CODE=   4460 BYTES,ARRAY AREA=   5680 BYTES,TOTAL AREA AVAILABLE=   59272  BYTES
 DIAGNOSTICS      NUMBER OF ERRORS=      0, NUMBER OF WARNINGS=      0, NUMBER OF EXTENSIONS=      0
 COMPILE TIME=    1.57 SEC,EXECUTION TIME=     1.77 SEC,  WATFIV - JUL 1973 V1L4     10.07.42    WEDNESDAY    16 JUL 75
```

```
    LEAST SQUARES FIT COEFFICIENTS
      0.47202858899791330 03
      0.42665561781290 0D 02

      X(I)          Y(I)          ACY(I)          R(I)       PERCENT ERROR
     3.00000     592.45000     600.63546        8.18546        1.38163
     2.58000     589.42000     582.63050       -6.78950       -1.15190
     2.00000     563.41000     557.76650       -5.64350       -1.00167
     1.00000     510.65000     514.89755        4.24755        0.83179

  CORRELATION COEFFICIENT =     0.980874      SIG =     7.370884      AVERAGE ERROR=  1.09 PERCENT

  PERCENT STANDARD ERROR =  1.31

    LEAST SQUARES FIT COEFFICIENTS
      0.42701442812343450 03
      0.56540656582115 5D 02
     -0.13727687201080380 02

      X(I)          Y(I)          ACY(I)          R(I)       PERCENT ERROR
     3.00000     592.45000     594.17744        1.72744        0.29158
     2.51000     589.42000     585.64994       -3.77006       -0.63962
     2.00000     563.41000     565.91181        2.50181        0.44405
     1.00000     510.65000     510.19081       -0.45919       -0.08992

  CORRELATION COEFFICIENT =     0.997246      SIG =     2.808755      AVERAGE ERROR=  0.37 PERCENT

  PERCENT STANDARD ERROR =  0.50

    LEAST SQUARES FIT COEFFICIENTS
      0.53703781723414 39D 03
     -0.91075164929315120 02
      0.16002117234202660 02
     -0.16310469539037330 02

      X(I)          Y(I)          ACY(I)          R(I)       PERCENT ERROR
     3.00000     592.45000     592.45000        0.00000        0.00000
     2.51000     589.42000     589.42000       -0.00000       -0.00000
     2.00000     563.41000     563.41000        0.00000        0.00000
     1.00000     510.65000     510.65000       -0.00000       -0.00000

  CORRELATION COEFFICIENT =     1.000000      SIG =     0.000000      AVERAGE ERROR=  0.00 PERCENT

  PERCENT STANDARD ERROR =  0.00

  CORE USAGE      OBJECT CODE=    4480 BYTES,ARRAY AREA=    5680 BYTES,TOTAL AREA AVAILABLE=    59272  BYTES

  DIAGNOSTICS       NUMBER OF ERRORS=       0, NUMBER OF WARNINGS=       0, NUMBER OF EXTENSIONS=       0

  COMPILE TIME=     1.99 SEC,EXECUTION TIME=     1.01 SEC,  WATFIV - JUL 1973 V1L4      9.49.36    WEDNESDAY    16 JUL 75
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```
LEAST SQUARES FIT COEFFICIENTS
   0.5016713292173604D 03
   0.3872529144724865D 02

   X(I)        Y(I)         ACY(I)        R(I)      PERCENT ERROR
  3.00000    606.00000    617.87720     11.87720      1.95993
  2.52000    602.92000    599.28426     -3.63574     -0.60302
  2.00000    597.37000    579.14191    -18.22809     -3.05139
  1.00000    530.42000    540.40662      9.98662      1.88278

CORRELATION COEFFICIENT =     0.921596      SIG =     13.975557      AVERAGE ERROR=  1.87 PERCENT

PERCENT STANDARD ERROR =  2.39

  LEAST SQUARES FIT COEFFICIENTS
   0.4150581937463126D 03
   0.1441018506340953D 03
  -0.2699181256328017D 02

   X(I)        Y(I)         ACY(I)        R(I)      PERCENT ERROR
  3.00000    606.00000    604.55843     -1.44157     -0.23788
  2.52000    602.92000    606.56769      3.64769      0.60500
  2.00000    597.37000    594.70864     -2.66136     -0.44551
  1.00000    530.42000    530.87523      0.45523      0.08582

CORRELATION COEFFICIENT =     0.997082      SIG =      2.749170      AVERAGE ERROR=  0.34 PERCENT

PERCENT STANDARD ERROR =  0.47

  LEAST SQUARES FIT COEFFICIENTS
   0.3068463562765985D 03
   0.3346533468263009D 03
  -0.1274636437224856D 03
   0.1538394062058631D 02

   X(I)        Y(I)         ACY(I)        R(I)      PERCENT ERROR
  3.00000    606.00000    606.00000     -0.00000     -0.00000
  2.52000    602.92000    602.92000      0.00000      0.00000
  2.00000    597.37000    597.37000     -0.00000     -0.00000
  1.00000    530.42000    530.42000      0.00000      0.00000

CORRELATION COEFFICIENT =     1.000000      SIG =      0.000000      AVERAGE ERROR=  0.00 PERCENT

PERCENT STANDARD ERROR =  0.00

CORE USAGE      OBJECT CODE=    4480 BYTES,ARRAY AREA=    5680 BYTES,TOTAL AREA AVAILABLE=   59272  BYTES
DIAGNOSTICS       NUMBER OF ERRORS=      0, NUMBER OF WARNINGS=      0, NUMBER OF EXTENSIONS=      0
COMPILE TIME=     1.96 SEC,EXECUTION TIME=     1.06 SEC,  WATFIV - JUL 1973 V1L4      9.50.20   WEDNESDAY    16 JUL 75
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$JOB    WATFIV   XXXXXXXXXX    HARJIT SINGH SETHI.
$ENTRY

   LEAST SQUARES FIT COEFFICIENTS
      0.4824347276142766D 03
      0.2228240450845344D 02

      X(I)         Y(I)        YCY(I)        R(I)      PERCENT ERROR
     2.58000    532.98000    539.92333     6.94333      1.30274
     2.00000    537.97000    526.99954   -10.97046     -2.03923
     1.00000    500.69000    504.71713     4.02713      0.80432

 CORRELATION COEFFICIENT =     0.880009      SIG =     9.611938       AVERAGE ERROR=  1.38 PERCENT

 PERCENT STANDARD ERROR =  1.83
   LEAST SQUARES FIT COEFFICIENTS
      0.4053296857267536D 03
      0.1244004714096690D 03
     -0.2904015713662277D 02

      X(I)         Y(I)        YCY(I)        R(I)      PERCENT ERROR
     2.58000    532.98000    532.98000    -0.00000     -0.00000
     2.00000    537.97000    537.97000     0.00000      0.00000
     1.00000    500.69000    500.69000    -0.00000     -0.00000

 CORRELATION COEFFICIENT =     1.000000      SIG =     0.000000       AVERAGE ERROR=  0.00 PERCENT

 PERCENT STANDARD ERROR =  0.00

 CORE USAGE        OBJECT CODE=     4480 BYTES,ARRAY AREA=     5680 BYTES,TOTAL AREA AVAILABLE=   59272  BYTES

 DIAGNOSTICS         NUMBER OF ERRORS=        0, NUMBER OF WARNINGS=       0, NUMBER OF EXTENSIONS=       0

 COMPILE TIME=     1.69 SEC,EXECUTION TIME=     0.49 SEC,  WATFIV - JUL 1973 V1L4       9.59.58    WEDNESDAY    16 JUL 75
```

```
$JOB    WATFIV  XXXXXXXXXX    HARJIT SINGH SETHI.
SENTRY

   LEAST SQUARES FIT COEFFICIENTS
      0.5022550553120435D 03
      0.2562273011897304D 02

     X(I)         Y(I)         /CY(I)        R(I)      PERCENT ERROR
    2.56000    564.03000    568.49170     4.46170      0.79104
    2.00000    560.68000    553.63052    -7.04948     -1.25731
    1.00000    525.42000    528.00779     2.58779      0.49252

CORRELATION COEFFICIENT =      0.957403       SIG =       6.176513       AVERAGE ERROR=  0.85 PERCENT

PERCENT STANDARD ERROR =  1.12

   LEAST SQUARES FIT COEFFICIENTS
      0.4529383064164044D 03
      0.9174254037535210D 02
     -0.1866084679179689D 02

     X(I)         Y(I)         /CY(I)        R(I)      PERCENT ERROR
    2.56000    564.03000    564.03000    -0.00000     -0.00000
    2.00000    560.66000    560.66000     0.00000      0.00000
    1.00000    525.42000    525.42000    -0.00000     -0.00000

CORRELATION COEFFICIENT =      1.000000       SIG =       0.000000       AVERAGE ERROR=  0.00 PERCENT

PERCENT STANDARD ERROR =  0.00

CORE USAGE      OBJECT CODE=    4460 BYTES,ARRAY AREA=    5680 BYTES,TOTAL AREA AVAILABLE=   59272  BYTES

DIAGNOSTICS       NUMBER OF ERRORS=        0, NUMBER OF WARNINGS=       0, NUMBER OF EXTENSIONS=       0

COMPILE TIME=     2.02 SEC,EXECUTION TIME=      0.51 SEC,  WATFIV - JUL 1973 V1L4       9.59.16     WEDNESDAY    16 JUL 75
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LEAST SQUARES FIT COEFFICIENTS
  0.67337330791229660 01
  0.11236415633937110 01

  X(I)        Y(I)        ACY(I)      R(I)       PERCENT ERROR
  3.32000     12.00000    11.12822    -0.87178   -7.26481
  3.00000     10.33000    10.70466     0.37466    3.62689
  2.58000      9.66000    10.14873     0.48873    5.05930
  2.00000      8.88000     9.38102     0.50102    5.64207
  1.00000      8.55000     8.05737    -0.49263   -5.76170

CORRELATION COEFFICIENT =    0.884696     SIG =     0.638928     AVERAGE ERROR=  5.47 PERCENT

PERCENT STANDARD ERROR =  6.46

LEAST SQUARES FIT COEFFICIENTS
  0.10382081209579030 02
 -0.27290128405372000 01
  0.94655352331835660 00

  X(I)        Y(I)        ACY(I)      R(I)       PERCENT ERROR
  3.32000     12.00000    11.75482    -0.24518   -2.04319
  3.00000     10.33000    10.71381     0.38381    3.71553
  2.58000      9.66000     9.64169    -0.01831   -0.18958
  2.00000      8.88000     8.71013    -0.16987   -1.91295
  1.00000      8.55000     8.59955     0.04955    0.57955

CORRELATION COEFFICIENT =    0.983963     SIG =     0.244476     AVERAGE ERROR=  1.69 PERCENT

PERCENT STANDARD ERROR =  2.47

LEAST SQUARES FIT COEFFICIENTS
  0.53718545441484950 01
  0.58042742577671040 01
 -0.33493764355261370 01
  0.65591469781574610 00

  X(I)        Y(I)        ACY(I)      R(I)       PERCENT ERROR
  3.32000     12.00000    11.92587    -0.07413   -0.61775
  3.00000     10.33000    10.52999     0.19999    1.93603
  2.58000      9.66000     9.47126    -0.18874   -1.95388
  2.00000      8.88000     8.95022     0.07022    0.79073
  1.00000      8.55000     8.54267    -0.00733   -0.08576

CORRELATION COEFFICIENT =    0.994254     SIG =     0.146715     AVERAGE ERROR=  1.08 PERCENT

PERCENT STANDARD ERROR =  1.48

LEAST SQUARES FIT COEFFICIENTS
  0.35309090226806520 02
 -0.59569856863654170 02
  0.44147163436712810 02
 -0.13933039818949920 02
  0.16016420190805750 01

  X(I)        Y(I)        ACY(I)      R(I)       PERCENT ERROR
  3.32000     12.00000    12.00000    -0.00000   -0.00000
  3.00000     10.33000    10.33000    -0.00000    0.00000
  2.58000      9.66000     9.66000    -0.00000   -0.00000
  2.00000      8.88000     8.88000     0.00000    0.00000
  1.00000      8.55000     8.55000    -0.00000   -0.00000

CORRELATION COEFFICIENT =    1.000000     SIG =     0.000000     AVERAGE ERROR=  0.00 PERCENT

PERCENT STANDARD ERROR =  0.00

CORE USAGE      OBJECT CODE=    4480 BYTES,ARRAY AREA=    5680 BYTES,TOTAL AREA AVAILABLE=   59272 BYTES

DIAGNOSTICS        NUMBER OF ERRORS=       0, NUMBER OF WARNINGS=       0, NUMBER OF EXTENSIONS=       0

COMPILE TIME=     1.97 SEC,EXECUTION TIME=     1.71 SEC,  WATFIV - JUL 1973 V1L4     10.09.43    WEDNESDAY    16 JUL 75
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LEAST SQUARES FIT COEFFICIENTS
   0.8082106291706373D 01
   0.1985871306005725D 01

   X(I)       Y(I)        ACY(I)       R(I)      PERCENT ERROR
 3.32000    16.00000    14.68848    -1.31152     -8.19701
 3.00000    13.66000    14.05172     0.39172      2.86764
 2.51000    12.11000    13.21597     1.10597      9.13274
 2.00000    11.55000    12.06185     0.51185      4.43159
 1.00000    10.77000    10.07198    -0.69802     -6.48117
CORRELATION COEFFICIENT =      0.880672     SIG =      0.980553        AVERAGE ERROR=  6.22 PERCENT

PERCENT STANDARD ERROR =  7.65

LEAST SQUARES FIT COEFFICIENTS
   0.1248056845105605D 02
  -0.4118474781672056D 01
   0.1476664123649925D 01

   X(I)       Y(I)        ACY(I)       R(I)      PERCENT ERROR
 3.32000    16.00000    15.63289    -0.36711     -2.29441
 3.00000    13.66000    14.06552     0.40552      2.96868
 2.51000    12.11000    12.45175     0.34175      2.82205
 2.00000    11.55000    11.05068    -0.49932     -4.32316
 1.00000    10.77000    10.88916     0.11916      1.10639
CORRELATION COEFFICIENT =      0.979974     SIG =      0.412168        AVERAGE ERROR=  2.70 PERCENT

PERCENT STANDARD ERROR =  2.22

LEAST SQUARES FIT COEFFICIENTS
   0.2026246869672880 01
   0.1393605745780860 02
  -0.7627792192322140 01
   0.1331697998065509D 01

   X(I)       Y(I)        ACY(I)       R(I)      PERCENT ERROR
 3.32000    16.00000    15.99322    -0.00678     -0.04238
 3.00000    13.66000    13.67829     0.01829      0.13393
 2.58000    12.11000    12.09273    -0.01727     -0.14258
 2.00000    11.55000    11.55642     0.00642      0.05561
 1.00000    10.77000    10.76933    -0.00067     -0.00623
CORRELATION COEFFICIENT =      0.999979     SIG =      0.013421        AVERAGE ERROR=  0.08 PERCENT

PERCENT STANDARD ERROR =  0.10

LEAST SQUARES FIT COEFFICIENTS
   0.5765432991484932D 01
   0.1082790843216660 01
  -0.3277395106715423D 01
   0.4667403472270100-01
   0.1465156274353036D 00

   X(I)       Y(I)        ACY(I)       R(I)      PERCENT ERROR
 3.32000    16.00000    16.00000    -0.00000     -0.00000
 3.00000    13.66000    13.66000     0.00000      0.00000
 2.51000    12.11000    12.11000    -0.00000     -0.00000
 2.00000    11.55000    11.55000     0.00000      0.00000
 1.00000    10.77000    10.77000    -0.00000     -0.00000
CORRELATION COEFFICIENT =      1.000000     SIG =      0.000000        AVERAGE ERROR=  0.00 PERCENT

PERCENT STANDARD ERROR =  0.00
CORE USAGE     OBJECT CODE=    4460 BYTES,ARRAY AREA=    5680 BYTES,TOTAL AREA AVAILABLE=   59272  BYTES
DIAGNOSTICS    NUMBER OF ERRORS=      0, NUMBER OF WARNINGS=      0, NUMBER OF EXTENSIONS=       0
COMPILE TIME=    1.56 SEC,EXECUTION TIME=    1.71 SEC,  WATFIV - JUL 1973 V1L4    10.10.25  WEDNESDAY    16 JUL 75
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LEAST SQUARES FIT COEFFICIENTS
   0.6332687031034937D 01
   0.1927651773712447D 01

   X(I)         Y(I)        ACY(I)       R(I)      PERCENT ERROR
  3.00000     13.22000     12.11504    -1.10436     -8.35369
  2.50000     10.66000     11.30603     0.64603      6.06030
  2.00000      9.00000     10.18799     1.18799     13.19989
  1.00000      8.99000      8.26034    -0.72966     -8.11637

CORRELATION COEFFICIENT =    0.830074     SIG =    1.092503     AVERAGE ERROR=  8.93 PERCENT
PERCENT STANDARD ERROR = 10.44

LEAST SQUARES FIT COEFFICIENTS
   0.1380325283463574D 02
  -0.[illegible]D 01
   0.2157626206522710D 01

   X(I)         Y(I)        ACY(I)       R(I)      PERCENT ERROR
  3.00000     13.22000     13.14438    -0.07562     -0.57203
  2.50000     10.66000     10.82504     0.16504      1.54825
  2.00000      9.00000      8.89048    -0.10952     -1.21692
  1.00000      8.99000      9.01010     0.02010      0.22361

CORRELATION COEFFICIENT =    0.998100     SIG =    0.122960     AVERAGE ERROR=  0.89 PERCENT
PERCENT STANDARD ERROR =  1.17

LEAST SQUARES FIT COEFFICIENTS
   0.[illegible]D 01
   0.1[illegible]D 01
  -0.[illegible]D 01
   0.7140310947555[illegible]D 00

   X(I)         Y(I)        ACY(I)       R(I)      PERCENT ERROR
  3.00000     13.22000     13.22000    -0.00000     -0.00000
  2.50000     10.66000     10.66000     0.00000      0.00000
  2.00000      9.00000      9.00000    -0.00000     -0.00000
  1.00000      8.99000      8.99000     0.00000      0.00000

CORRELATION COEFFICIENT =    1.000000     SIG =    0.000000     AVERAGE ERROR=  0.00 PERCENT
PERCENT STANDARD ERROR =  0.00

CORE USAGE     OBJECT CODE=   4480 BYTES,ARRAY AREA=    5660 BYTES,TOTAL AREA AVAILABLE=   58848  BYTES
DIAGNOSTICS      NUMBER OF ERRORS=      0, NUMBER OF WARNINGS=      0, NUMBER OF EXTENSIONS=      0
COMPILE TIME=    2.02 SEC,EXECUTION TIME=     1.03 SEC,  WATFIV - JUL 1973 V1L4     23.40.57   WEDNESDAY    23 JUL 75
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$JOB     WATFIV  XXXXXXXXXX     HARJIT SINGH SETHI.
SENTRY

  LEAST SQUARES FIT COEFFICIENTS
     0.6425345439365477D 01
     0.2398559799624296D 01

     X(I)         Y(I)         ACY(I)        R(I)       PERCENT ERROR
    2.59000      12.90000     12.61363     -0.28637     -2.21992
    2.00000      10.77000     11.22247      0.45247      4.20116
    1.00000       8.99000      8.82391     -0.16609     -1.84755
CORRELATION COEFFICIENT =       0.979280       SIG =       0.396434       AVERAGE ERROR=  2.76 PERCENT
PERCENT STANDARD ERROR =  3.64
  LEAST SQUARES FIT COEFFICIENTS
    0.9605460497599211D 01
   -0.1813190746358839D 01
    0.1197730248799619D 01

     X(I)         Y(I)         ACY(I)        R(I)       PERCENT ERROR
    2.58000      12.90000     12.90000     -0.00000     -0.00000
    2.00000      10.77000     10.77000      0.00000      0.00000
    1.00000       8.99000      8.99000     -0.00000     -0.00000
CORRELATION COEFFICIENT =       1.000000       SIG =       0.000000       AVERAGE ERROR=  0.00 PERCENT
PERCENT STANDARD ERROR =  0.00
CORE USAGE       OBJECT CODE=    4480 BYTES,ARRAY AREA=    5680 BYTES,TOTAL AREA AVAILABLE=   59272  BYTES
DIAGNOSTICS        NUMBER OF ERRORS=      0, NUMBER OF WARNINGS=      0, NUMBER OF EXTENSIONS=
COMPILE TIME=     1.96 SEC,EXECUTION TIME=     0.51 SEC,  WATFIV - JUL 1973 V1L4     10.00.40    WEDNESDAY    16 JUL 75
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University of Windsor

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$JOB    WATFIV   XXXXXXXXXX   HARJIT SINGH SETHI.
$ENTRY

   LEAST SQUARES FIT COEFFICIENTS
      0.6114620557294925D 01
      0.2949123356293051D 01

      X(I)         Y(I)         ACY(I)        R(I)       PERCENT ERROR
     2.50000     16.00000     15.71337     -0.28663     -1.79144
     2.00000     13.55000     14.00288      0.45288      3.34227
     1.00000     11.22000     11.05375     -0.16625     -1.48169

CORRELATION COEFFICIENT =     0.986125      SIG =      0.396795      AVERAGE ERROR=  2.21 PERCENT

PERCENT STANDARD ERROR =  2.92

   LEAST SQUARES FIT COEFFICIENTS
      0.1128764295067638D 02
     -0.1226464426014609D 01
      0.1198821475338216D 01

      X(I)         Y(I)         ACY(I)        R(I)       PERCENT ERROR
     2.50000     16.00000     16.00000     -0.00000     -0.00000
     2.00000     13.55000     13.55000      0.00000      0.00000
     1.00000     11.22000     11.22000     -0.00000     -0.00000

CORRELATION COEFFICIENT =     1.000000      SIG =      0.000000      AVERAGE ERROR=  0.00 PERCENT

PERCENT STANDARD ERROR =  0.00

CORE USAGE       OBJECT CODE=     4460 BYTES,ARRAY AREA=     5680 BYTES,TOTAL AREA AVAILABLE=    59272  BYTES

DIAGNOSTICS        NUMBER OF ERRORS=        0, NUMBER OF WARNINGS=        0, NUMBER OF EXTENSIONS=       0

COMPILE TIME=     2.02 SEC,EXECUTION TIME=      0.49 SEC,  WATFIV - JUL 1973 V1L4      10.01.08     WEDNESDAY     16 JUL 75
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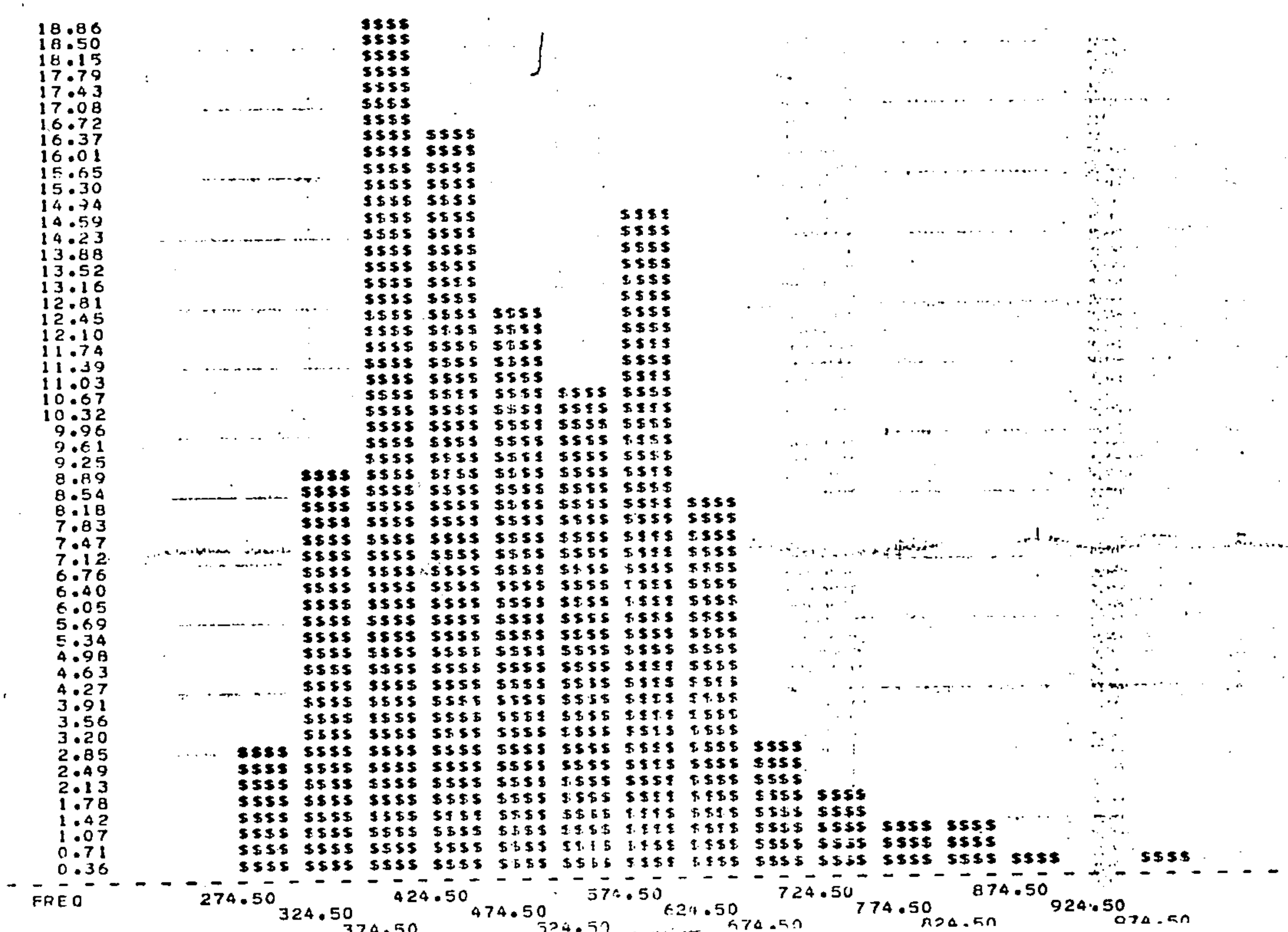
APPENDIX F

1. Histograms and Frequency Distributions Charts for the Pilot Study (24 in number).

2. Histograms and Frequency Distributions Charts for the Major Study (48 in number).

*Each histogram is titled.

HISTOGRAM FOR THE CONDITION FOR SET=3, REACH=1, S.I.=3.32 BITS, R.I.=1.00 BIT.



FREQUENCY DISTRIBUTION FORTHE CONDITION FOR SET=3, REACH=1, S.I.=3.32 BITS, R.I.=1.00 BIT.

MAXIMUM = 988 MINIMUM = 271 RANGE= 717 INTERVAL WIDTH = 50

MEAN = 481.87 IN INTERVAL 5. ST. DVN. = 120.91 MEDIAN = 458.00

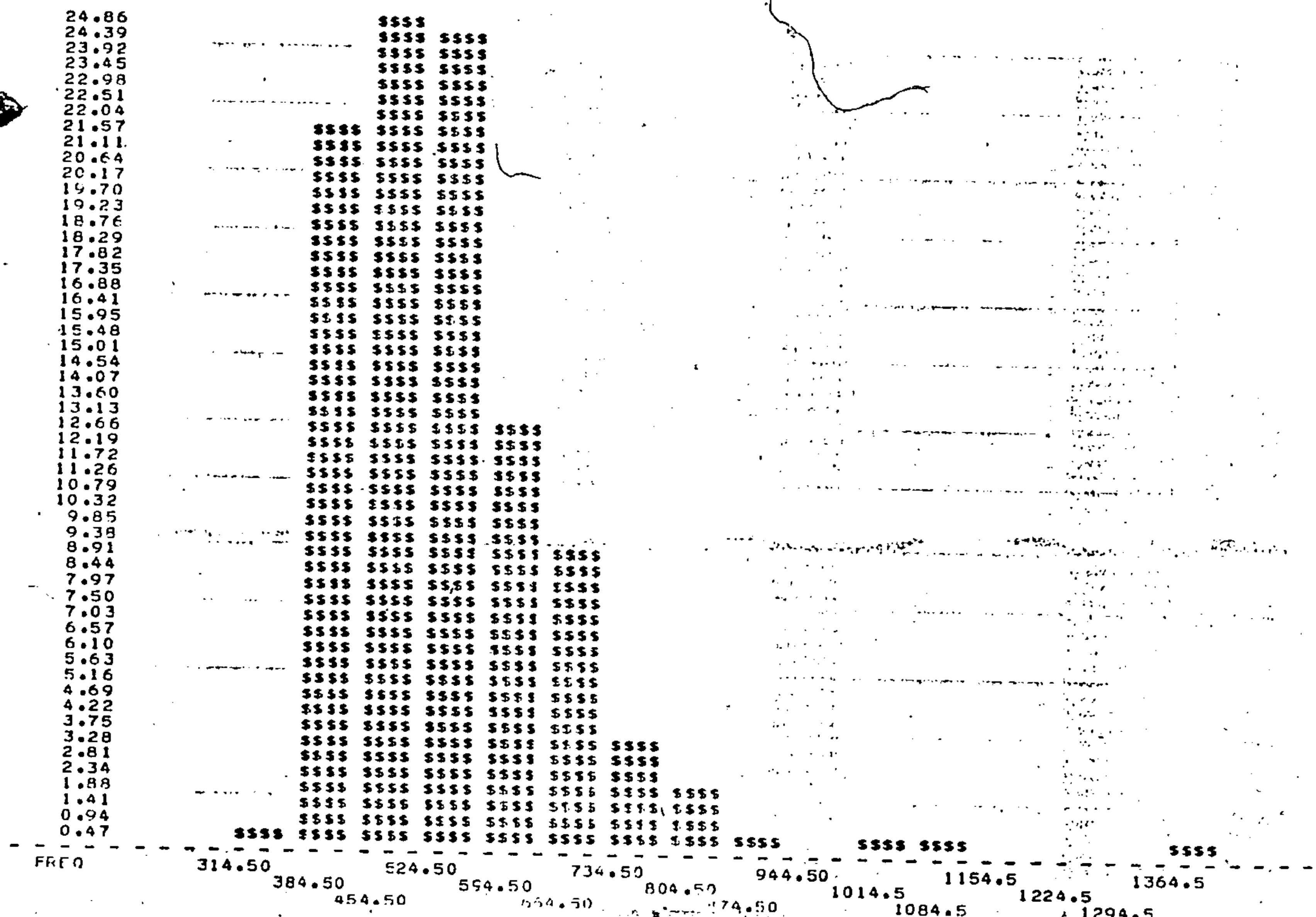
INT. NO.	EXACT LIMITS		MID-POINT	F	FX	D	FD	F*D**2	CUM F	- %
15	950 TO	999	974.50	1	0.29	10	10	100	350	100.00
14	900 TO	949	924.50	0	0.00	9	0	0	349	99.71
13	850 TO	899	874.50	1	0.29	8	8	64	349	99.71
12	800 TO	849	824.50	4	1.14	7	28	196	348	99.43
11	750 TO	799	774.50	4	1.14	6	24	144	344	98.29
10	700 TO	749	724.50	6	1.71	5	30	150	340	97.14
9	650 TO	699	674.50	10	2.86	4	40	160	334	95.43
8	600 TO	649	624.50	29	8.29	3	87	261	324	92.57
7	550 TO	599	574.50	51	14.57	2	102	204	295	84.29
6	500 TO	549	524.50	37	10.57	1	37	37	244	69.71
5	450 TO	499	474.50	43	12.29	0	0	0	207	59.14
4	400 TO	449	424.50	57	16.29	-1	-57	57	164	46.86
3	350 TO	399	374.50	66	18.86	-2	-132	264	107	30.57
2	300 TO	349	324.50	31	8.86	-3	-93	279	41	11.71
1	250 TO	299	274.50	10	2.86	-4	-40	160	10	2.86
						SUMS =	44	2076		

REGROUPED FOR CHISQ TESTS TO GIVE 11 INTERVALS WITHFREQUENCIES OF

10 31 66 57 43 37 51 29 10 10 6

CHISQ NORMAL = 1.6408 CHISQ UNIFORM = 139.09

HISTOGRAM FOR THE CONDITION FOR SET=3, REACH=2, S.I.=3.32 BITS, R.I.=1.00 BIT.



FREQUENCY DISTRIBUTION FORTHE CONDITION FOR SET=3, REACH=2, S.I.=3.32 BITS, R.I.=1.00 BIT.

MAXIMUM = 1375 MINIMUM = 298 RANGE= 1077 INTERVAL WIDTH = 70

MEAN = 519.64 IN INTERVAL 4, ST. DVN. = 131.23 MEDIAN = 497.00

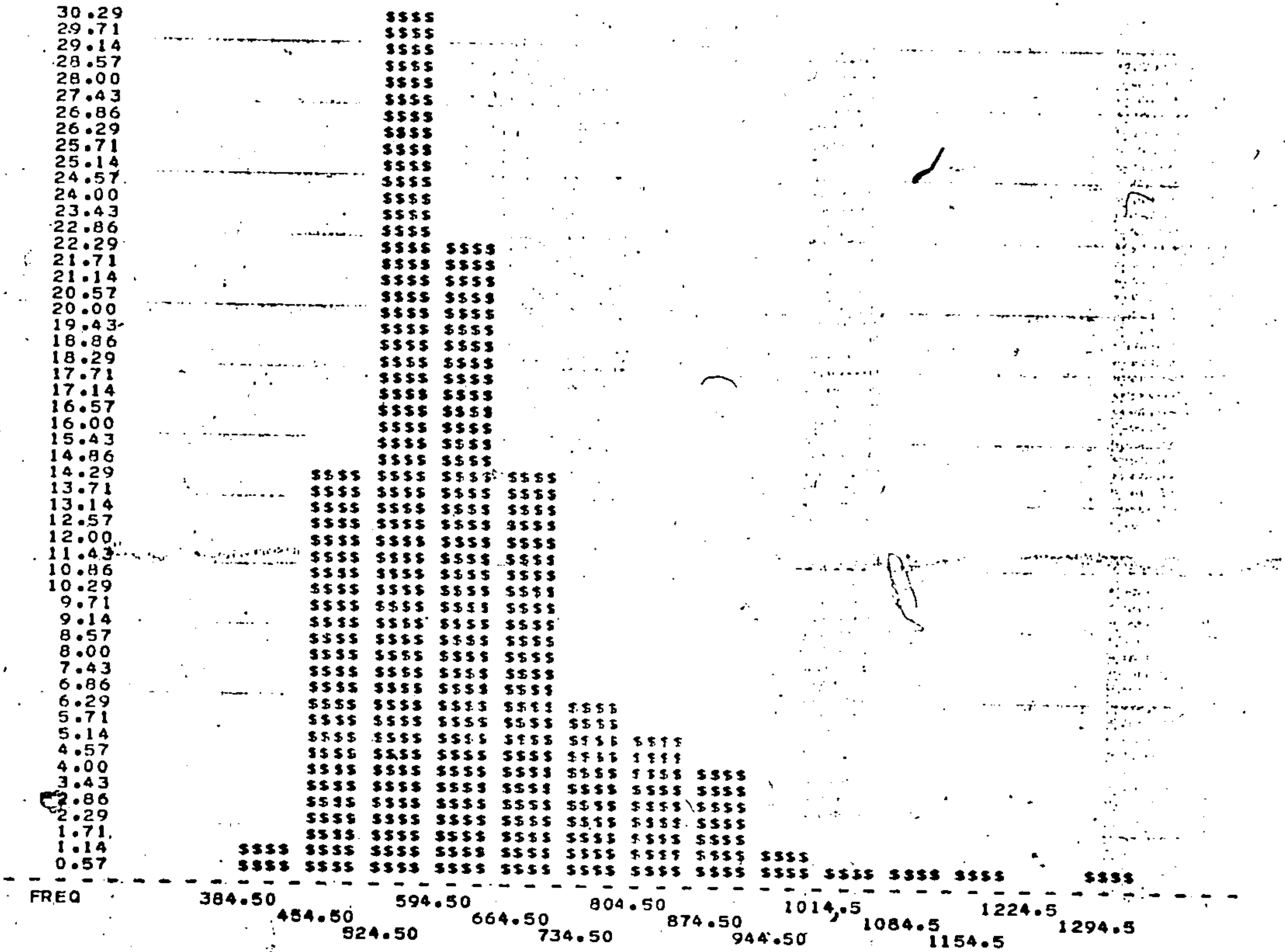
INT. NO.	EXACT LIMITS		MID-POINT	F	FX	D	FD	F*D**2	CUM F	- %
16	1330 TO	1399	1364.5	2	0.57	12	24	288	350	100.00
15	1260 TO	1329	1294.5	0	0.00	11	0	0	348	99.43
14	1190 TO	1259	1224.5	0	0.00	10	0	0	348	99.43
13	1120 TO	1189	1154.5	0	0.00	9	0	0	348	99.43
12	1050 TO	1119	1084.5	2	0.57	8	16	128	348	99.43
11	980 TO	1049	1014.5	1	0.29	7	7	49	346	98.86
10	910 TO	979	944.50	0	0.00	6	0	0	345	98.57
9	840 TO	909	874.50	2	0.57	5	10	50	345	98.57
8	770 TO	839	804.50	6	1.71	4	24	96	343	98.00
7	700 TO	769	734.50	11	3.14	3	33	99	337	96.29
6	630 TO	699	664.50	31	8.86	2	62	124	326	93.14
5	560 TO	629	594.50	44	12.57	1	44	44	295	84.29
4	490 TO	559	524.50	86	24.57	0	0	0	251	71.71
3	420 TO	489	454.50	87	24.86	-1	-87	87	165	47.14
2	350 TO	419	384.50	76	21.71	-2	-152	304	78	22.29
1	280 TO	349	314.50	2	0.57	-3	-6	18	2	0.57
						SUMS =	-25	1287		

REGROUPED FOR CHISQ TESTS TO GIVE 8 INTERVALS WITHFREQUENCIES OF

78 87 86 44 31 11 8 5

CHISQ NORMAL = 428.21 CHISQ UNIFORM = 202.14

HISTOGRAM FOR THE CONDITION FOR SET=3, REACH=1, S.I.=3.32 BITS, R.I.=2.00 BITS.



FREQUENCY DISTRIBUTION FORTHE CONDITION FOR SET=3, REACH=1, S.I.=3.32 BITS, R.I.=2.00 BITS.

MAXIMUM = 1315 MINIMUM = 354 RANGE= 961 INTERVAL WIDTH = 70

MEAN = 602.97 IN INTERVAL 4. ST. DVN. = 135.57 MEDIAN = 571.00

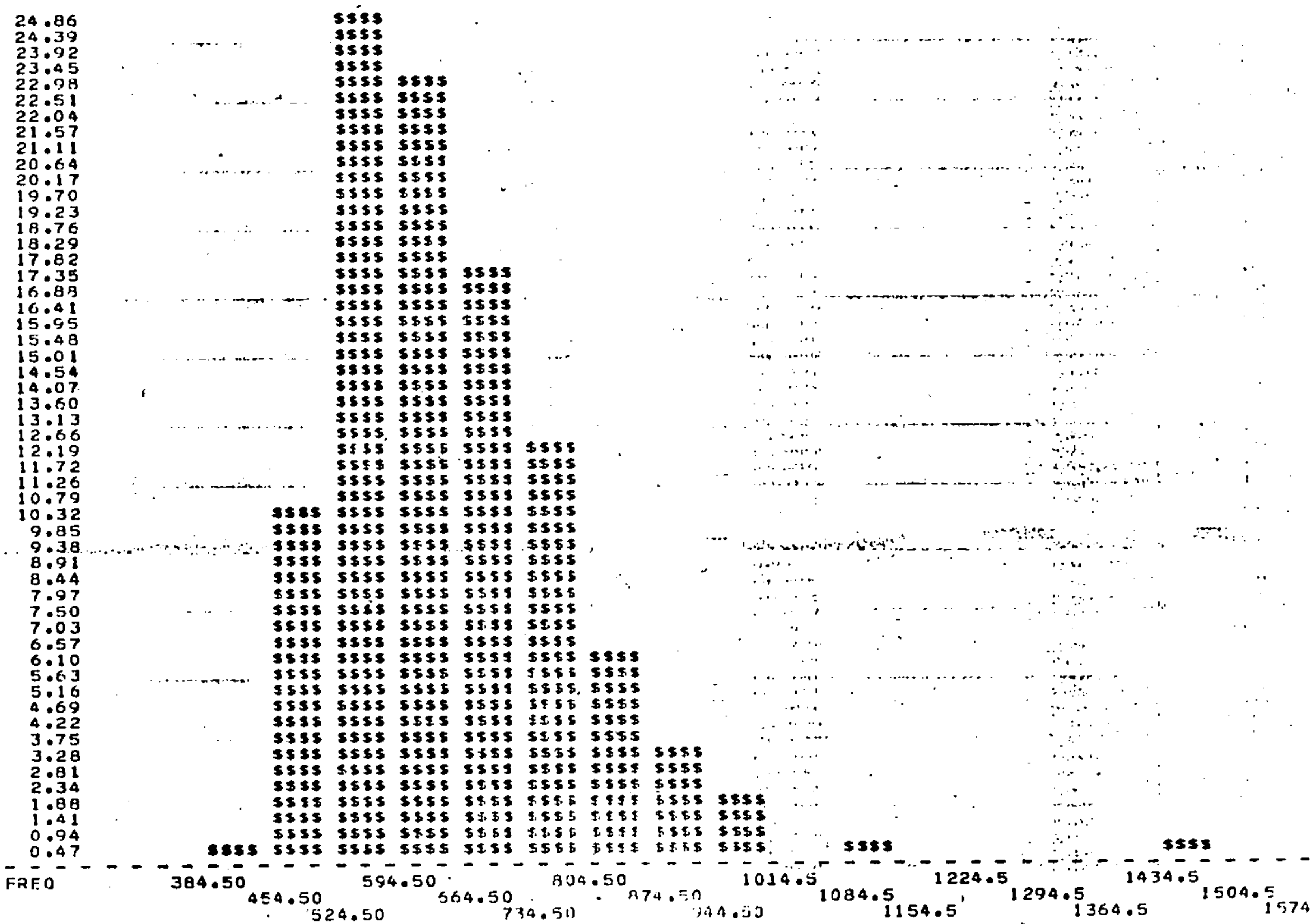
INT. NO.	EXACT LIMITS			MID-POINT	F	FX	D	FD	F*D**2	CUM F	- %
14	1260	TO	1329	1294.5	2	0.57	10	20	200	350	100.00
13	1190	TO	1259	1224.5	0	0.00	9	0	0	348	99.43
12	1120	TO	1189	1154.5	1	0.29	8	8	64	348	99.43
11	1050	TO	1119	1084.5	1	0.29	7	7	49	347	99.14
10	980	TO	1049	1014.5	2	0.57	6	12	72	346	98.86
9	910	TO	979	944.50	3	0.86	5	15	75	344	98.29
8	840	TO	909	874.50	14	4.00	4	56	224	341	97.43
7	770	TO	839	804.50	18	5.14	3	54	162	327	93.43
6	700	TO	769	734.50	22	6.29	2	44	88	309	88.29
5	630	TO	699	664.50	50	14.29	1	50	50	287	82.00
4	560	TO	629	594.50	77	22.00	0	0	0	237	67.71
3	490	TO	559	524.50	106	30.29	-1	-106	106	160	45.71
2	420	TO	489	454.50	50	14.29	-2	-100	200	54	15.43
1	350	TO	419	384.50	4	1.14	-3	-12	36	4	1.14
							SUMS =	48	1326		

REGROUPED FOR CHISQ TESTS TO GIVE 8 INTERVALS WITHFREQUENCIES OF

54 106 77 50 22 18 17 6

CHISQ NORMAL = 5.8580 CHISQ UNIFORM = 192.03

HISTOGRAM FOR THE CONDITION FOR SET=3, REACH=2, S.I.=3.32 BITS, R.I.=2.00 BITS.



FREQUENCY DISTRIBUTION FORTHE CONDITION FOR SET=3. REACH=2. S.I.=3.32 BITS, R.I.=2.00 BITS.

MAXIMUM = 1689 MINIMUM = 407 RANGE= 1282 INTERVAL WIDTH = 70

MEAN = 625.58 IN INTERVAL 4, ST. DVN. = 136.29 MEDIAN = 600.00

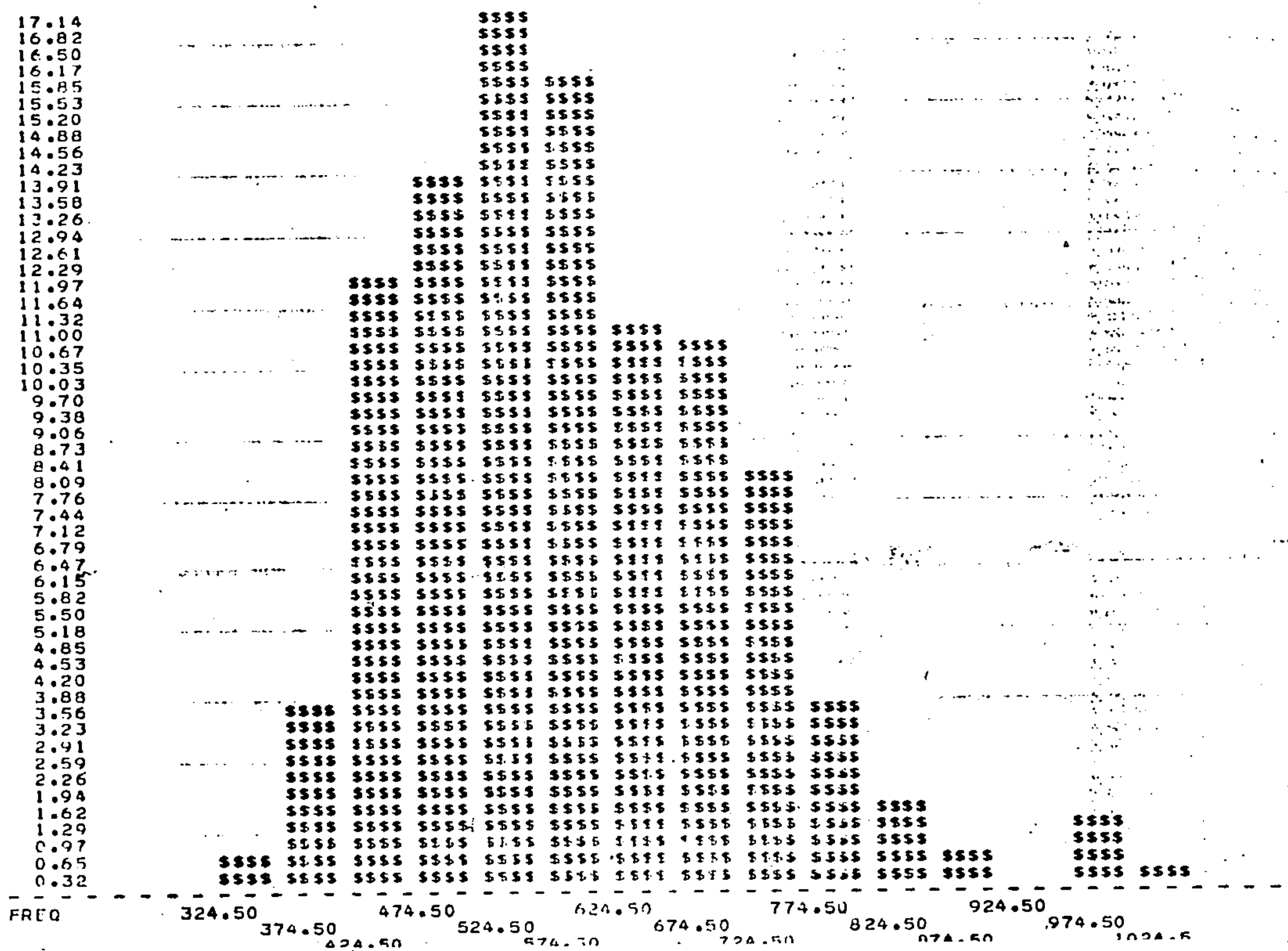
INT. NO.	EXACT LIMITS	MID-POINT	F	FX	D	FD	F*D**2	CUM F	- %
20	1680 TO 1749	1714.5	1	0.29	16	16	256	350	100.00
19	1610 TO 1679	1644.5	0	0.00	15	0	0	349	99.71
18	1540 TO 1609	1574.5	0	0.00	14	0	0	349	99.71
17	1470 TO 1539	1504.5	0	0.00	13	0	0	349	99.71
16	1400 TO 1469	1434.5	1	0.29	12	12	144	349	99.71
15	1330 TO 1399	1364.5	0	0.00	11	0	0	348	99.43
14	1260 TO 1329	1294.5	0	0.00	10	0	0	348	99.43
13	1190 TO 1259	1224.5	0	0.00	9	0	0	348	99.43
12	1120 TO 1189	1154.5	0	0.00	8	0	0	348	99.43
11	1050 TO 1119	1084.5	1	0.29	7	7	49	348	99.43
10	980 TO 1049	1014.5	0	0.00	6	0	0	347	99.14
9	910 TO 979	944.50	6	1.71	5	30	150	347	99.14
8	840 TO 909	874.50	11	3.14	4	44	176	341	97.43
7	770 TO 839	804.50	22	6.29	3	66	198	330	94.29
6	700 TO 769	734.50	42	12.00	2	84	168	308	88.00
5	630 TO 699	664.50	61	17.43	1	61	61	266	76.00
4	560 TO 629	594.50	81	23.14	0	0	0	205	58.57
3	490 TO 559	524.50	87	24.86	-1	-87	87	124	35.43
2	420 TO 489	454.50	36	10.29	-2	-72	144	37	10.57
1	350 TO 419	384.50	1	0.29	-3	-3	9	1	0.29
					SUMS =	156	1442		

REGROUPED FOR CHISQ TESTS TO GIVE 8 INTERVALS WITHFREQUENCIES OF

37 87 81 61 42 22 11 9

CHISQ NORMAL = 2.2626 CHISQ UNIFORM = 145.31

HISTOGRAM FOR THE CONDITION FOR SET=2, REACH=1, S.I.=3.00 BITS, R.I.=2.00 BITS.



FREQUENCY DISTRIBUTION FORTHE CONDITION FOR SET=2, REACH=1, S.I.=3.00 BITS, R.I.=2.00 BITS.

MAXIMUM = 1023 MINIMUM = 315 RANGE= 708 INTERVAL WIDTH = 50

MEAN = 573.09 IN INTERVAL 6. ST. DVN. = 121.15 MEDIAN = 555.50

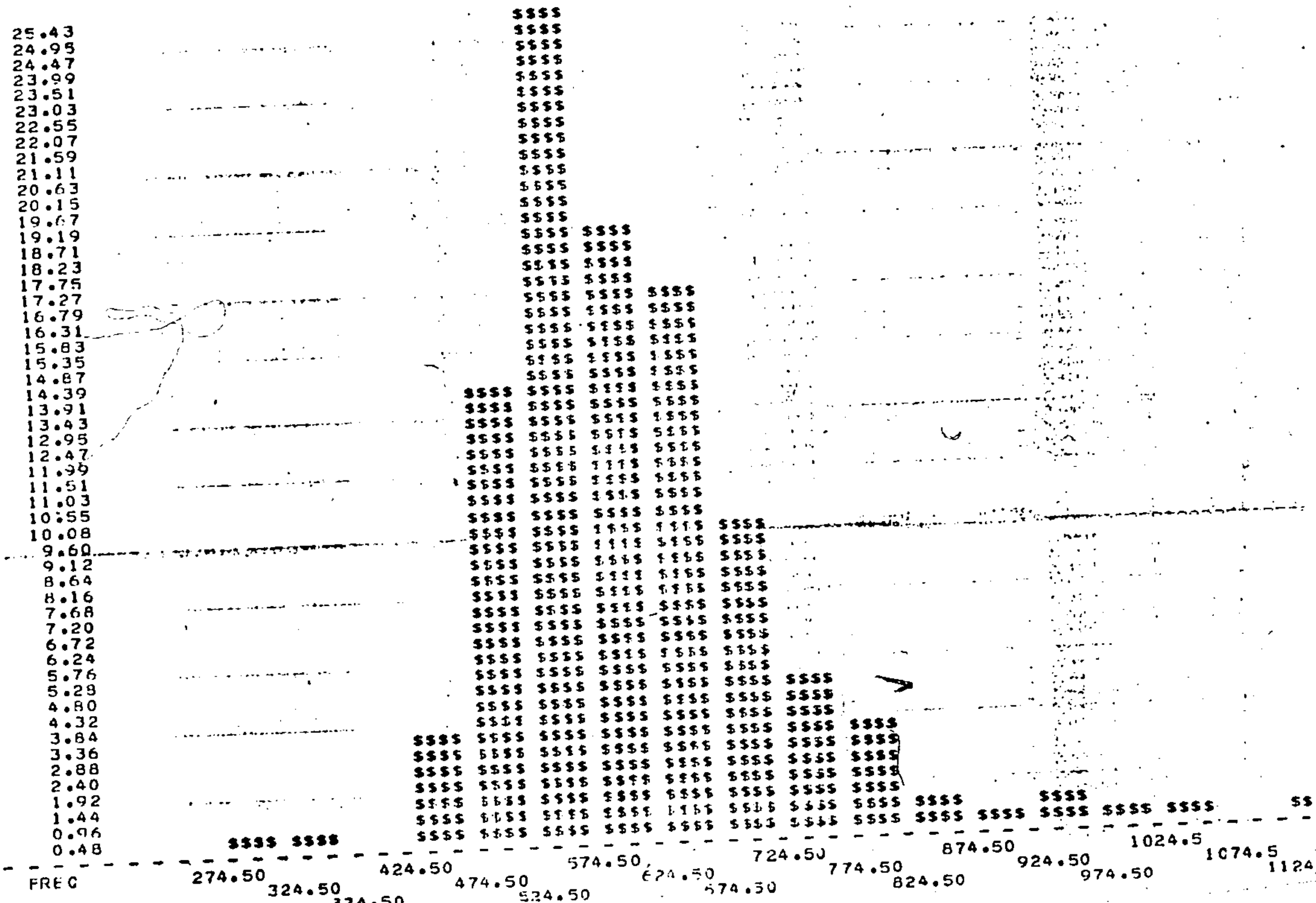
INT. NO.	EXACT LIMITS		MID-POINT	F	FX	D	FD	F*D**2	CUM F	- %
15	1000 TO	1049	1024.5	1	0.29	9	9	81	350	100.00
14	950 TO	999	974.50	4	1.14	8	32	256	349	99.71
13	900 TO	949	924.50	0	0.00	7	0	0	345	98.57
12	850 TO	899	874.50	2	0.57	6	12	72	345	98.57
11	800 TO	849	824.50	6	1.71	5	30	150	343	98.00
10	750 TO	799	774.50	12	3.43	4	48	192	337	96.29
9	700 TO	749	724.50	28	8.00	3	84	252	325	92.86
8	650 TO	699	674.50	37	10.57	2	74	148	297	84.86
7	600 TO	649	624.50	38	10.86	1	38	38	260	74.29
6	550 TO	599	574.50	56	16.00	0	0	0	222	63.43
5	500 TO	549	524.50	60	17.14	-1	-60	60	166	47.43
4	450 TO	499	474.50	49	14.00	-2	-98	196	106	30.29
3	400 TO	449	424.50	42	12.00	-3	-126	378	57	16.29
2	350 TO	399	374.50	13	3.71	-4	-52	208	15	4.29
1	300 TO	349	324.50	2	0.57	-5	-10	50	2	0.57
						SUMS =	-19	2081		

REGROUPED FOR CHISQ TESTS TO GIVE 11 INTERVALS WITHFREQUENCIES OF

15 42 49 60 56 38 37 28 12 8 5

CHISQ NORMAL = 1.1237 CHISQ UNIFORM = 120.05

HISTOGRAM FOR THE CONDITION FOR SET=2, REACH=2, S.I.=3.00 BITS, R.I.=2.00 BITS.



FREQUENCY DISTRIBUTION FORTHE CONDITION FOR SET=2, REACH=2, S.I.=3.00 BITS, R.I.=2.00 BITS.

MAXIMUM = 1115 MINIMUM = 284 RANGE= 831 INTERVAL WIDTH = 50

MEAN = 585.21 IN INTERVAL 7. ST. DVN. = 107.23 MEDIAN = 566.50

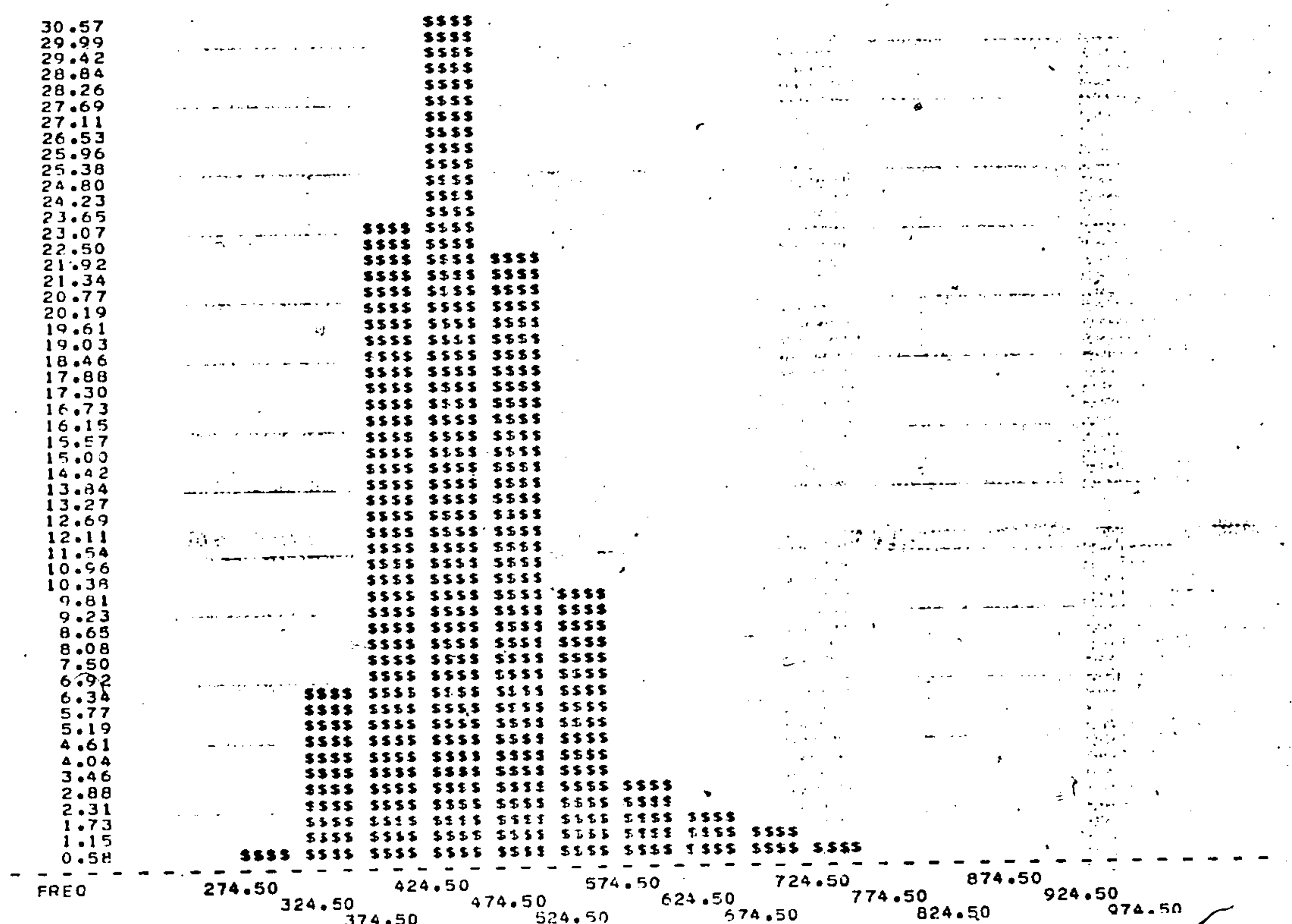
INT. NO.	EXACT LIMITS		MID-POINT	F	F%	D	FD	F*D**2	CUM F	- %
18	1100 TO	1149	1124.5	1	0.29	11	11	121	350	100.00
17	1050 TO	1099	1074.5	0	0.00	10	0	0	349	99.71
16	1000 TO	1049	1024.5	1	0.29	9	9	81	349	99.71
15	950 TO	999	974.50	2	0.57	8	16	128	348	99.43
14	900 TO	949	924.50	3	0.86	7	21	147	346	98.86
13	850 TO	899	874.50	2	0.57	6	12	72	343	98.00
12	800 TO	849	824.50	4	1.14	5	20	100	341	97.43
11	750 TO	799	774.50	12	3.43	4	48	192	337	96.29
10	700 TO	749	724.50	17	4.86	3	51	153	325	92.86
9	650 TO	699	674.50	33	9.43	2	66	132	308	88.00
8	600 TO	649	624.50	58	16.57	1	58	58	275	78.57
7	550 TO	599	574.50	66	18.86	0	0	0	217	62.00
6	500 TO	549	524.50	89	25.43	-1	-89	89	151	43.14
5	450 TO	499	474.50	48	13.71	-2	-96	192	62	17.71
4	400 TO	449	424.50	12	3.43	-3	-36	108	14	4.00
3	350 TO	399	374.50	0	0.00	-4	0	0	2	0.57
2	300 TO	349	324.50	1	0.29	-5	-5	25	2	0.57
1	250 TO	299	274.50	1	0.29	-6	-6	36	1	0.29
						SUMS =	80	1634		

REGROUPED FOR CHISQ TESTS TO GIVE 10 INTERVALS WITHFREQUENCIES OF

14 48 89 66 58 33 17 12 6 7

CHISQ NORMAL = 5.1634 CHISQ UNIFORM = 214.23

HISTOGRAM FOR THE CONDITION FOR SET=2, REACH=1, S.I.=3.00 BITS, R.I.=1.00 BIT.



FREQUENCY DISTRIBUTION FORTHE CONDITION FOR SET=2, REACH=1, S.I.=3.00 BITS, R.I.=1.00 BIT.

MAXIMUM = 995 MINIMUM = 293 RANGE= 702 INTERVAL WIDTH = 50

MEAN = 443.95 IN INTERVAL 4. ST. DVN. = 86.494 MEDIAN = 430.50

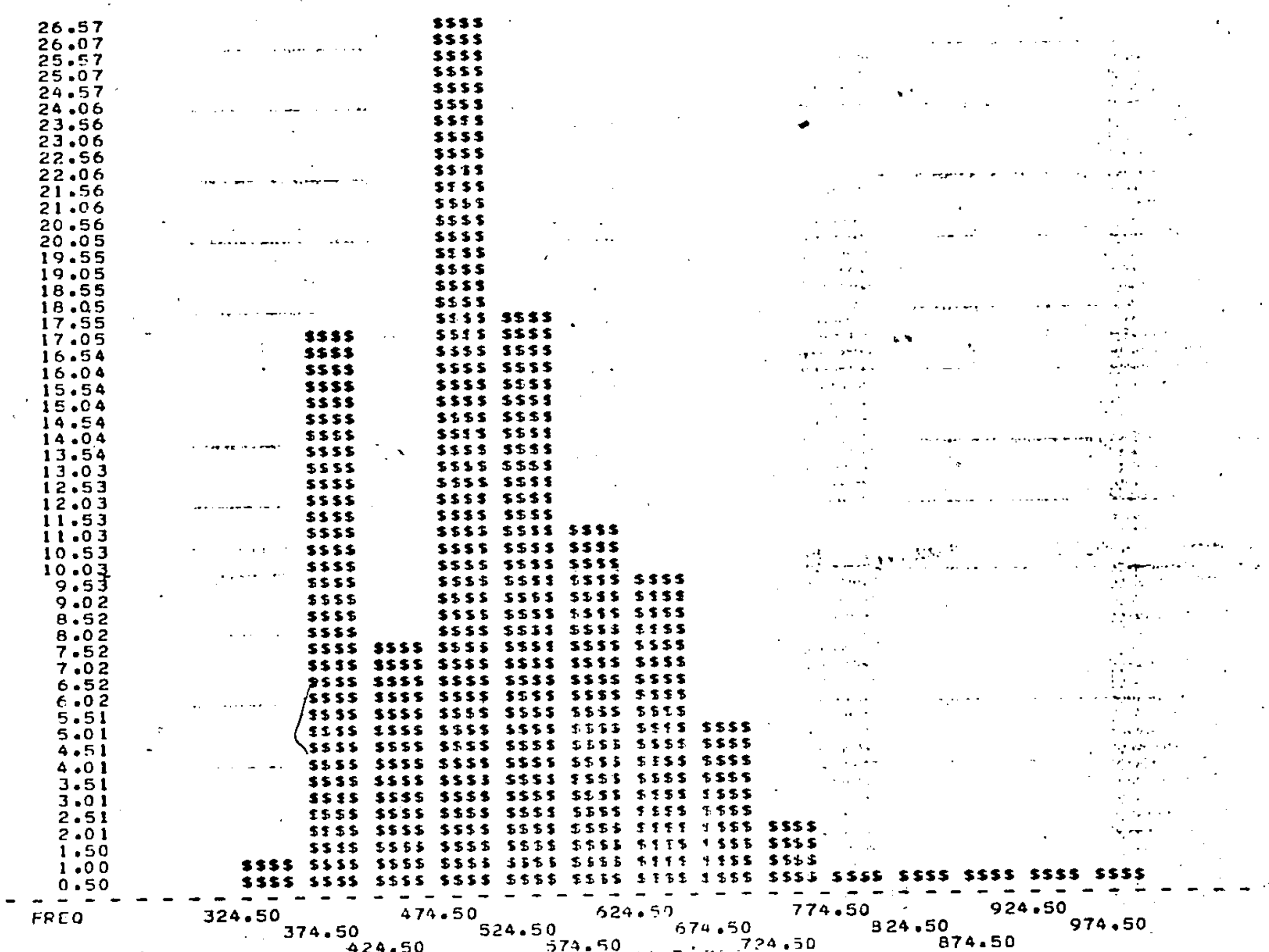
INT. NO.	EXACT LIMITS		MID-POINT	F	FX	D	FD	F*D**2	CUM F	- X
15	950 TO	999	974.50	1	0.29	11	11	121	350	100.00
14	900 TO	949	924.50	0	0.00	10	0	0	349	99.71
13	850 TO	899	874.50	1	0.29	9	9	81	349	99.71
12	800 TO	849	824.50	1	0.29	8	8	64	348	99.43
11	750 TO	799	774.50	1	0.29	7	7	49	347	99.14
10	700 TO	749	724.50	3	0.86	6	18	108	346	98.86
9	650 TO	699	674.50	4	1.14	5	20	100	343	98.00
8	600 TO	649	624.50	6	1.71	4	24	96	339	96.86
7	550 TO	599	574.50	11	3.14	3	33	99	333	95.14
6	500 TO	549	524.50	34	9.71	2	68	136	322	92.00
5	450 TO	499	474.50	76	21.71	1	76	76	288	82.29
4	400 TO	449	424.50	107	30.57	0	0	0	212	60.57
3	350 TO	399	374.50	81	23.14	-1	-81	81	105	30.00
2	300 TO	349	324.50	22	6.29	-2	-44	88	24	6.86
1	250 TO	299	274.50	2	0.57	-3	-6	18	2	0.57
						SUMS =	143	1117		

REGROUPED FOR CHISQ TESTS TO GIVE 8 INTERVALS WITHFREQUENCIES OF

24 81 107 76 34 11 10 7

CHISQ NORMAL = 12.492 CHISQ UNIFORM = 239.44

HISTOGRAM FOR THE CONDITION FOR SET=2, REACH=2, S.I.=3.00 BITS, R.I.=1.00 BIT.



FREQUENCY DISTRIBUTION FORTHE CONDITION FOR SET=2, REACH=2, S.I.=3.00 BITS, R.I.=1.00 BIT.

MAXIMUM = 998 MINIMUM = 339 RANGE= 659 INTERVAL WIDTH = 50

MEAN = 511.76 IN INTERVAL 5. ST. DVN. = 107.31 MEDIAN = 495.00

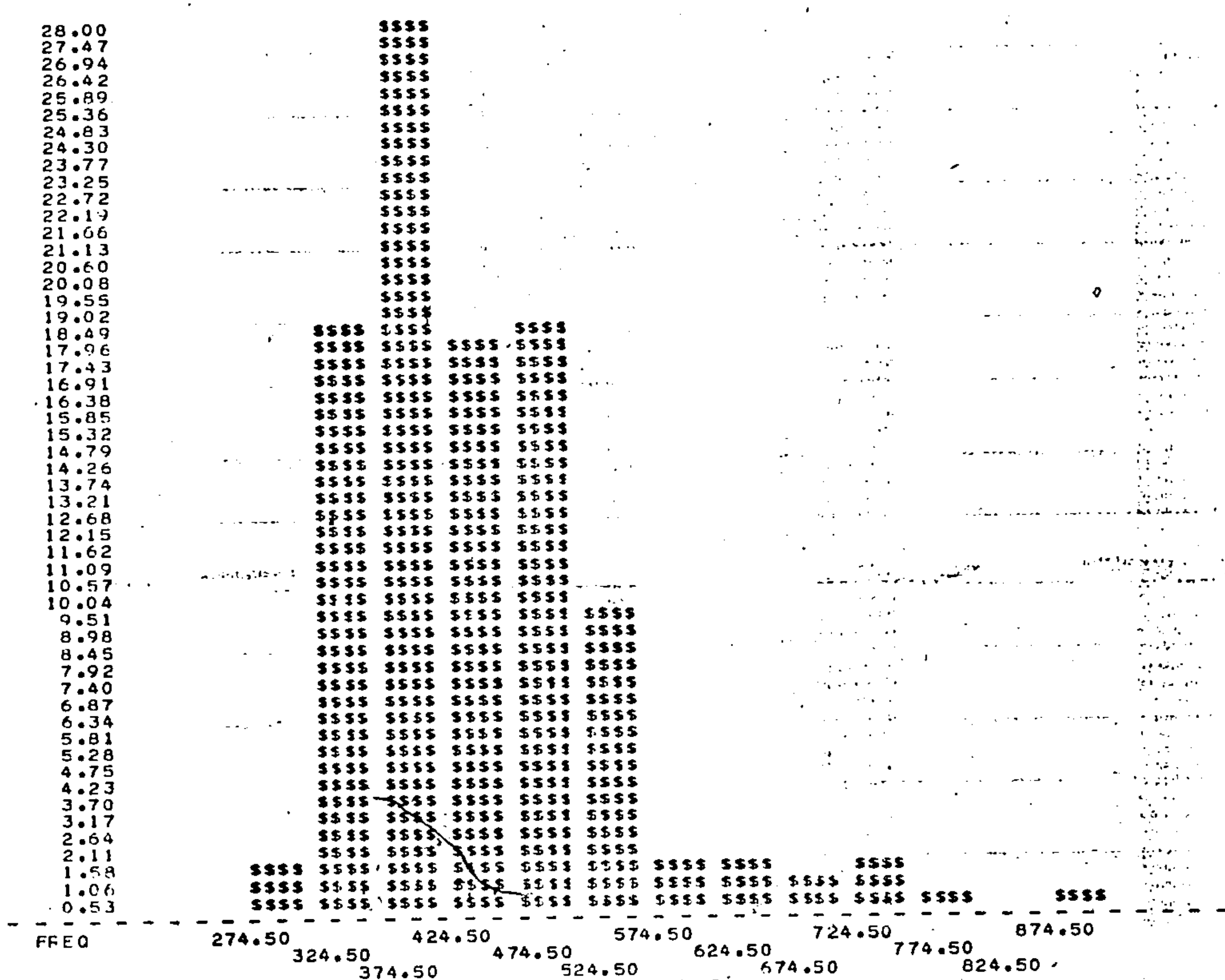
INT. NO.	EXACT LIMITS	MID-POINT	F	F%	D	FD	F*D**2	CUM F	- %
14	950 TO 999	974.50	1	0.29	9	9	81	350	100.00
13	900 TO 949	924.50	2	0.57	8	16	128	349	99.71
12	850 TO 899	874.50	2	0.57	7	14	98	347	99.14
11	800 TO 849	824.50	2	0.57	6	12	72	345	98.57
10	750 TO 799	774.50	2	0.57	5	10	50	343	98.00
9	700 TO 749	724.50	7	2.00	4	28	112	341	97.43
8	650 TO 699	674.50	17	4.86	3	51	153	334	95.43
7	600 TO 649	624.50	34	9.71	2	68	136	317	90.57
6	550 TO 599	574.50	38	10.86	1	38	38	283	80.86
5	500 TO 549	524.50	62	17.71	0	0	0	245	70.00
4	450 TO 499	474.50	93	26.57	-1	-93	93	183	52.29
3	400 TO 449	424.50	27	7.71	-2	-54	108	90	25.71
2	350 TO 399	374.50	60	17.14	-3	-180	540	63	18.00
1	300 TO 349	324.50	3	0.86	-4	-12	48	3	0.86
					SUMS =	-93	1657		

REGROUPED FOR CHISQ TESTS TO GIVE 9 INTERVALS WITHFREQUENCIES OF

63 27 93 62 38 34 17 11 5

CHISQ NORMAL = 5.0638 CHISQ UNIFORM = 170.10

HISTOGRAM FOR THE CONDITION FOR SET=1, REACH=1, S.I.= 2.58 BITS, R.I.=1.00 BIT.



FREQUENCY DISTRIBUTION FORTHE CONDITION FOR SET=1, REACH=1, S.I.= 2.58 BITS, R.I.=1.00 BIT.

MAXIMUM = 871 MINIMUM = 270 RANGE= 601 INTERVAL WIDTH = 50

MEAN = 423.65 IN INTERVAL 4. ST. DVN. = 90.805 MEDIAN = 404.00

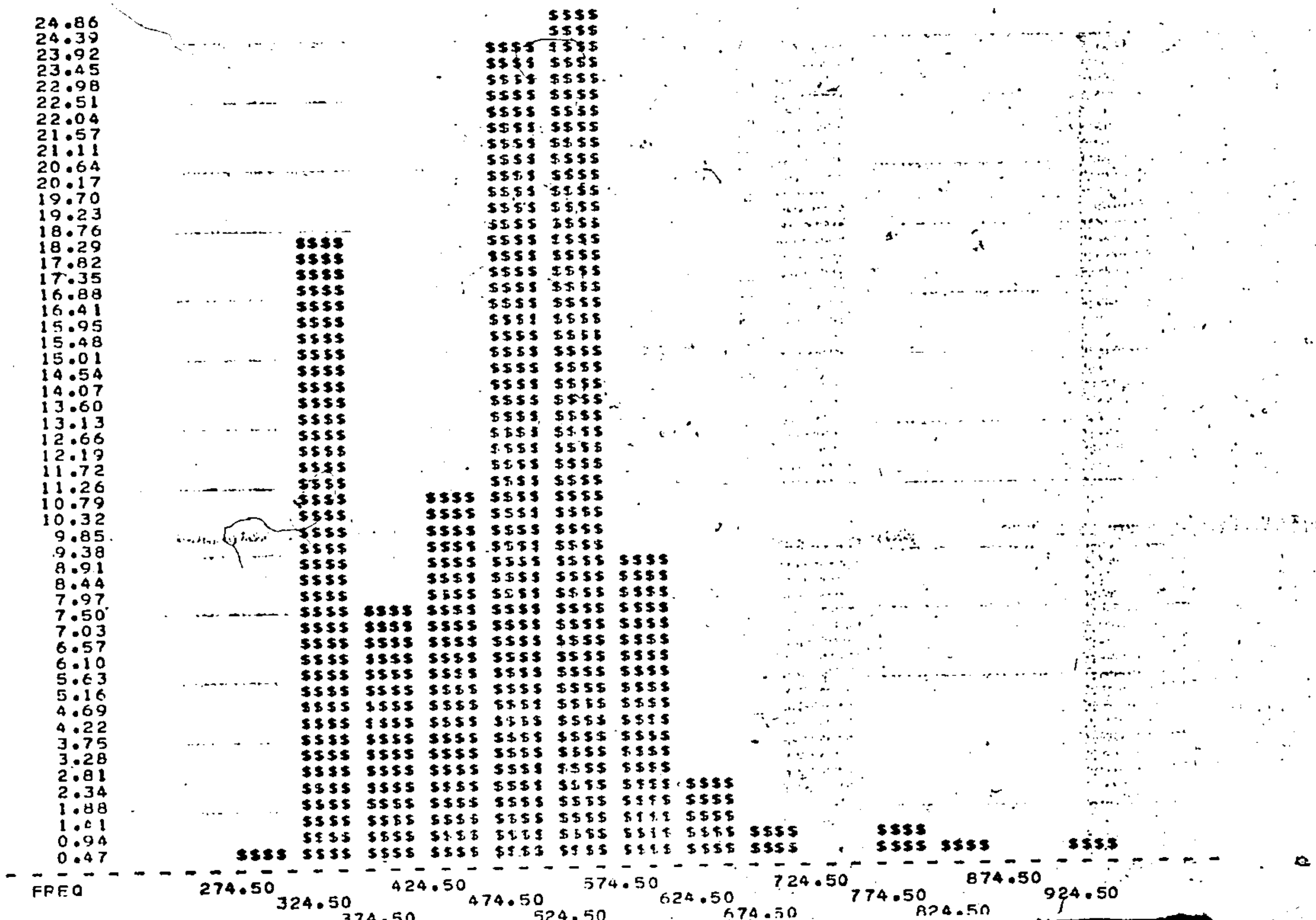
INT. NO.	EXACT LIMITS			MID-POINT	F	FX	D	FD	F*D**2	CUM F	- %
13	850	TO	899	874.50	1	0.29	9	9	81	350	100.00
12	800	TO	849	824.50	0	0.00	8	0	0	349	99.71
11	750	TO	799	774.50	2	0.57	7	14	98	349	99.71
10	700	TO	749	724.50	5	1.43	6	30	180	347	99.14
9	650	TO	699	674.50	3	0.86	5	15	75	342	97.71
8	600	TO	649	624.50	5	1.43	4	20	80	339	96.86
7	550	TO	599	574.50	6	1.71	3	18	54	334	95.43
6	500	TO	549	524.50	34	9.71	2	68	136	328	93.71
5	450	TO	499	474.50	64	18.29	1	64	64	294	84.00
4	400	TO	449	424.50	63	18.00	0	0	0	230	65.71
3	350	TO	399	374.50	98	28.00	-1	-98	98	167	47.71
2	300	TO	349	324.50	64	18.29	-2	-128	256	69	19.71
1	250	TO	299	274.50	5	1.43	-3	-15	45	5	1.43
							SUMS =	-3	1167		

REGROUPED FOR CHISQ TESTS TO GIVE 9 INTERVALS WITHFREQUENCIES OF

5 64 98 63 64 34 6 8 8

CHISQ NORMAL = 6.0257 CHISQ UNIFORM = 244.26

HISTOGRAM FOR THE CONDITION FOR SET=1, REACH=2, S.I.=2.58 BITS, R.I.=1.00 BIT.



FREQUENCY DISTRIBUTION FORTHE CONDITION FOR SET=1, REACH=2, S.I.=2.58 BITS, R.I.=1.00 BIT.

MAXIMUM = 907 MINIMUM = 259 RANGE= 648 INTERVAL WIDTH = 50

MEAN = 466.63 IN INTERVAL 5. ST. DVN. = 96.675 MEDIAN = 477.50

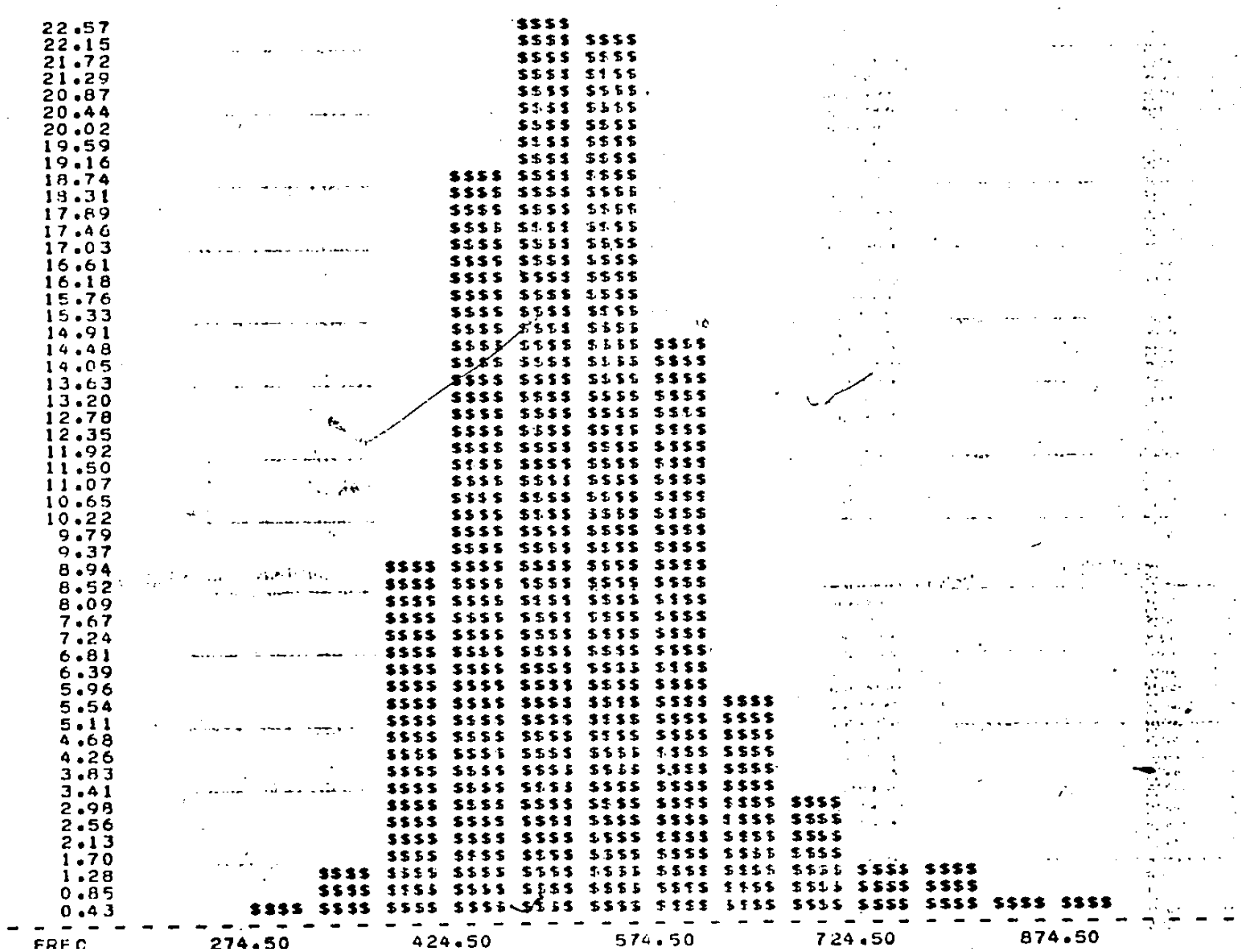
INT. NO.	EXACT LIMITS			MID-POINT	F	FX	D	FD	F*D**2	CUM F	- %
14	900	TO	949	924.50	1	0.29	9	9	81	350	100.00
13	850	TO	899	874.50	0	0.00	8	0	0	349	99.71
12	800	TO	849	824.50	1	0.29	7	7	49	349	99.71
11	750	TO	799	774.50	4	1.14	6	24	144	348	99.43
10	700	TO	749	724.50	0	0.00	5	0	0	344	98.29
9	650	TO	699	674.50	4	1.14	4	16	64	344	98.29
8	600	TO	649	624.50	8	2.29	3	24	72	340	97.14
7	550	TO	599	574.50	31	8.86	2	62	124	332	94.86
6	500	TO	549	524.50	87	24.86	1	87	87	301	86.00
5	450	TO	499	474.50	84	24.00	0	0	0	214	61.14
4	400	TO	449	424.50	37	10.57	-1	-37	37	130	37.14
3	350	TO	399	374.50	27	7.71	-2	-54	108	93	26.57
2	300	TO	349	324.50	64	18.29	-3	-192	576	66	18.86
1	250	TO	299	274.50	2	0.57	-4	-8	32	2	0.57
							SUMS =	-62	1374		

REGROUPEC FOR CHISQ TESTS TO GIVE 8 INTERVALS WITHFREQUENCIES OF

66 27 37 84 87 31 12 6

CHISQ NORMAL = 1.4238 CHISQ UNIFORM = 157.89

HISTOGRAM FOR THE CONDITION FOR SET=1, REACH=1, S.I.= 2.58 BITS, R.I.=2.00 BITS.



FREQUENCY DISTRIBUTION FORTHE CONDITION FOR SET=1, REACH=1, S.I.= 2.58 BITS. R.I.=2.00 BITS.

MAXIMUM = 862 MINIMUM = 287 RANGE= 575 INTERVAL WIDTH = 50

MEAN = 503.26 IN INTERVAL 6. ST. DVN. = 90.476 MEDIAN = 493.50

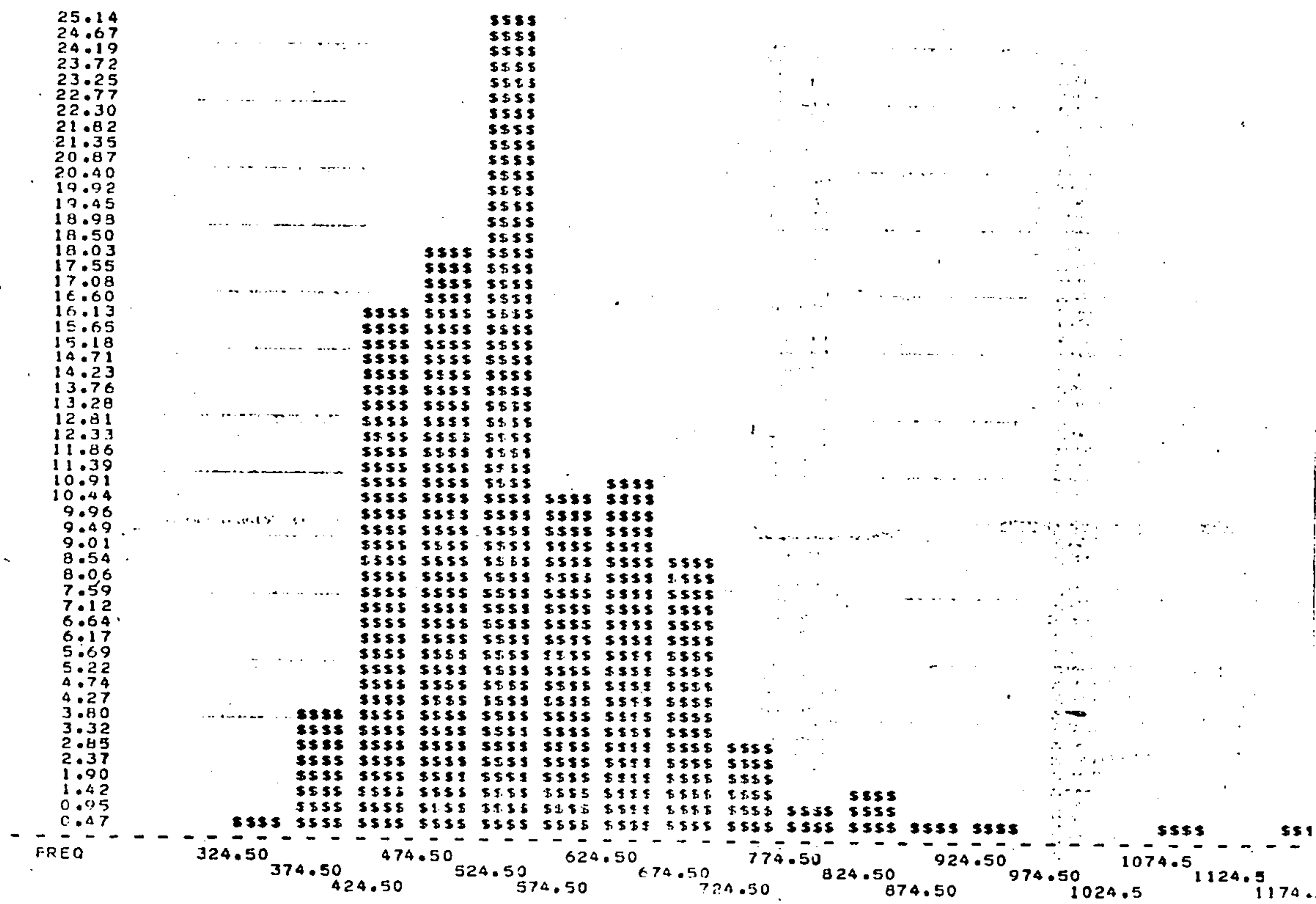
INT. NO.	EXACT LIMITS		MID-POINT	F	FX	D	FD	F*D**2	CUM F	%
13	850 TO	899	874.50	1	0.29	7	7	49	350	100.00
12	800 TO	849	824.50	2	0.57	6	12	72	349	99.71
11	750 TO	799	774.50	4	1.14	5	20	100	347	99.14
10	700 TO	749	724.50	4	1.14	4	16	64	343	98.00
9	650 TO	699	674.50	11	3.14	3	33	99	339	96.86
8	600 TO	649	624.50	19	5.43	2	38	76	328	93.71
7	550 TO	599	574.50	51	14.57	1	51	51	309	88.29
6	500 TO	549	524.50	78	22.29	0	0	0	258	73.71
5	450 TO	499	474.50	79	22.57	-1	-79	79	180	51.43
4	400 TO	449	424.50	65	18.57	-2	-130	260	101	28.86
3	350 TO	399	374.50	31	8.86	-3	-93	279	36	10.29
2	300 TO	349	324.50	4	1.14	-4	-16	64	5	1.43
1	250 TO	299	274.50	1	0.29	-5	-5	25	1	0.29
						SUMS =	-146	1218		

REGROUPED FOR CHISQ TESTS TO GIVE 9 INTERVALS WITHFREQUENCIES OF

5 31 65 79 78 51 19 15 7

CHISQ NORMAL = 0.75783 CHISQ UNIFORM = 184.14

HISTOGRAM FOR THE CONDITION FOR SET=1, REACH=2, S.I.=2.58 BITS, R.I.=2.00 BITS.



FREQUENCY DISTRIBUTION FORTHE CONDITION FOR SET=1, REACH=2, S.I.=2.58 BITS, R.I.=2.00 BITS.

MAXIMUM = 1187 MINIMUM = 335 RANGE= 852 INTERVAL WIDTH = 50

MEAN = 540.61 IN INTERVAL 5, ST. DVN. = 110.61 MEDIAN = 522.50

INT. NO.	EXACT LIMITS		MID-POINT	F	FX	D	FD	F*D**2	CUM F	- %
18	1150 TO	1199	1174.5	1	0.29	13	13	169	350	100.00
17	1100 TO	1149	1124.5	0	0.00	12	0	0	349	99.71
16	1050 TO	1099	1074.5	1	0.29	11	11	121	349	99.71
15	1000 TO	1049	1024.5	0	0.00	10	0	0	348	99.43
14	950 TO	999	974.50	0	0.00	9	0	0	348	99.43
13	900 TO	949	924.50	1	0.29	8	8	64	348	99.43
12	850 TO	899	874.50	1	0.29	7	7	49	347	99.14
11	800 TO	849	824.50	5	1.43	6	30	180	346	98.86
10	750 TO	799	774.50	4	1.14	5	20	100	341	97.43
9	700 TO	749	724.50	10	2.86	4	40	160	337	96.29
8	650 TO	699	674.50	30	8.57	3	90	270	327	93.43
7	600 TO	649	624.50	39	11.14	2	78	156	297	84.86
6	550 TO	599	574.50	35	10.29	1	36	36	258	73.71
5	500 TO	549	524.50	88	25.14	0	0	0	222	63.43
4	450 TO	499	474.50	63	18.00	-1	-63	63	134	38.29
3	400 TO	449	424.50	56	16.00	-2	-112	224	71	20.29
2	350 TO	399	374.50	13	3.71	-3	-39	117	15	4.29
1	300 TO	349	324.50	2	0.57	-4	-8	32	2	0.57
						SUMS =	111	1741		

REGROUPED FOR CHISQ TESTS TO GIVE 9 INTERVALS WITHFREQUENCIES OF

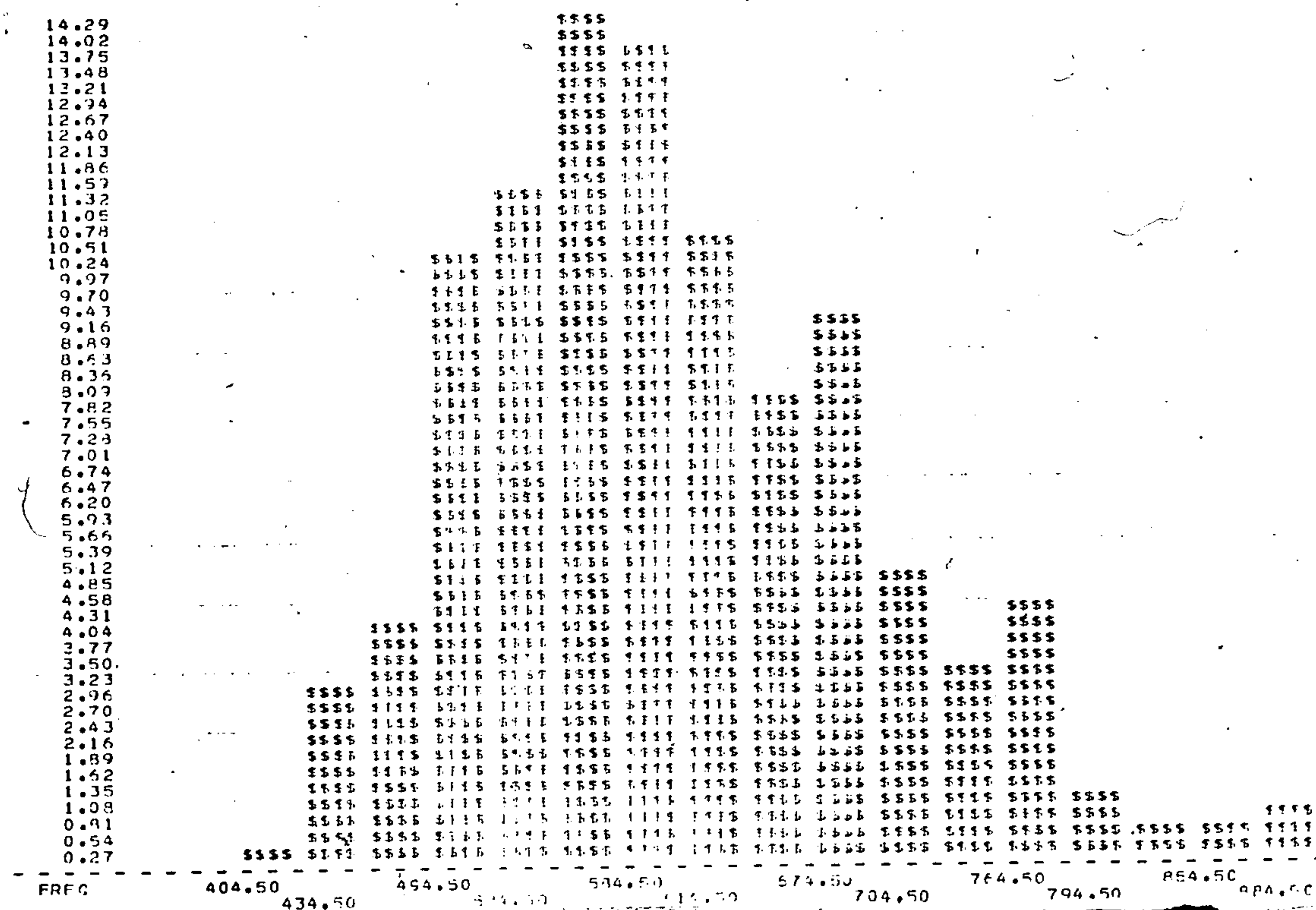
15 56 63 88 36 39 30 14 9

CHISQ NORMAL = 1.3294 CHISQ UNIFORM = 140.32

HISTOGRAMS AND FREQUENCY DISTRIBUTION

CHARTS FOR THE MAJOR STUDY

HISTOGRAM FOR THE CONDITION WHEN REACH=1. S.I.=3.32 BITS. R.I.=3.32 BITS.



FREQUENCY DISTRIBUTION FORTHE CONDITION WHEN REACH=1, S.I.=3.32 BITS, R.I.=3.32 BITS.

MAXIMUM = 904 MINIMUM = 413 RANGE= 491 INTERVAL WIDTH = 30

MEAN = 596.36 IN INTERVAL 7. ST. DVN. = 92.641 MEDIAN = 582.50

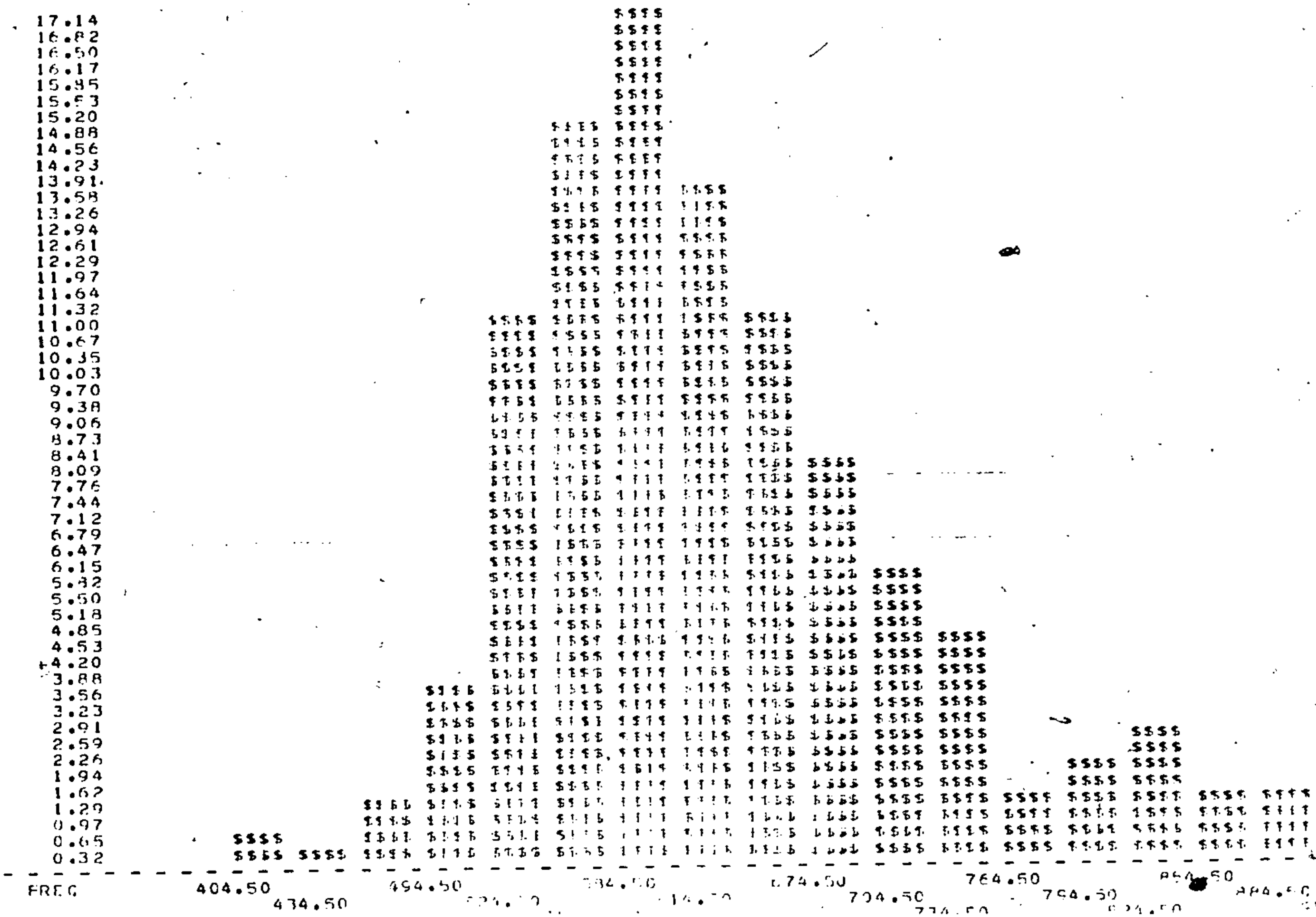
INT. NO.	EXACT LIMITS		MID-POINT	F	FX	D	FD	F*D**2	CUM F	- %
18	900 TO	929	914.50	1	0.29	11	11	121	350	100.00
17	870 TO	899	884.50	3	0.86	10	30	300	349	99.71
16	840 TO	869	854.50	2	0.57	9	18	162	346	98.86
15	810 TO	839	824.50	2	0.57	8	16	128	344	98.29
14	780 TO	809	794.50	4	1.14	7	28	196	342	97.71
13	750 TO	779	764.50	15	4.29	6	90	540	338	96.57
12	720 TO	749	734.50	11	3.14	5	55	275	323	92.29
11	690 TO	719	704.50	17	4.86	4	68	272	312	89.14
10	660 TO	689	674.50	32	9.14	3	96	288	295	84.29
9	630 TO	659	644.50	27	7.71	2	54	108	263	75.14
8	600 TO	629	614.50	37	10.57	1	37	37	236	67.43
7	570 TO	599	584.50	48	13.71	0	0	0	199	56.86
6	540 TO	569	554.50	50	14.29	-1	-50	50	151	43.14
5	510 TO	539	524.50	40	11.43	-2	-80	160	101	28.86
4	480 TO	509	494.50	36	10.29	-3	-108	324	61	17.43
3	450 TO	479	464.50	14	4.00	-4	-56	224	25	7.14
2	420 TO	449	434.50	10	2.86	-5	-50	250	11	3.14
1	390 TO	419	404.50	1	0.29	-6	-6	36	1	0.29
						SUMS =	153	3471		

REGROUPED FOR CHISQ TESTS TO GIVE 14 INTERVALS WITHFREQUENCIES OF

11 14 36 40 50 48 37 27 32 17 11 15 6 6

CHISQ NORMAL = 0.57275 CHISQ UNIFORM = 123.84

HISTOGRAM FOR THE CONDITION WHEN REACH=2. S.I.=3.32 BITS. R.I.=3.32 BITS.



FREQUENCY DISTRIBUTION FORTHE CONDITION WHEN REACH=2, S.I.=3.32 BITS, R.I.=3.32 BITS.

MAXIMUM = 933 MINIMUM = 408 RANGE= 525 INTERVAL WIDTH = 30

MEAN = 619.79 IN INTERVAL 8. ST. DVN. = 90.138 MEDIAN = 605.50

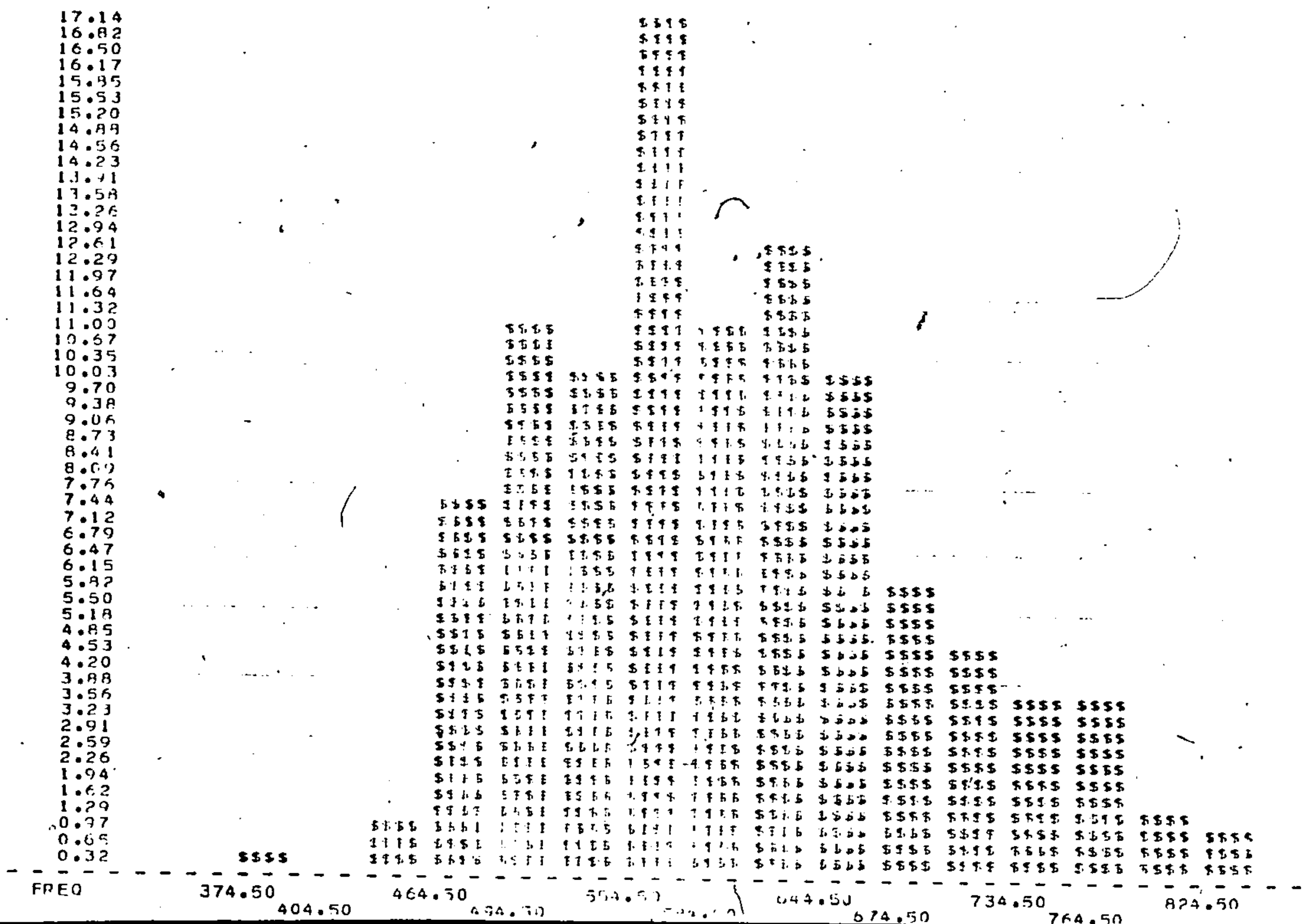
INT. NO.	EXACT LIMITS	MID-POINT	F	FX	D	FD	F*D**2	CUM F	- X
19	930 TO 959	944.50	1	0.29	11	11	121	350	100.00
18	900 TO 929	914.50	0	0.00	10	0	0	349	99.71
17	870 TO 899	884.50	4	1.14	9	36	324	349	99.71
16	840 TO 869	854.50	4	1.14	8	32	256	345	98.57
15	810 TO 839	824.50	9	2.57	7	63	441	341	97.43
14	780 TO 809	794.50	7	2.00	6	42	252	332	94.86
13	750 TO 779	764.50	5	1.43	5	25	125	325	92.86
12	720 TO 749	734.50	16	4.57	4	64	256	320	91.43
11	690 TO 719	704.50	20	5.71	3	60	180	304	86.86
10	660 TO 689	674.50	28	8.00	2	56	112	284	81.14
9	630 TO 659	644.50	39	11.14	1	39	39	256	73.14
8	600 TO 629	614.50	47	13.43	0	0	0	217	62.00
7	570 TO 599	584.50	60	17.14	-1	-60	60	170	48.57
6	540 TO 569	554.50	52	14.86	-2	-104	208	110	31.43
5	510 TO 539	524.50	39	11.14	-3	-117	351	58	16.57
4	480 TO 509	494.50	12	3.43	-4	-48	192	19	5.43
3	450 TO 479	464.50	4	1.14	-5	-20	100	7	2.00
2	420 TO 449	434.50	1	0.29	-6	-6	36	3	0.86
1	390 TO 419	404.50	2	0.57	-7	-14	98	2	0.57
					SUMS =	59	3151		

REGROUPED FOR CHISQ TESTS TO GIVE 14 INTERVALS WITH FREQUENCIES OF

7 12 39 52 60 47 39 28 20 16 5 7 13 5

CHISQ NORMAL = 1.1706 CHISQ UNIFORM = 169.24

HISTOGRAM FOR THE CONDITION WHEN REACH=1, S.I.=3.32 BITS, R.I.=3.00 BITS.



POOR COPY

FREQUENCY DISTRIBUTION FORTHE CONDITION WHEN REACH=1, S.I.=3.32 BITS, R.I.=3.00 BITS.

MAXIMUM = 834 MINIMUM = 381 RANGE= 453 INTERVAL WIDTH = 30

MEAN = 591.07 IN INTERVAL 8. ST. DVN. = 85.324 MEDIAN = 581.50

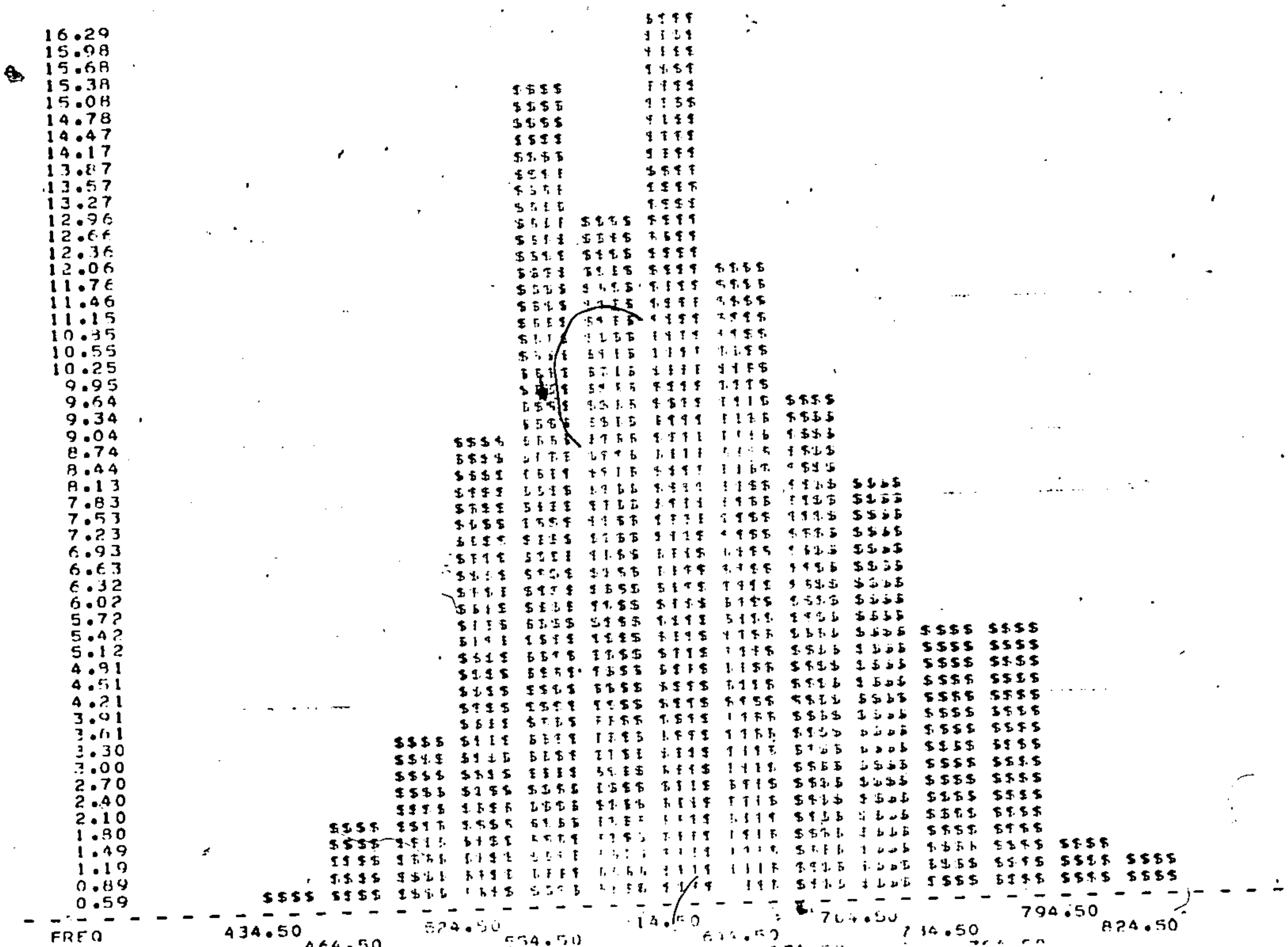
INT. NO.	EXACT LIMITS		MID-POINT	F	FX	D	FD	F*D**2	CUM F - %	
16	810 TO	839	824.50	3	0.86	8	24	192	350	100.00
15	780 TO	809	794.50	5	1.43	7	35	245	347	99.14
14	750 TO	779	764.50	12	3.43	6	72	432	342	97.71
13	720 TO	749	734.50	13	3.71	5	65	325	330	94.29
12	690 TO	719	704.50	16	4.57	4	64	256	317	90.57
11	660 TO	689	674.50	20	5.71	3	60	180	301	86.00
10	630 TO	659	644.50	35	10.00	2	70	140	281	80.29
9	600 TO	629	614.50	44	12.57	1	44	44	246	70.29
8	570 TO	599	584.50	39	11.14	0	0	0	282	57.71
7	540 TO	569	554.50	60	17.14	-1	-60	60	163	46.57
6	510 TO	539	524.50	35	10.00	-2	-70	140	103	29.43
5	480 TO	509	494.50	38	10.86	-3	-114	342	68	19.43
4	450 TO	479	464.50	26	7.43	-4	-104	416	30	8.57
3	420 TO	449	434.50	3	0.86	-5	-15	75	4	1.14
2	390 TO	419	404.50	0	0.00	-6	0	0	1	0.29
1	360 TO	389	374.50	1	0.29	-7	-7	49	1	0.29
						SUMS =	64	2896		

REGROUPED FOR CHISQ TESTS TO GIVE 12 INTERVALS WITHFREQUENCIES OF

30 38 35 60 39 44 35 20 16 13 12 8

CHISQ NORMAL = 0.91056 CHISQ UNIFORM = 91.737

HISTOGRAM FOR THE CONDITION WHEN REACH=2, S.I.=3.32 BITS, R.I.=3.00 BITS.



FREQUENCY DISTRIBUTION FORTHE CONDITION WHEN REACH=2, S.I.=3.32 BITS, R.I.=3.00 BITS,

MAXIMUM = 839 MINIMUM = 431 RANGE= 408 INTERVAL WIDTH = 30

MEAN = 620.06 IN INTERVAL 7. ST. DVN. = 78.507 MEDIAN = 612.00

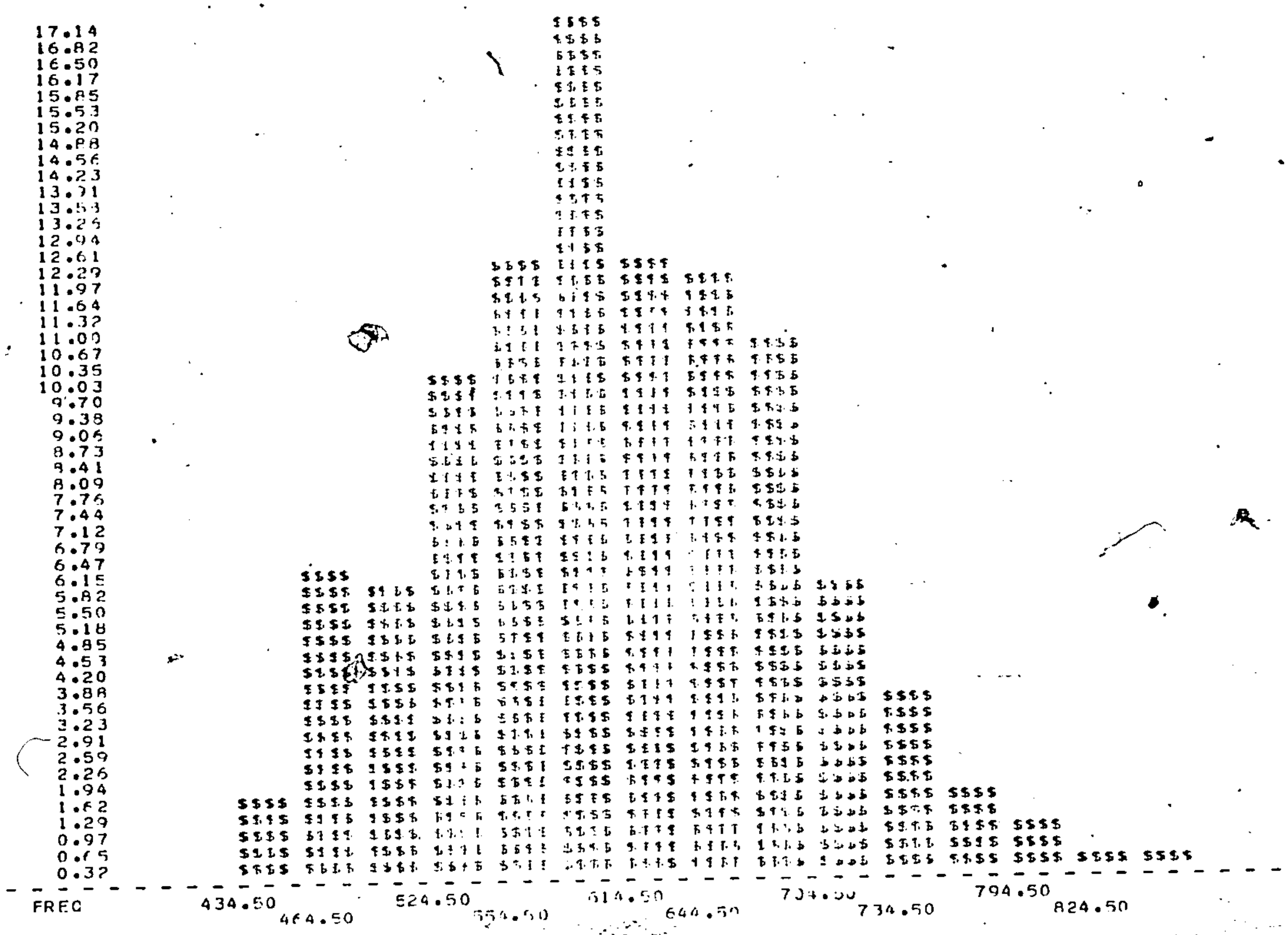
INT. NO.	EXACT LIMITS	MID-POINT	F	F%	D	FD	F*D**2	CUM F	- %
14	810 TO 839	824.50	3	0.86	7	21	147	350	100.00
13	780 TO 809	794.50	4	1.14	6	24	144	347	99.14
12	750 TO 779	764.50	18	5.14	5	90	450	343	98.00
11	720 TO 749	734.50	18	5.14	4	72	288	325	92.86
10	690 TO 719	704.50	28	8.00	3	84	252	307	87.71
9	660 TO 689	674.50	33	9.43	2	66	132	279	79.71
8	630 TO 659	644.50	41	11.71	1	41	41	246	70.29
7	600 TO 629	614.50	57	16.29	0	0	0	205	58.57
6	570 TO 599	584.50	44	12.57	-1	-44	44	148	42.29
5	540 TO 569	554.50	53	15.14	-2	-106	212	104	29.71
4	510 TO 539	524.50	31	8.85	-3	-93	279	51	14.57
3	480 TO 509	494.50	12	3.43	-4	-48	192	20	5.71
2	450 TO 479	464.50	6	1.71	-5	-30	150	8	2.29
1	420 TO 449	434.50	2	0.57	-6	-12	72	2	0.57
					SUMS =	65	2403		

REGROUPED FOR CHISQ TESTS TO GIVE 12 INTERVALS WITHFREQUENCIES OF

8 12 31 53 44 57 41 33 28 18 18 7

CHISQ NORMAL = 0.17916 CHISQ UNIFORM = 109.91

HISTOGRAM FOR THE CONDITION WHEN REACH=1, S.I.=3.32 BITS, R.I.=2.58 BITS.



FREQUENCY DISTRIBUTION FORTHE CONDITION WHEN REACH=1, S.I.=3.32 BITS, R.I.=2.58 BITS.

MAXIMUM = 865 MINIMUM = 420 RANGE= 445 INTERVAL WIDTH = 30

MEAN = 598.55 IN INTERVAL 6. ST. DVN. = 80.202 MEDIAN = 594.00

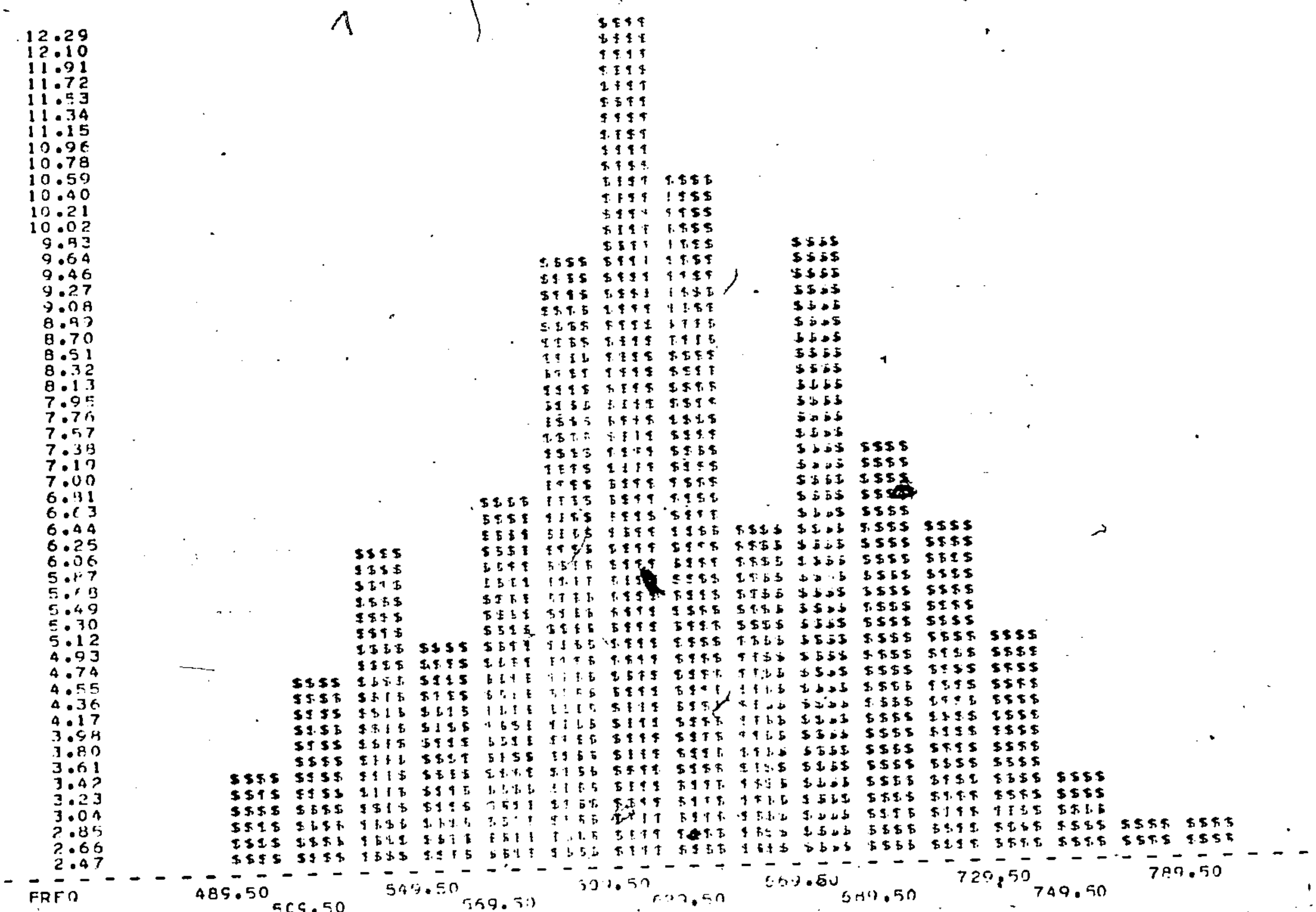
INT. NO.	EXACT LIMITS		MID-POINT	F	F%	D	FD	F*D**2	CUM F	- %
15	840 TO	869	854.50	1	0.29	9	9	81	350	100.00
14	810 TO	839	824.50	1	0.29	8	8	64	349	99.71
13	780 TO	809	794.50	3	0.86	7	21	147	348	99.43
12	750 TO	779	764.50	6	1.71	6	36	216	345	98.57
11	720 TO	749	734.50	12	3.43	5	60	300	339	96.86
10	690 TO	719	704.50	20	5.71	4	80	320	327	93.43
9	660 TO	689	674.50	37	10.57	3	111	333	307	87.71
8	630 TO	659	644.50	42	12.00	2	84	168	270	77.14
7	600 TO	629	614.50	43	12.29	1	43	43	228	65.14
6	570 TO	599	584.50	60	17.14	0	0	0	185	52.86
5	540 TO	569	554.50	43	12.29	-1	-43	43	125	35.71
4	510 TO	539	524.50	35	10.00	-2	-70	140	82	23.43
3	480 TO	509	494.50	20	5.71	-3	-60	180	47	13.43
2	450 TO	479	464.50	21	6.00	-4	-84	336	27	7.71
1	420 TO	449	434.50	6	1.71	-5	-30	150	6	1.71
						SUMS =	165	2521		

REGROUPED FOR CHISQ TESTS TO GIVE 13 INTERVALS WITHFREQUENCIES OF

6 21 20 35 43 60 43 42 37 20 12 6 5

CHISQ NORMAL = 0.12293 CHISQ UNIFORM = 137.98

HISTOGRAM FOR THE CONDITION WHEN REACH=2, S.I.=3.32 BITS, T.I.=2.58 BITS.



FREQUENCY DISTRIBUTION FORTHE CONDITION WHEN REACH=2, S.I.=3.32 BITS, R.I.=2.58 BITS.

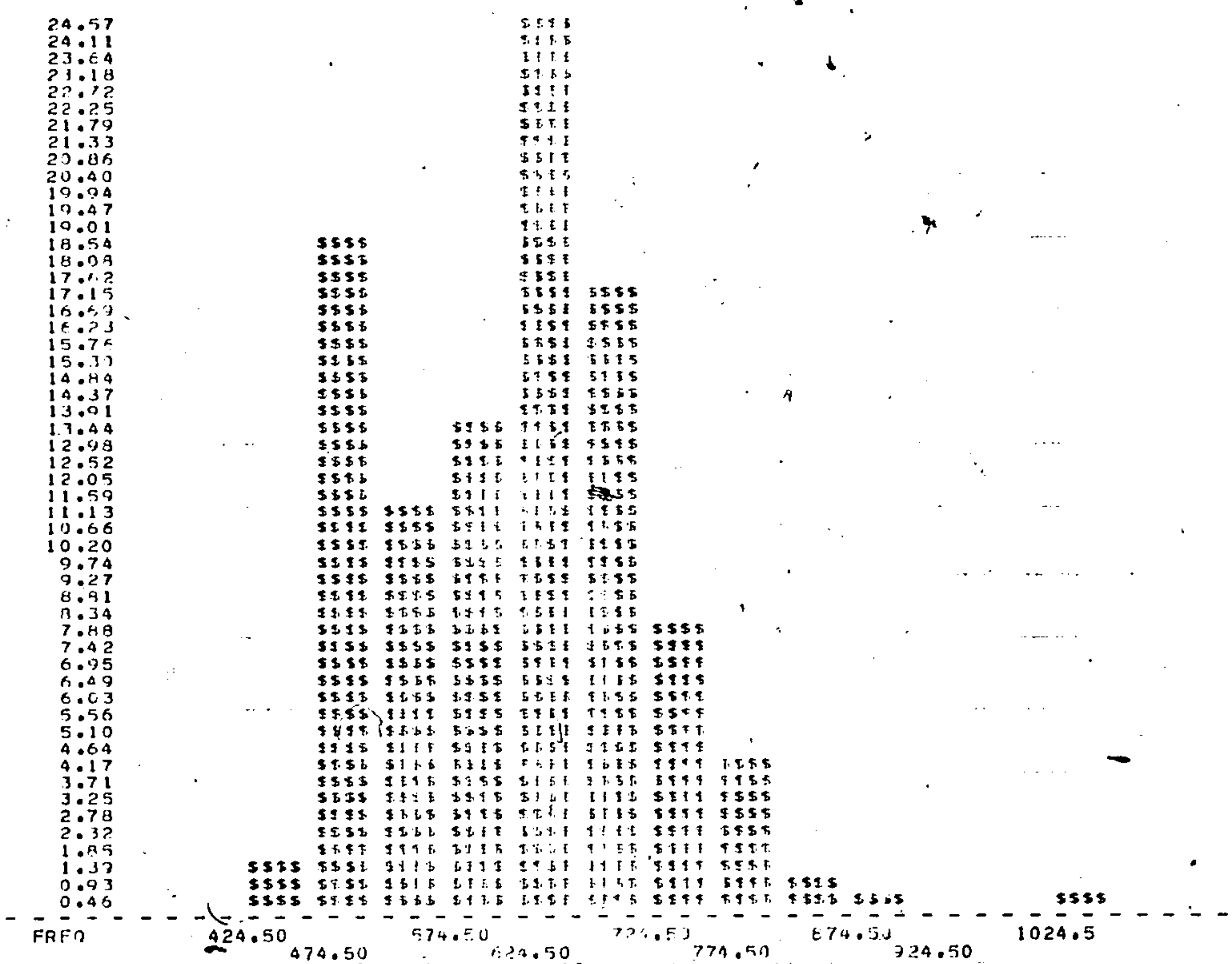
MAXIMUM = 797 MINIMUM = 484 RANGE= 313 INTERVAL WIDTH = 20

MEAN = 629.69 IN INTERVAL 8. ST. DVN. = 74.481 MEDIAN = 626.50

INT. NO.	EXACT LIMITS		MID-POINT	F	FX	D	FD	F*D**2	CUM F	%
16	780 TO	799	789.50	9	2.57	8	72	576	350	100.00
15	760 TO	779	769.50	9	[illegible].57	7	63	441	341	97.43
14	740 TO	759	749.50	11	3.14	6	66	396	332	94.86
13	720 TO	739	729.50	17	4.86	5	85	425	321	91.71
12	700 TO	719	709.50	22	6.29	4	88	352	304	86.86
11	680 TO	699	689.50	25	7.14	3	75	225	282	80.57
10	660 TO	679	669.50	34	9.71	2	68	136	257	73.43
9	640 TO	659	649.50	22	6.29	1	22	22	223	63.71
8	620 TO	639	629.50	36	10.29	0	0	0	201	57.43
7	600 TO	619	609.50	43	12.29	-1	-43	43	165	47.14
6	580 TO	599	589.50	33	9.43	-2	-66	132	122	34.86
5	560 TO	579	569.50	23	6.57	-3	-69	207	89	25.43
4	540 TO	559	549.50	17	4.86	-4	-68	272	66	18.86
3	520 TO	539	529.50	21	6.00	-5	-105	525	49	14.00
2	500 TO	519	509.50	16	4.57	-6	-96	576	28	8.00
1	480 TO	499	489.50	12	3.43	-7	-84	588	12	3.43
						SUMS =	8	4916		

CHISQ NORMAL = 0.29465 CHISQ UNIFORM = 71.211

HISTOGRAM FOR THE CONDITION WHEN REACH=2, S.I.=3.32 BITS, R.I.=2.00 BITS.



FREQUENCY DISTRIBUTION FORTHE CONDITION WHEN REACH=2, S.I.=3.32 BITS, R.I.=2.00 BITS.

MAXIMUM = 1030 MINIMUM = 407 RANGE= 623 INTERVAL WIDTH = 50

MEAN = 602.13 IN INTERVAL 5, ST. DVN. = 93.481 MEDIAN = 613.00

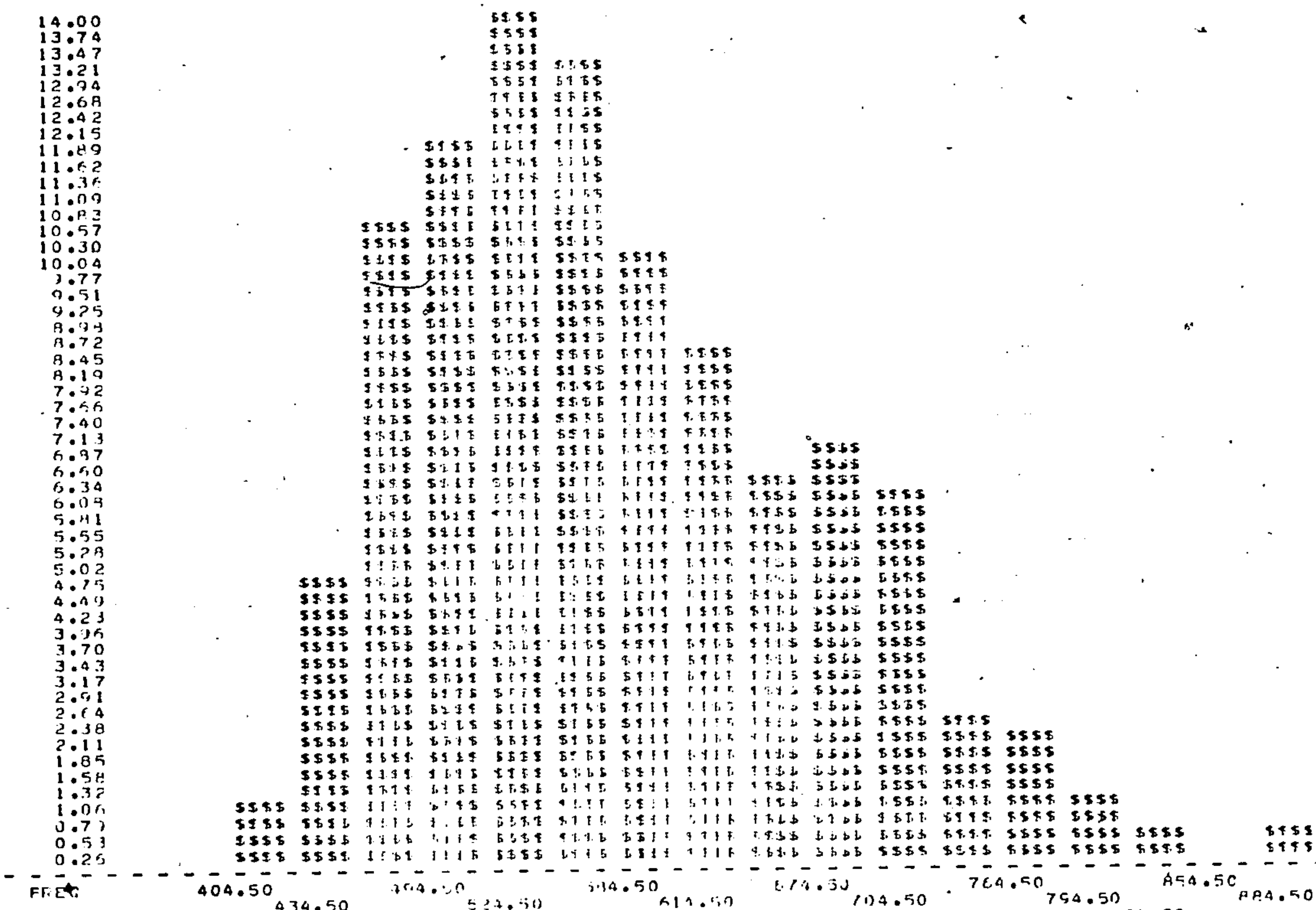
INT. NO.	EXACT LIMITS	MID-POINT	F	FX	D	FD	F*D**2	CUM F	X
13	1000 TO 1049	1024.5	1	0.29	8	8	64	350	100.00
12	950 TO 999	974.50	0	0.00	7	0	0	349	99.71
11	900 TO 949	924.50	0	0.00	6	0	0	349	99.71
10	850 TO 899	874.50	1	0.29	5	5	25	349	99.71
9	800 TO 849	824.50	3	0.86	4	12	48	348	99.43
8	750 TO 799	774.50	15	4.29	3	45	135	345	98.57
7	700 TO 749	724.50	28	8.00	2	56	112	330	94.29
6	650 TO 699	674.50	60	17.14	1	60	60	302	86.29
5	600 TO 649	624.50	86	24.57	0	0	0	242	69.14
4	550 TO 599	574.50	47	13.43	-1	-47	47	156	44.57
3	500 TO 549	524.50	39	11.14	-2	-78	156	109	31.14
2	450 TO 499	474.50	65	18.57	-3	-195	585	70	20.00
1	400 TO 449	424.50	5	1.43	-4	-20	80	5	1.43
					SUMS =	-154	1312		

REGROUPED FOR CHISQ TESTS TO GIVE 9 INTERVALS WITHFREQUENCIES OF

5 65 39 47 86 60 28 15 5

CHISQ NORMAL = 0.27792 CHISQ UNIFORM = 164.54

HISTOGRAM FOR THE CONDITION WHEN REACH=1, S.I.=3.32 BITS, R.I.=2.00 BITS.



FREQUENCY DISTRIBUTION FORTHE CONDITION WHEN REACH=1, S.I.=3.32 BITS, R.I.=2.00 BITS.

MAXIMUM = 886 MINIMUM = 414 RANGE= 472 INTERVAL WIDTH = 30

MEAN = 572.19 IN INTERVAL 7, ST. DVN. = 92.419 MEDIAN = 558.00

INT. NO.	EXACT LIMITS		MID-POINT	F	FX	D	FD	F*D**2	CUM F	– X
17	870 TO	899	884.50	2	0.57	10	20	200	350	100.00
16	840 TO	869	854.50	0	0.00	9	0	0	348	99.43
15	810 TO	839	824.50	2	0.57	8	16	128	348	99.43
14	780 TO	809	794.50	4	1.14	7	28	196	346	98.86
13	750 TO	779	764.50	7	2.00	6	42	252	342	97.71
12	720 TO	749	734.50	8	2.29	5	40	200	335	95.71
11	690 TO	719	704.50	21	6.00	4	84	336	327	93.43
10	660 TO	689	674.50	24	6.86	3	72	216	306	87.43
9	630 TO	659	644.50	22	6.29	2	44	88	282	80.57
8	600 TO	629	614.50	30	8.57	1	30	30	260	74.29
7	570 TO	599	584.50	15	10.00	0	0	0	230	65.71
6	540 TO	569	554.50	46	13.14	-1	-46	46	195	55.71
5	510 TO	539	524.50	49	14.00	-2	-98	196	149	42.57
4	480 TO	509	494.50	42	12.00	-3	-126	378	100	28.57
3	450 TO	479	464.50	37	10.57	-4	-148	592	58	16.57
2	420 TO	449	434.50	17	4.86	-5	-85	425	21	6.00
1	390 TO	419	404.50	4	1.14	-6	-24	144	4	1.14

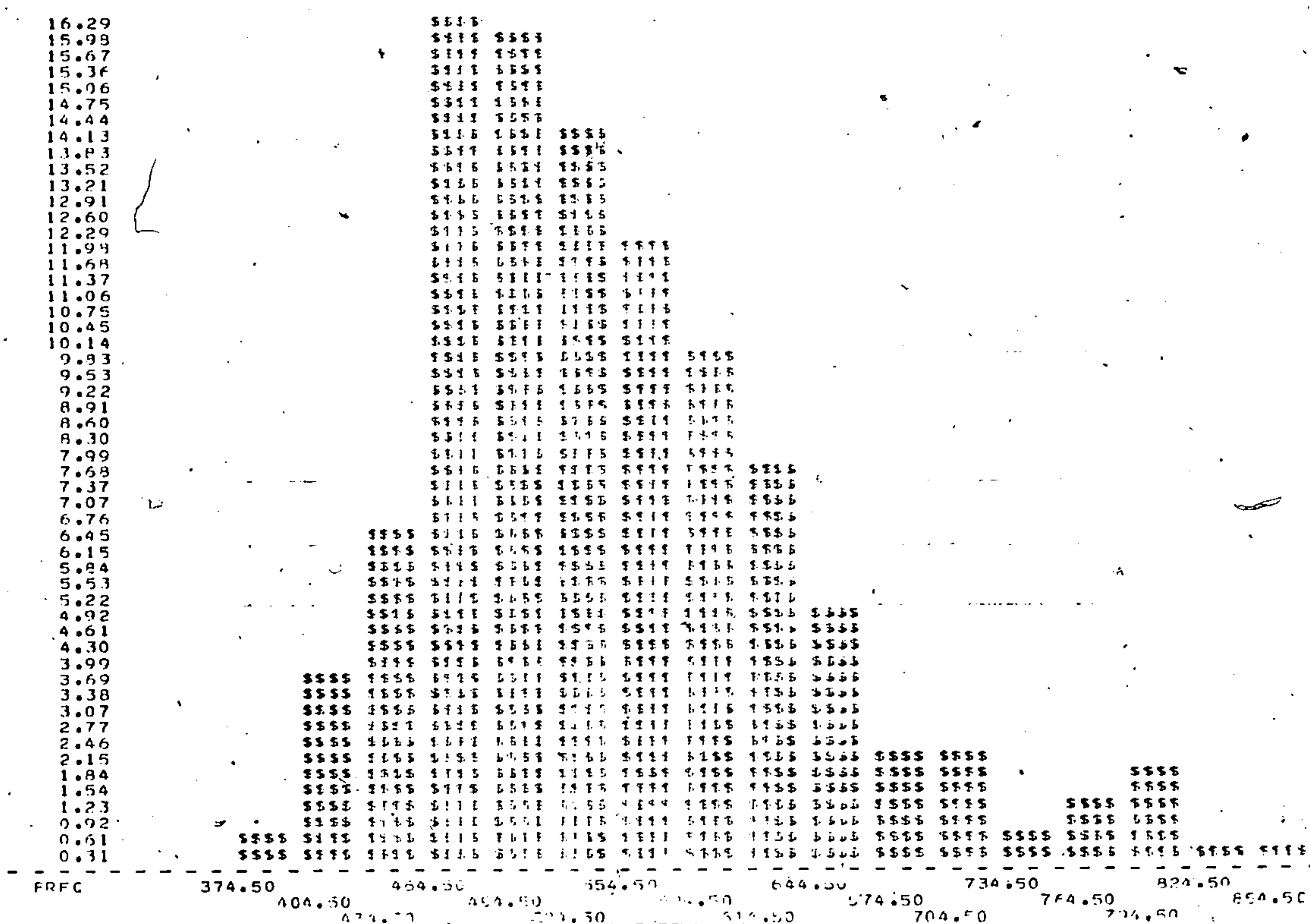
1 SUMS = -151 3427

REGROUPED FOR CHISQ TESTS TO GIVE 13 INTERVALS WITHFREQUENCIES OF

21 37 42 49 46 35 30 22 24 21 8 7 8

CHISQ NORMAL = 1.3954 CHISQ UNIFORM = 91.777

HISTOGRAM FOR THE CONDITION WHEN REACH=2, S.I.=3.32 BITS, R.I.=1.00 BIT.



FREQUENCY DISTRIBUTION FORTHE CONDITION WHEN REACH=2, S.I.=3.32 BITS, R.I.=1.00 BIT.

MAXIMUM = 844 MINIMUM = 384 RANGE= 460 INTERVAL WIDTH = 30

MEAN = 538.44 IN INTERVAL 6. ST. DVN. = 85.237 MEDIAN = 525.50

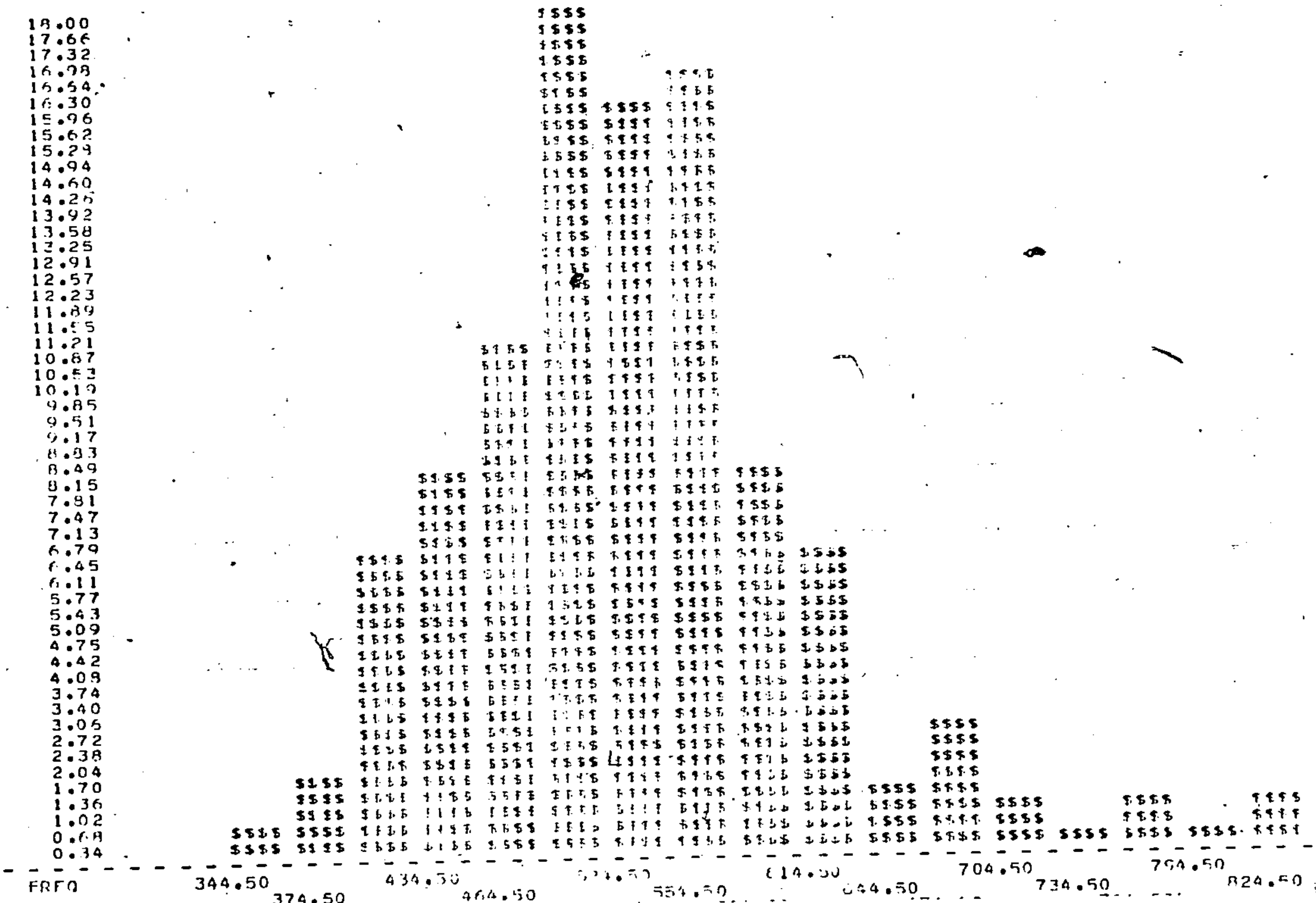
INT. NO.	EXACT LIMITS		MID-POINT	F	FX	D	FD	F*D**2	CUM F	%
17	840 TO	869	854.50	1	0.29	11	11	121	350	100.00
16	810 TO	839	824.50	1	0.29	10	10	100	349	99.71
15	780 TO	809	794.50	6	1.71	9	54	486	348	99.43
14	750 TO	779	764.50	4	1.14	8	32	256	342	97.71
13	720 TO	749	734.50	2	0.57	7	14	98	338	96.57
12	690 TO	719	704.50	7	2.00	6	42	252	336	96.00
11	660 TO	689	674.50	8	2.29	5	40	200	329	94.00
10	630 TO	659	644.50	17	4.86	4	68	272	321	91.71
9	600 TO	629	614.50	27	7.71	3	81	243	304	86.86
8	570 TO	599	584.50	34	9.71	2	68	136	277	79.14
7	540 TO	569	554.50	42	12.00	1	42	42	243	69.43
6	510 TO	539	524.50	50	14.29	0	0	0	201	57.43
5	480 TO	509	494.50	56	16.00	-1	-56	56	151	43.14
4	450 TO	479	464.50	57	16.29	-2	-114	228	95	27.14
3	420 TO	449	434.50	23	6.57	-3	-69	207	38	10.86
2	390 TO	419	404.50	13	3.71	-4	-52	208	15	4.29
1	360 TO	389	374.50	2	0.57	-5	-10	50	2	0.57
						SUMS =	161	2955		

REGROUPED FOR CHISQ TESTS TO GIVE 13 INTERVALS WITHFREQUENCIES OF

15 23 57 56 50 42 34 27 17 8 7 6 8

CHISQ NORMAL = 1.2158 CHISQ UNIFORM = 162.20

HISTOGRAM FOR THE CONDITION WHEN REACH=1. S.I.=3.32 BITS. R.I.=1.00 BIT.



FREQUENCY DISTRIBUTION FORTHE CONDITION WHEN REACH=I, S.I.=3.32 BITS, R.I.=1.00 BIT.

MAXIMUM = 839 MINIMUM = 351 RANGE= 483 INTERVAL WIDTH = 30

MEAN = 523.62 IN INTERVAL 7, ST. DVN. = 70.308 MEDIAN = 518.00

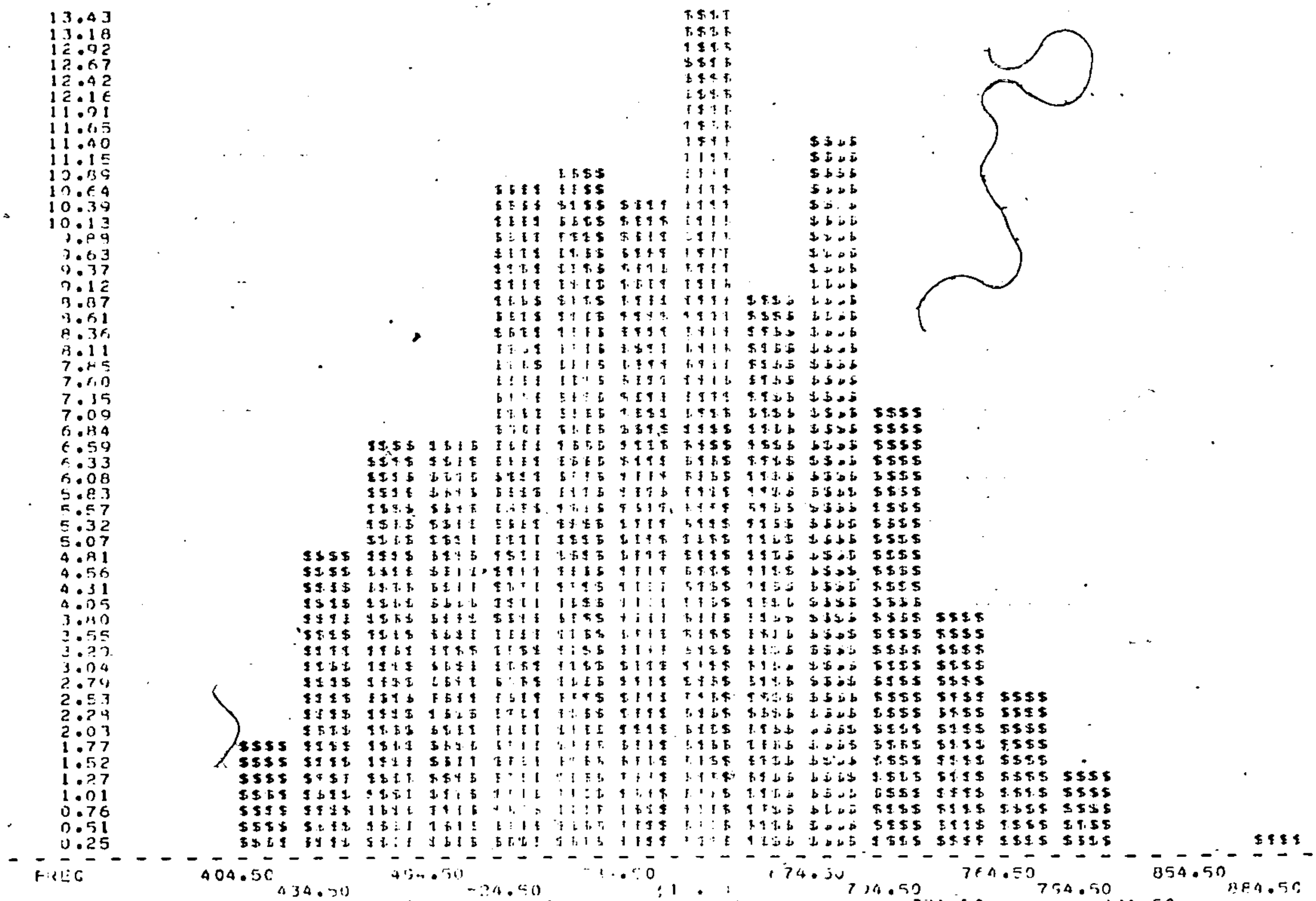
INT. NO.	EXACT LIMITS	MID-POINT	F	F%	D	FD	F*D**2	CUM F	CUM %
17	810 TO 839	824.50	3	0.86	10	30	300	350	100.00
16	780 TO 809	794.50	1	0.29	9	9	81	347	99.14
15	750 TO 779	764.50	3	0.86	8	24	192	346	98.86
14	720 TO 749	734.50	1	0.29	7	7	49	343	98.00
13	690 TO 719	704.50	4	1.14	6	24	144	342	97.71
12	660 TO 689	674.50	9	2.57	5	45	225	338	96.57
11	630 TO 659	644.50	5	1.43	4	20	80	329	94.30
10	600 TO 629	614.50	22	6.29	3	66	198	324	92.57
9	570 TO 599	584.50	28	8.00	2	56	112	302	86.29
8	540 TO 569	554.50	58	16.57	1	58	58	274	78.29
7	510 TO 539	524.50	56	16.00	0	0	0	216	61.71
6	480 TO 509	494.50	63	18.00	-1	-63	63	160	45.71
5	450 TO 479	464.50	38	10.86	-2	-76	152	97	27.71
4	420 TO 449	434.50	29	8.29	-3	-87	261	59	16.86
3	390 TO 419	404.50	22	6.29	-4	-88	352	30	8.57
2	360 TO 389	374.50	6	1.71	-5	-30	150	8	2.29
1	330 TO 359	344.50	2	0.57	-6	-12	72	2	0.57
					SUMS =	-17	2489		

REGROUPED FOR CHISQ TESTS TO GIVE 13 INTERVALS WITHFREQUENCIES OF

8 22 29 38 63 56 58 28 22 5 9 5 7

CHISQ NORMAL = 1.8012 CHISQ UNIFORM = 197.86

HISTOGRAM FOR THE CONDITION WHEN REACH=1, S.I.=3.00 BITS, F.I.=3.00 BITS.



FREQUENCY DISTRIBUTION FORTHE CONDITION WHEN REACH=1. S.I.=3.00 BITS. R.I.=1.00 BIT.

MAXIMUM = 758 MINIMUM = 306 RANGE= 452 INTERVAL WIDTH = 30

MEAN = 510.65 IN INTERVAL 8. ST. DVN. = 90.827 MEDIAN = 519.00

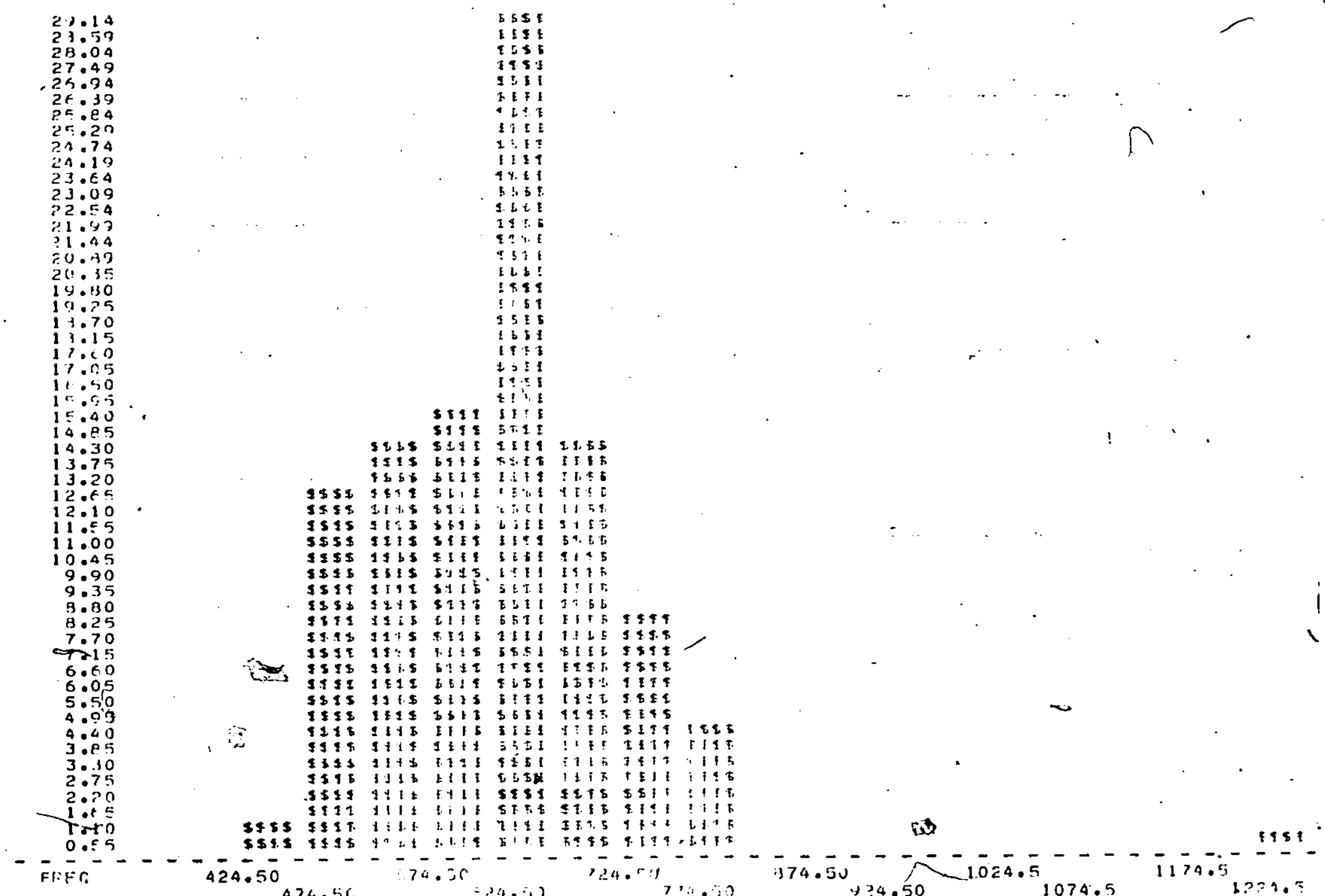
INT. NO.	EXACT LIMITS		MID-POINT	F	F%	D	FD	F*D**2	CUM F.	%
16	750 TO	779	764.50	4	1.14	8	32	256	350	100.00
15	720 TO	749	734.50	5	1.43	7	35	245	346	98.86
14	690 TO	719	704.50	3	0.86	6	18	108	341	97.43
13	660 TO	689	674.50	6	1.71	5	30	150	338	96.57
12	630 TO	659	644.50	10	2.86	4	40	160	332	94.86
11	600 TO	629	614.50	25	7.14	3	75	225	322	92.00
10	570 TO	599	584.50	28	8.00	2	56	112	297	84.86
9	540 TO	569	554.50	47	13.43	1	47	47	269	76.86
8	510 TO	539	524.50	64	18.29	0	0	0	222	63.43
7	480 TO	509	494.50	40	11.43	-1	-40	40	158	45.14
6	450 TO	479	464.50	24	6.86	-2	-48	96	118	33.71
5	420 TO	449	434.50	22	6.29	-3	-66	198	94	26.86
4	390 TO	419	404.50	32	9.14	-4	-128	512	72	20.57
3	360 TO	389	374.50	28	8.00	-5	-140	700	40	11.43
2	330 TO	359	344.50	9	2.57	-6	-54	324	12	3.43
1	300 TO	329	314.50	3	0.86	-7	-21	147	3	0.86
						SUMS =	-164	3320		

REGROUPED FOR CHISQ TESTS TO GIVE 13 INTERVALS WITHFREQUENCIES OF

12 28 32 22 24 40 64 47 28 25 10 6 9

CHISQ NORMAL = 0.47296 CHISQ UNIFORM = 117.55

HISTOGRAM FOR THE CONDITION WHEN REACH=2, S.I.=3.00 BITS, R.I.=3.00 BITS.



FREQUENCY DISTRIBUTION FORTHE CONDITION WHEN REACH=2, S.I.=3.00 BITS, R.T.=1.00 BIT.

MAXIMUM = 788 MINIMUM = 378 RANGE= 410 INTERVAL WIDTH = 30

MEAN = 530.42 IN INTERVAL 6, ST. DVN. = 69.471 MEDIAN = 526.00

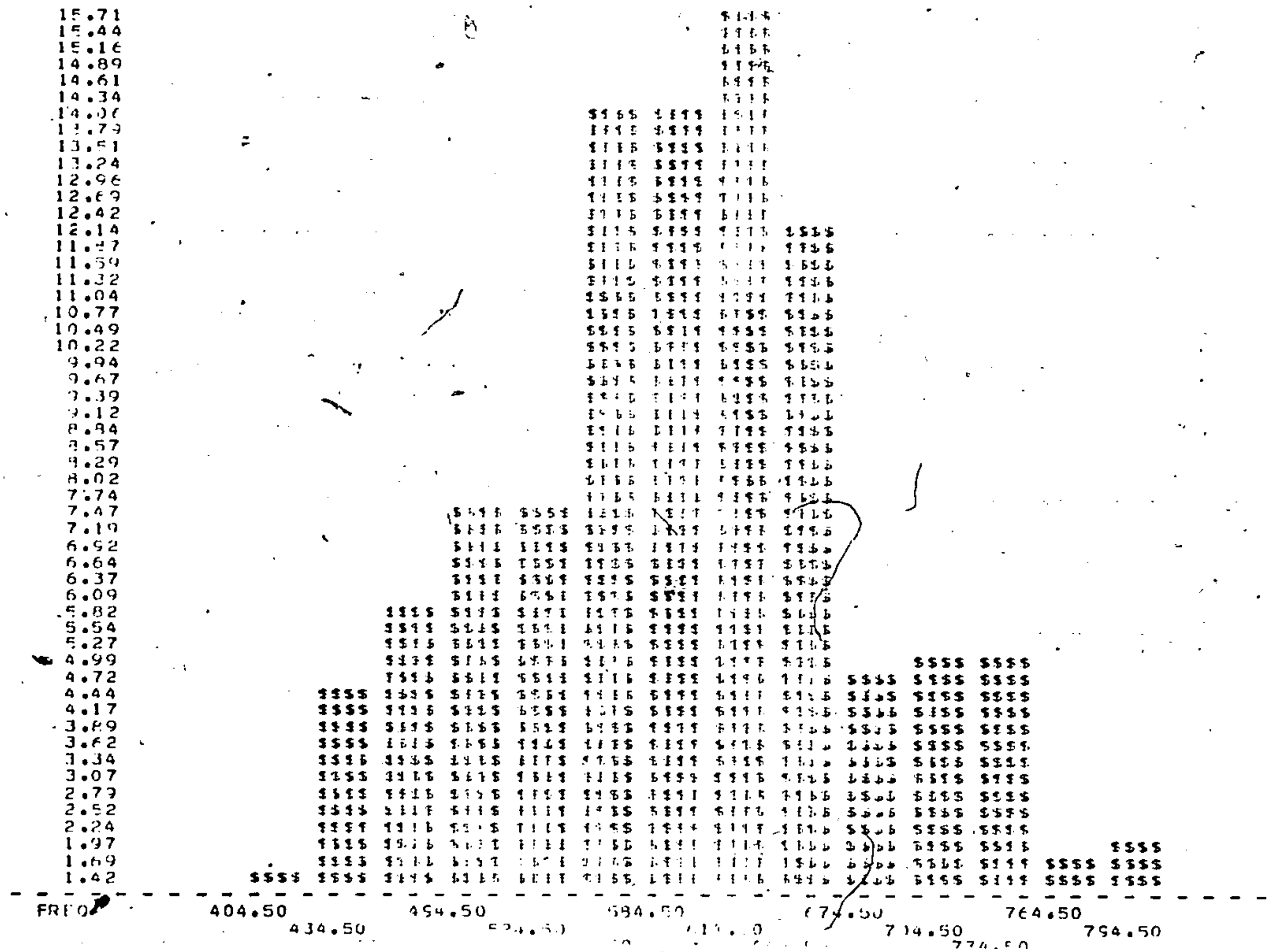
INT. NO.	EXACT LIMITS		MID-POINT	F	FX	D	FD	F*D**2	CUM F	- %
15	780 TO	809	794.50	1	0.29	9	9	81	350	100.00
14	750 TO	779	764.50	1	0.29	8	8	64	349	99.71
13	720 TO	749	734.50	1	0.29	7	7	49	348	99.43
12	690 TO	719	704.50	3	0.86	6	18	108	347	99.14
11	660 TO	689	674.50	7	2.00	5	35	175	344	98.29
10	630 TO	659	644.50	17	4.86	4	68	272	337	96.29
9	600 TO	629	614.50	29	8.29	3	87	261	320	91.43
8	570 TO	599	584.50	41	11.71	2	82	164	291	83.14
7	540 TO	569	554.50	49	14.00	1	49	49	250	71.43
6	510 TO	539	524.50	55	15.71	0	0	0	201	57.43
5	480 TO	509	494.50	54	15.43	-1	-54	54	146	41.71
4	450 TO	479	464.50	54	15.43	-2	-108	216	92	26.29
3	420 TO	449	434.50	27	7.71	-3	-81	243	38	10.86
2	390 TO	419	404.50	8	2.29	-4	-32	128	11	3.14
1	360 TO	389	374.50	3	0.86	-5	-15	75	3	0.86
						SUMS =	73	1939		

REGROUPED FOR CHISQ TESTS TO GIVE 11 INTERVALS WITHFREQUENCIES OF

11 27 54 54 55 49 41 29 17 7 6

CHISQ NORMAL = 0.34347 CHISQ UNIFORM = 121.55

HISTOGRAM FOR THE CONDITION WHEN REACH=1, S.I.=3.00 BITS, R.I.=2.58 BITS.



FREQUENCY DISTRIBUTION FORTHE CONDITION WHEN REACH=1, S.I.=3.00 BITS, R.I.=2.58 BITS.

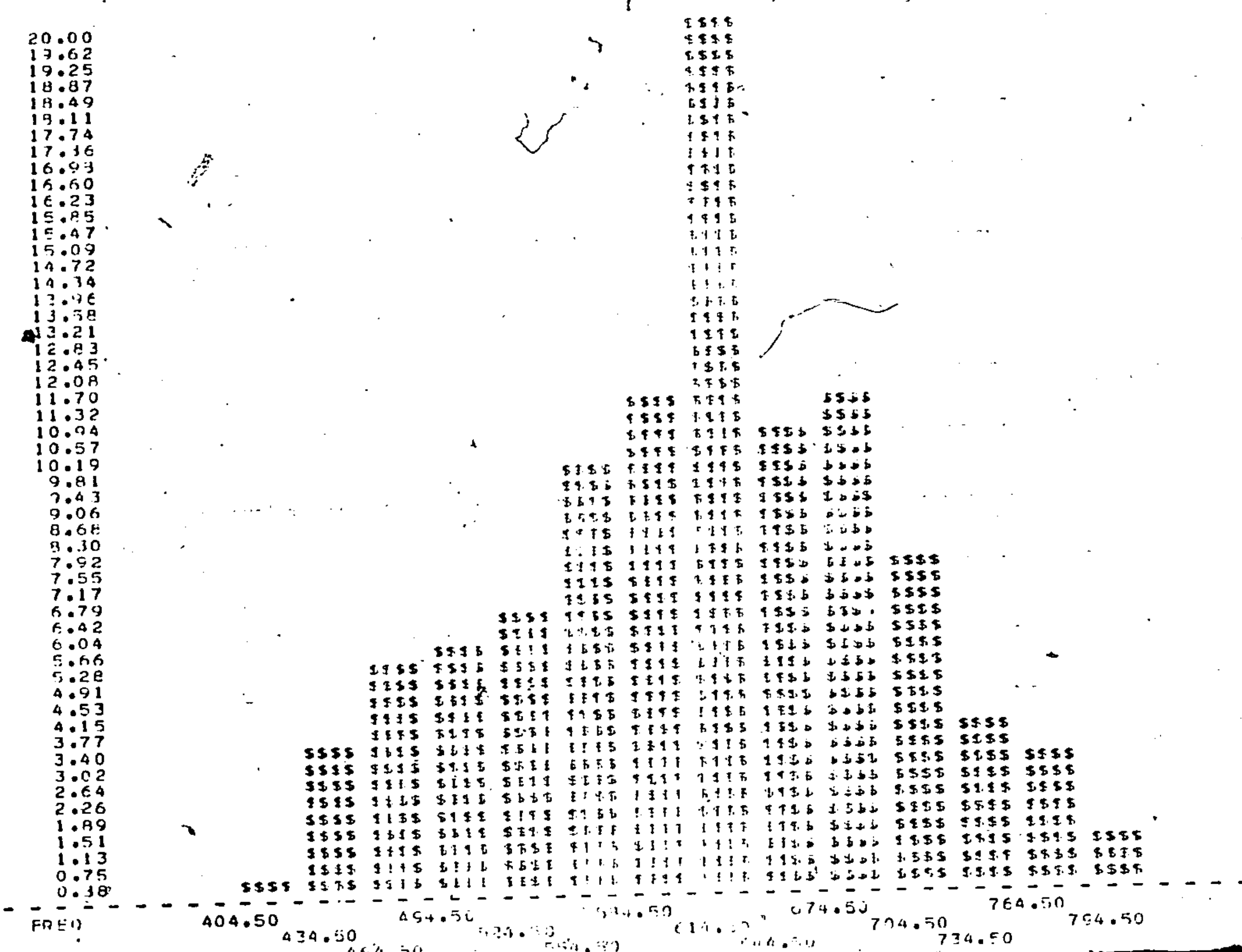
MAXIMUM = 795 - MINIMUM = 392 RANGE= 403 INTERVAL WIDTH = 30

MEAN = 589.42 IN INTERVAL 7. ST. DVN. = 85.180 MEDIAN = 592.50

INT. NO.	EXACT LIMITS		MID-POINT	F	F%	D	FD	F*D**2	CUM F	%
14	780 TO	809	794.50	7	2.00	7	49	343	350	100.00
13	750 TO	779	764.50	6	1.71	6	36	216	343	98.00
12	720 TO	749	734.50	17	4.86	5	85	425	337	96.29
11	690 TO	719	704.50	17	4.86	4	68	272	320	91.43
10	660 TO	689	674.50	16	4.57	3	48	144	303	86.57
9	630 TO	659	644.50	42	12.00	2	84	168	287	82.00
8	600 TO	629	614.50	55	15.71	1	55	55	245	70.00
7	570 TO	599	584.50	49	14.00	0	0	0	190	54.29
6	540 TO	569	554.50	49	14.00	-1	-49	49	141	40.29
5	510 TO	539	524.50	26	7.43	-2	-52	104	92	26.29
4	480 TO	509	494.50	26	7.43	-3	-78	234	66	18.86
3	450 TO	479	464.50	20	5.71	-4	-80	320	40	11.43
2	420 TO	449	434.50	15	4.29	-5	-75	375	20	5.71
1	390 TO	419	404.50	5	1.43	-6	-30	180	5	1.43
						SUMS =	61	2885		

CHISQ NORMAL = 0.17667 CHISQ UNIFORM = 150.48

HISTOGRAM FOR THE CONDITION WHEN REACH=2, S.I.=3.00 BITS, R.I.=2.58 BITS.



FREQUENCY DISTRIBUTION FORTHE CONDITION WHEN REACH=2, S.I.=3.00 BITS, R.I.=2.58 BITS.

MAXIMUM = 805 MINIMUM = 413 RANGE= 392 INTERVAL WIDTH = 30

MEAN = 605.92 IN INTERVAL 8. ST. DVN. = 83.223 MEDIAN = 610.50

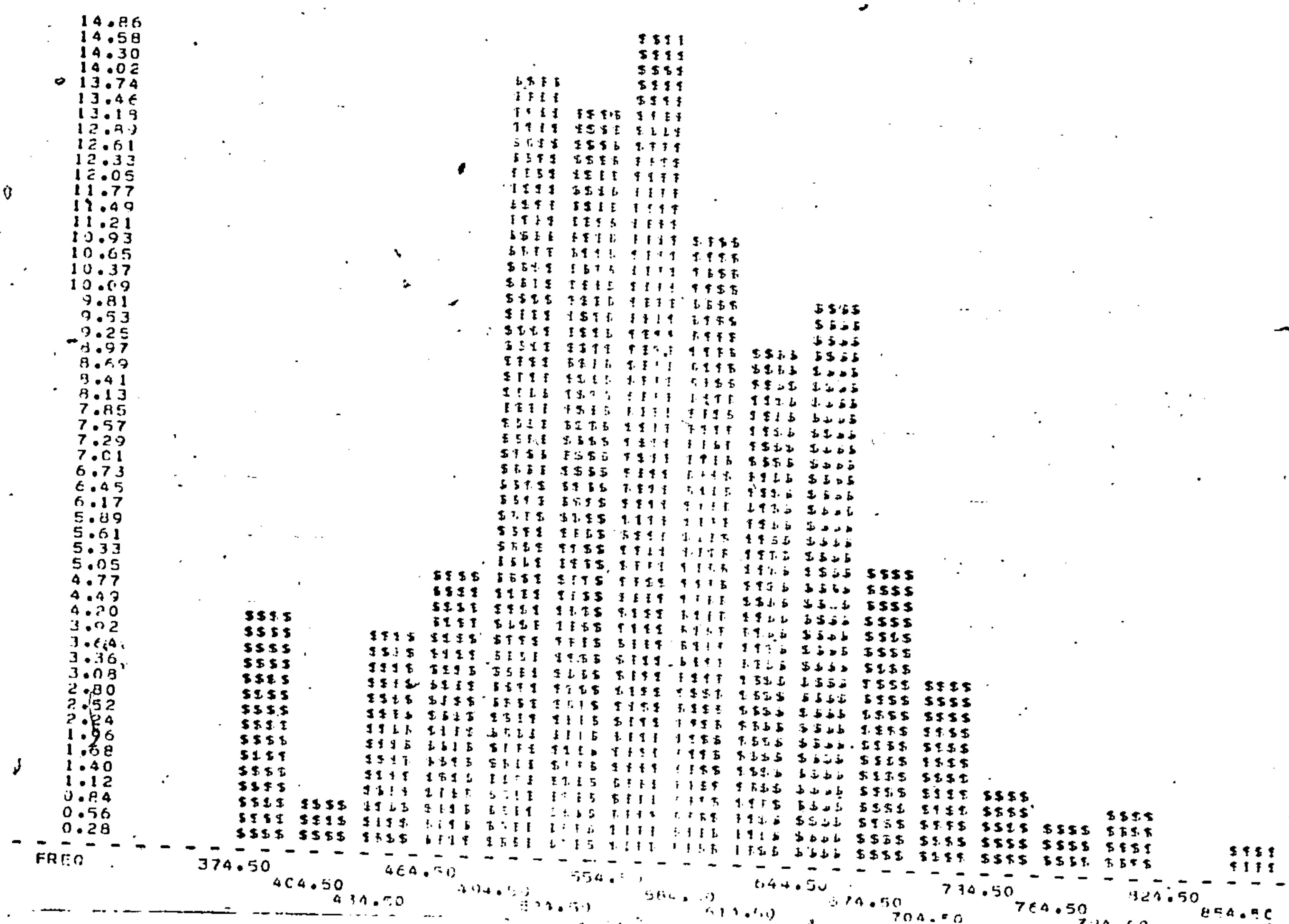
INT. NO.	EXACT LIMITS		MID-POINT	F	FX	D	FD	F*D**2	CUM F	- %
14	780 TO	809	794.50	4	1.14	6	24	144	350	100.00
13	750 TO	779	764.50	11	3.14	5	55	275	346	98.86
12	720 TO	749	734.50	13	3.71	4	52	208	335	95.71
11	690 TO	719	704.50	26	7.43	3	78	234	322	92.00
10	660 TO	689	674.50	40	11.43	2	80	160	296	84.57
9	630 TO	659	644.50	37	10.57	1	37	37	256	73.14
8	600 TO	629	614.50	70	20.00	0	0	0	219	62.57
7	570 TO	599	584.50	40	11.43	-1	-40	40	149	42.57
6	540 TO	569	554.50	35	10.00	-2	-70	140	109	31.14
5	510 TO	539	524.50	22	6.29	-3	-66	198	74	21.14
4	480 TO	509	494.50	20	5.71	-4	-80	320	52	14.86
3	450 TO	479	464.50	19	5.43	-5	-95	475	32	9.14
2	420 TO	449	434.50	12	3.43	-6	-72	432	13	3.71
1	390 TO	419	404.50	1	0.29	-7	-7	49	1	0.29
						SUMS =	-104	2712		

REGROUPED FOR CHISQ TESTS TO GIVE 12 INTERVALS WITHFREQUENCIES OF

13 19 20 22 35 40 70 37 40 26 13 15

CHISQ NORMAL = 0.31457 CHISQ UNIFORM = 101.92

HISTOGRAM FOR THE CONDITION WHEN REACH=1, S.I.=3.00 BITS, R.I.=2.00 BITS.



FREQUENCY DISTRIBUTION FORTHE CONDITION WHEN REACH=1, S.I.=3.00 BITS, R.I.=2.00 BITS.

MAXIMUM = 874 MINIMUM = 372 RANGE= 302 INTERVAL WIDTH 30

MEAN = 563.41 IN INTERVAL 7. ST. DVN. = 90.376 MEDIAN = 561.00

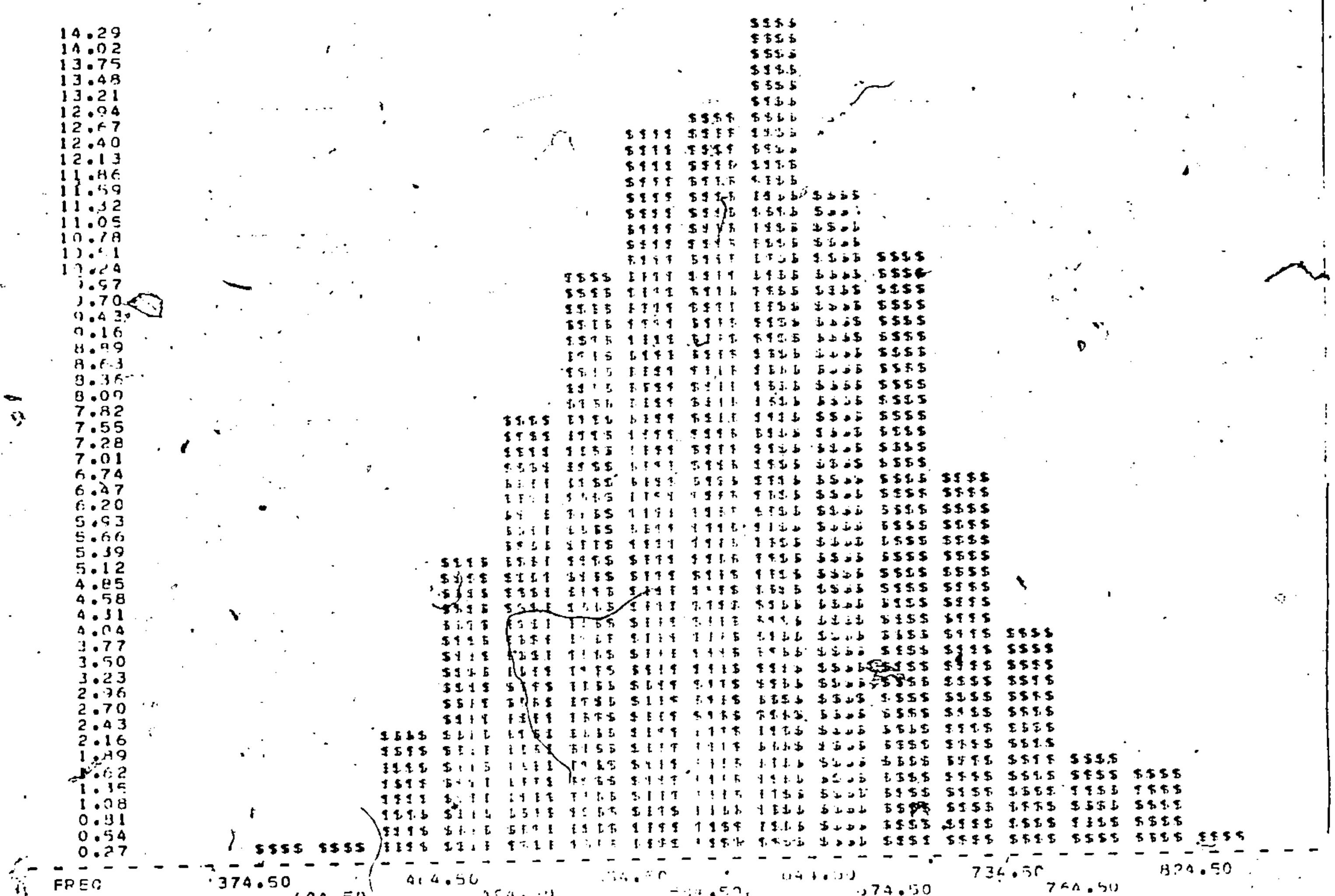
INT. NO.	EXACT LIMITS	MID-POINT	F	FX	D	FD	FD**2	CUM F - X	
19	870 TO 899	884.50	1	0.29	11	11	121	350	100.00
17	840 TO 869	854.50	2	0.57	10	20	200	349	99.71
16	810 TO 839	824.50	0	0.00	9	0	0	347	99.14
15	780 TO 809	794.50	4	1.14	8	32	256	347	99.14
14	750 TO 779	764.50	3	0.86	7	21	147	343	98.00
13	720 TO 749	734.50	5	1.43	6	30	180	340	97.14
12	690 TO 719	704.50	12	3.43	5	60	300	335	95.71
11	660 TO 699	674.50	17	5.43	4	76	304	323	92.29
10	630 TO 659	644.50	35	10.00	3	105	315	304	86.86
9	600 TO 629	614.50	32	9.14	2	64	128	269	76.86
8	570 TO 599	584.50	39	11.14	1	39	39	237	67.71
7	540 TO 569	554.50	52	14.86	0	0	0	198	56.57
6	510 TO 539	524.50	47	13.43	-1	-47	47	146	41.71
5	480 TO 509	494.50	49	14.00	-2	-98	196	99	28.29
4	450 TO 479	464.50	18	5.14	-3	-54	162	50	14.29
3	420 TO 449	434.50	14	4.00	-4	-56	224	32	9.14
2	390 TO 419	404.50	3	0.86	-5	-15	75	18	5.14
1	360 TO 389	374.50	15	4.29	-6	-90	540	15	4.29
					SUMS =	98	3234		

REGROUPED FOR CHISQ TESTS TO GIVE 13 INTERVALS WITHFREQUENCIES OF

15 17 18 49 47 52 39 32 35 17 12 8 7

CHISQ NORMAL = 0.63384 CHISQ UNIFORM = 115.77

HISTOGRAM FOR THE CONDITION WHEN REACH=2, S.I.=3.00 BITS, R.I.=2.00 BITS.



FREQUENCY DISTRIBUTION FORTHE CONDITION WHEN REACH=2, S.I.=3.00 BITS, R.I.=2.00 BITS.

MAXIMUM = 827 MINIMUM = 380 RANGE= 447 INTERVAL WIDTH = 30

MEAN = 557.37 IN INTERVAL 8, ST. DVN. = 83.072 MEDIAN = 597.50

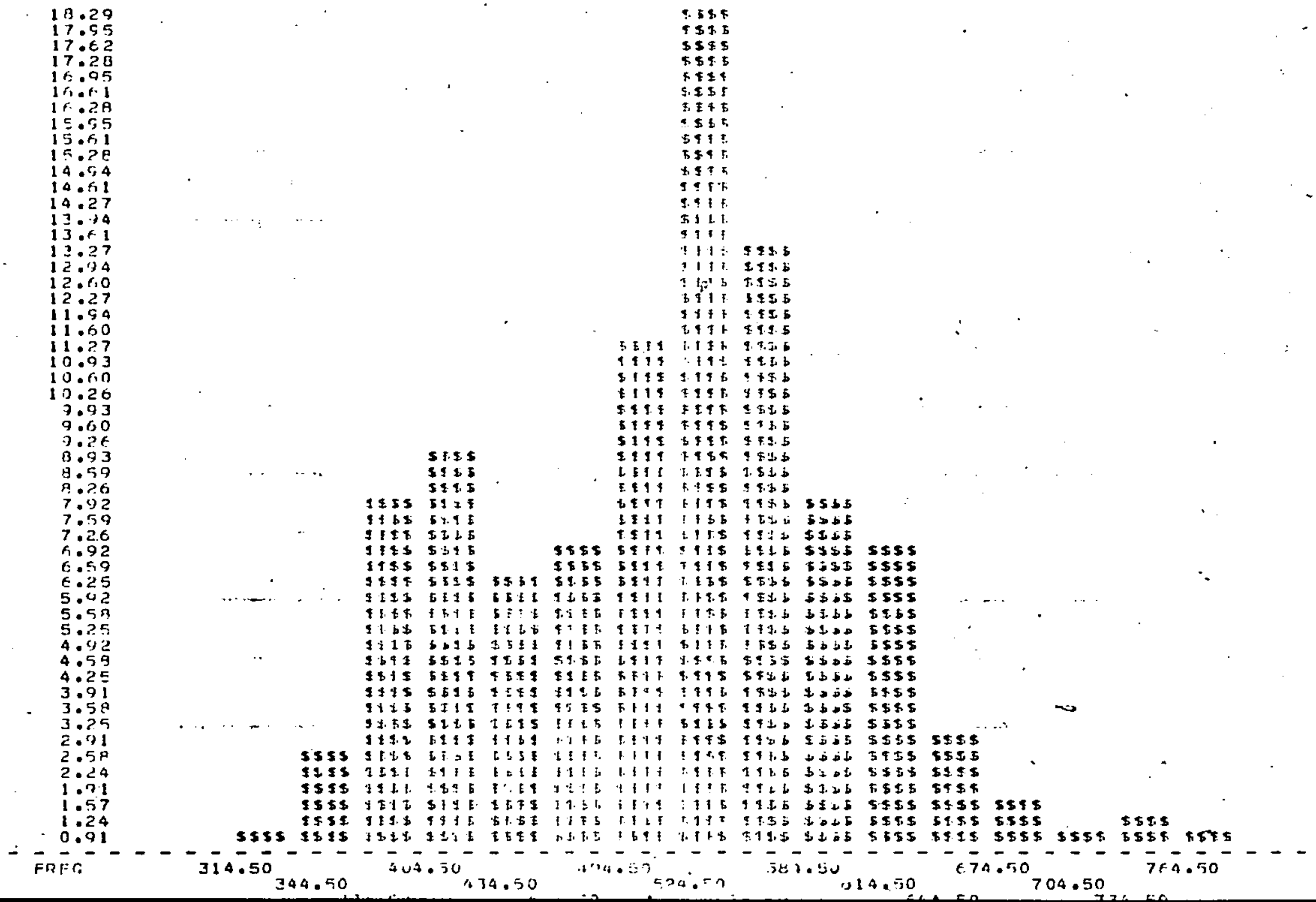
INT. NO.	EXACT LIMITS	MID-POINT	F	F%	D	FD	F*D**2	CUM F	%
16	810 TO 839	824.50	1	0.29	8	8	64	350	100.00
15	780 TO 809	794.50	5	1.43	7	35	245	349	99.71
14	750 TO 779	764.50	6	1.71	6	36	216	344	98.29
13	720 TO 749	734.50	13	3.71	5	65	325	338	96.57
12	690 TO 719	704.50	23	6.57	4	92	368	325	92.86
11	660 TO 689	674.50	36	10.29	3	108	324	302	86.29
10	630 TO 659	644.50	40	11.43	2	80	160	266	76.00
9	600 TO 629	614.50	50	14.29	1	50	50	226	64.57
8	570 TO 599	584.50	44	12.57	0	0	0	176	50.29
7	540 TO 569	554.50	43	12.29	-1	-43	43	132	37.71
6	510 TO 539	524.50	35	10.00	-2	-70	140	89	25.43
5	480 TO 509	494.50	26	7.43	-3	-78	234	54	15.43
4	450 TO 479	464.50	18	5.14	-4	-72	288	28	8.00
3	420 TO 449	434.50	8	2.29	-5	-40	200	10	2.86
2	390 TO 419	404.50	1	0.29	-6	-6	36	2	0.57
1	360 TO 389	374.50	1	0.29	-7	-7	49	1	0.29
					SUMS =	158	2742		

REGROUPED FOR CHISQ TESTS TO GIVE 13 INTERVALS WITHFREQUENCIES OF

10 18 26 35 43 44 50 40 36 23 13 6 6

CHISQ NORMAL = 0.15988 CHISQ UNIFORM = 105.97

HISTOGRAM FOR THE CONDITION WHEN REACH=1. S.I.=3.00 BITS, R.I.=1.00 BIT.



FREQUENCY DISTRIBUTION FORTHE CONDITION WHEN REACH=1, S.I.=3.00 BITS, R.I.=3.00 BITS.

MAXIMUM = 872 MINIMUM = 391 RANGE= 481 INTERVAL WIDTH = 30

MEAN = 592.45 IN INTERVAL 7. ST. DVN. = 90.303 MEDIAN = 594.50

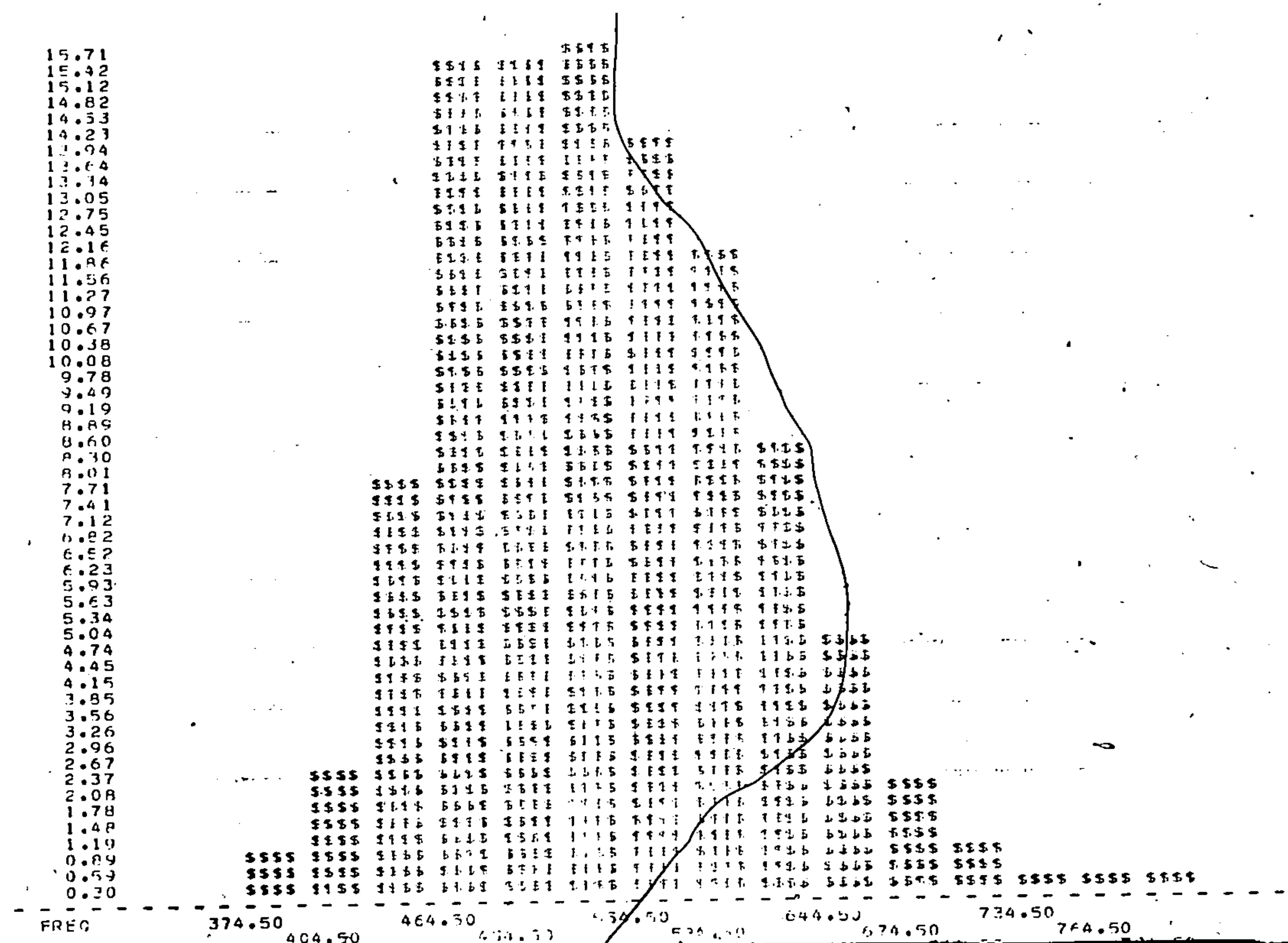
INT. NO.	EXACT LIMITS		MID-POINT	F	FX	D	FD	F*D**2	CUM F	%
17	870 TO	899	884.50	1	0.29	10	10	100	350	100.00
16	840 TO	869	854.50	0	0.00	9	0	0	349	99.71
15	810 TO	839	824.50	0	0.00	8	0	0	349	99.71
14	780 TO	809	794.50	4	1.14	7	28	196	349	99.71
13	750 TO	779	764.50	9	2.57	6	54	324	345	98.57
12	720 TO	749	734.50	13	3.71	5	65	325	336	96.00
11	690 TO	719	704.50	25	7.14	4	100	400	323	92.29
10	660 TO	689	674.50	40	11.43	3	120	360	298	85.14
9	630 TO	659	644.50	31	8.86	2	62	124	258	73.71
8	600 TO	629	614.50	47	13.43	1	47	47	227	64.86
7	570 TO	599	584.50	36	10.29	0	0	0	180	51.43
6	540 TO	569	554.50	38	10.86	-1	-38	38	144	41.14
5	510 TO	539	524.50	37	10.57	-2	-74	148	106	30.29
4	480 TO	509	494.50	23	6.57	-3	-69	207	69	19.71
3	450 TO	479	464.50	23	6.57	-4	-92	368	46	13.14
2	420 TO	449	434.50	17	4.86	-5	-85	425	23	6.57
1	390 TO	419	404.50	6	1.71	-6	-36	216	6	1.71
						SUMS =	92	3278		

REGROUPED FOR CHISQ TESTS TO GIVE 14 INTERVALS WITHFREQUENCIES OF

6 17 23 23 37 38 36 47 31 40 25 13 9 5

CHISQ NORMAL = 0.48577 CHISQ UNIFORM = 96.480

HISTOGRAM FOR THE CONDITION WHEN REACH=2. S.I.=3.00 BITS. R.I.=1.00 BIT.



FREQUENCY DISTRIBUTION FORTHE CONDITION WHEN REACH=2, S.I.=3.00 UITS, R.I.=3.00 BITS.

MAXIMUM = 1237 MINIMUM = 417 RANGE= 820 INTERVAL WIDTH = 50

MEAN = 605.79 IN INTERVAL 5. ST. DVN. = 68.673 MEDIAN = 611.00

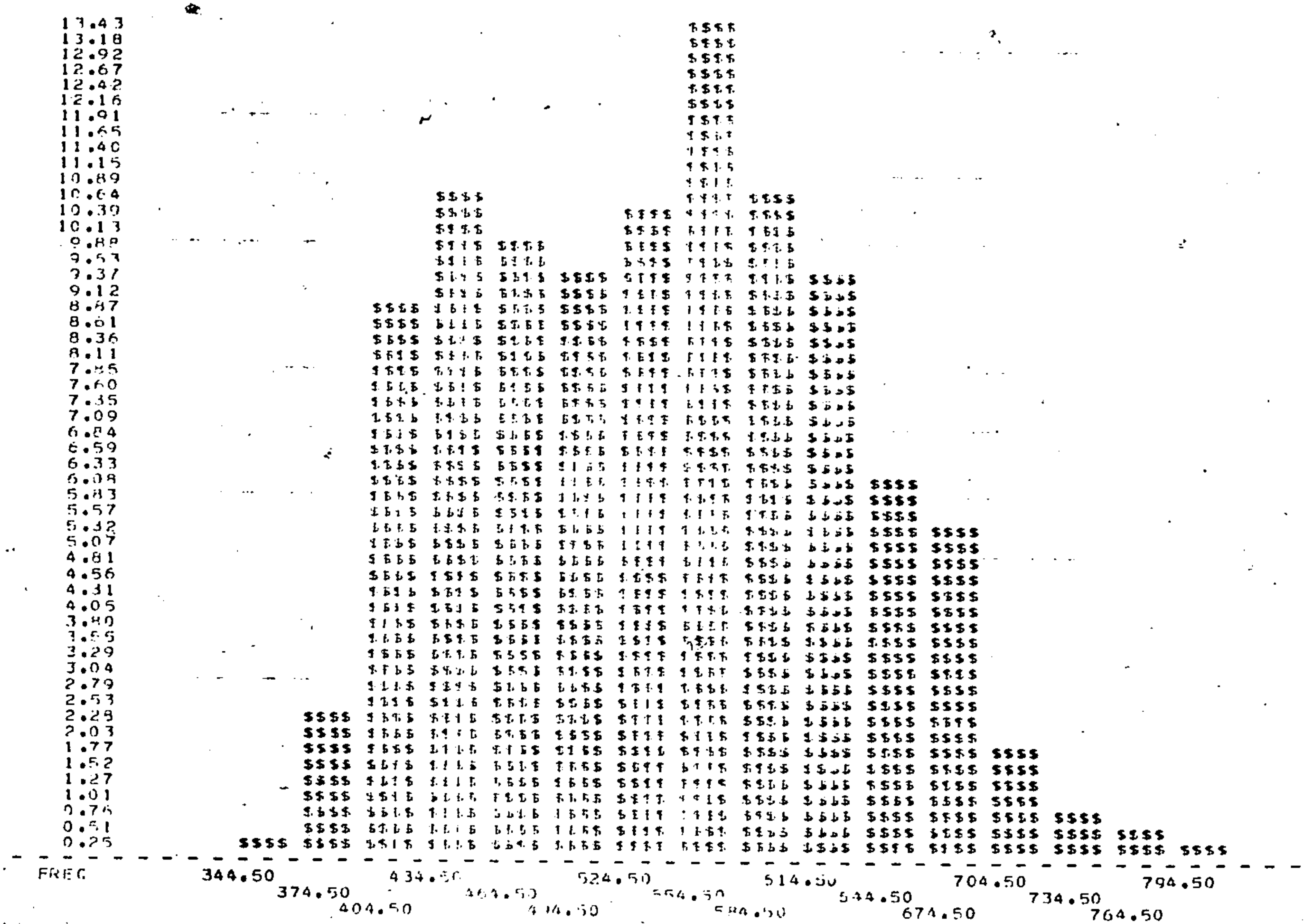
INT. NO.	EXACT LIMITS			MID-POINT	F	FX	D	FD	F*D**2	CUM F	- %
17	1200	TO	1249	1224.5	1	0.29	12	12	144	350	100.00
16	1150	TO	1199	1174.5	0	0.00	11	0	0	349	99.71
15	1100	TO	1149	1124.5	0	0.00	10	0	0	349	99.71
14	1050	TO	1099	1074.5	0	0.00	9	0	0	349	99.71
13	1000	TO	1049	1024.5	0	0.00	8	0	0	349	99.71
12	950	TO	999	974.50	0	0.00	7	0	0	349	99.71
11	900	TO	949	924.50	0	0.00	6	0	0	349	99.71
10	850	TO	899	874.50	0	0.00	5	0	0	349	99.71
9	800	TO	849	824.50	0	0.00	4	0	0	349	99.71
8	750	TO	799	774.50	16	4.57	3	48	144	349	99.71
7	700	TO	749	724.50	28	8.00	2	56	112	333	95.14
6	650	TO	699	674.50	50	14.29	1	50	50	305	87.14
5	600	TO	649	624.50	102	29.14	0	0	0	255	72.86
4	550	TO	599	574.50	54	15.43	-1	-54	54	153	43.71
3	500	TO	549	524.50	51	14.57	-2	-102	204	99	28.29
2	450	TO	499	474.50	44	12.57	-3	-132	396	48	13.71
1	400	TO	449	424.50	4	1.14	-4	-16	64	4	1.14
							SUMS =	-138	1168		

REGROUPED FOR CHISQ TESTS TO GIVE 7 INTERVALS WITHFREQUENCIES OF

48 51 54 102 50 28 17

CHISQ NORMAL = 0.19514 CHISQ UNIFORM = 85.260

HISTOGRAM FOR THE CONDITION WHEN REACH=1. S.I.=2.58 BITS. R.I.=2.58 BITS.



FREQUENCY DISTRIBUTION FORTHE CONDITION WHEN REACH=1, S.I.=2.58 BITS, R.I.=2.58 BITS.

MAXIMUM = 789 MINIMUM = 342 RANGE= 447 INTERVAL WIDTH = 30

MEAN = 532.98 IN INTERVAL 7. ST. DVN. = 88.563 MEDIAN = 534.00

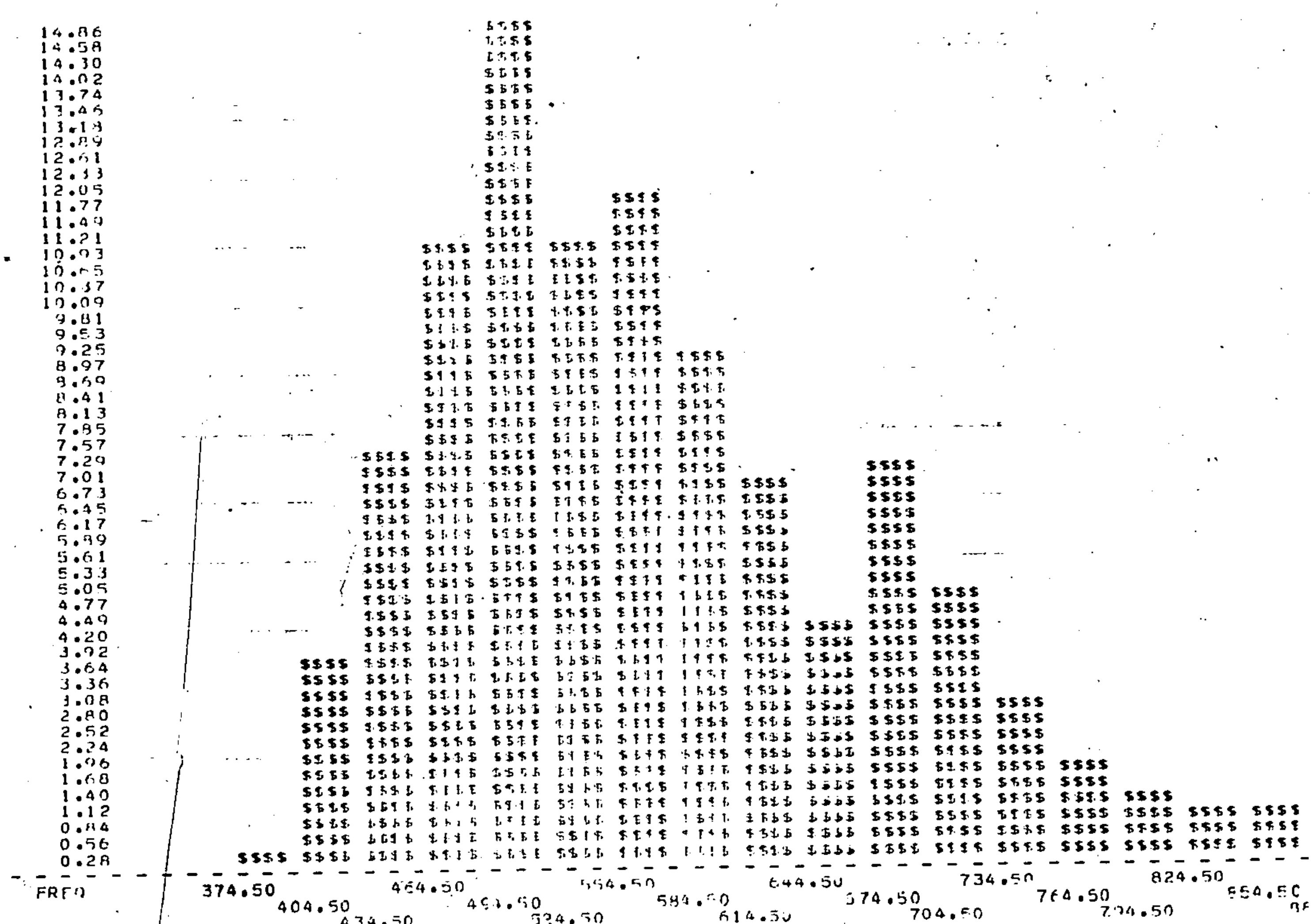
INT. NO.	EXACT LIMITS	MID-POINT	F	FX	D	FD	F*D**2	CUM F	%
16	780 TO 809	794.50	1	0.29	9	9	81	350	100.00
15	750 TO 779	764.50	2	0.57	8	16	128	349	99.71
14	720 TO 749	734.50	3	0.86	7	21	147	347	99.14
13	690 TO 719	704.50	6	1.71	6	36	216	344	98.29
12	660 TO 689	674.50	19	5.43	5	95	475	338	96.57
11	630 TO 659	644.50	21	6.00	4	84	336	319	91.14
10	600 TO 629	614.50	33	9.43	3	99	297	298	85.14
9	570 TO 599	584.50	37	10.57	2	74	148	265	75.71
8	540 TO 569	554.50	47	13.43	1	47	47	228	65.14
7	510 TO 539	524.50	36	10.29	0	0	0	181	51.71
6	480 TO 509	494.50	33	9.43	-1	-33	33	145	41.43
5	450 TO 479	464.50	35	10.00	-2	-70	140	112	32.00
4	420 TO 449	434.50	37	10.57	-3	-111	333	77	22.00
3	390 TO 419	404.50	31	8.86	-4	-124	496	40	11.43
2	360 TO 389	374.50	8	2.29	-5	-40	200	9	2.57
1	330 TO 359	344.50	1	0.29	-6	-6	36	1	0.29
					SUMS =	97	3113		

REGROUPED FOR CHISQ TESTS TO GIVE 13 INTERVALS WITHFREQUENCIES OF

9 31 37 35 33 36 47 37 33 21 19 6 6

CHISQ NORMAL = 0.81974 CHISQ UNIFORM = 79.446

HISTOGRAM FOR THE CONDITION WHEN REACH=2, S.I.=2.58 BITS, R.I.=2.58 BITS.



FREQUENCY DISTRIBUTION FORTHE CONDITION WHEN REACH=2. S.I.=2.59 BITS. R.I.=2.59 BITS.

MAXIMUM = 883 MINIMUM = 381 RANGE= 502 INTERVAL WIDTH = 30

MEAN = 574.03 IN INTERVAL 7. ST. DVN. = 103.48 MEDIAN = 546.50

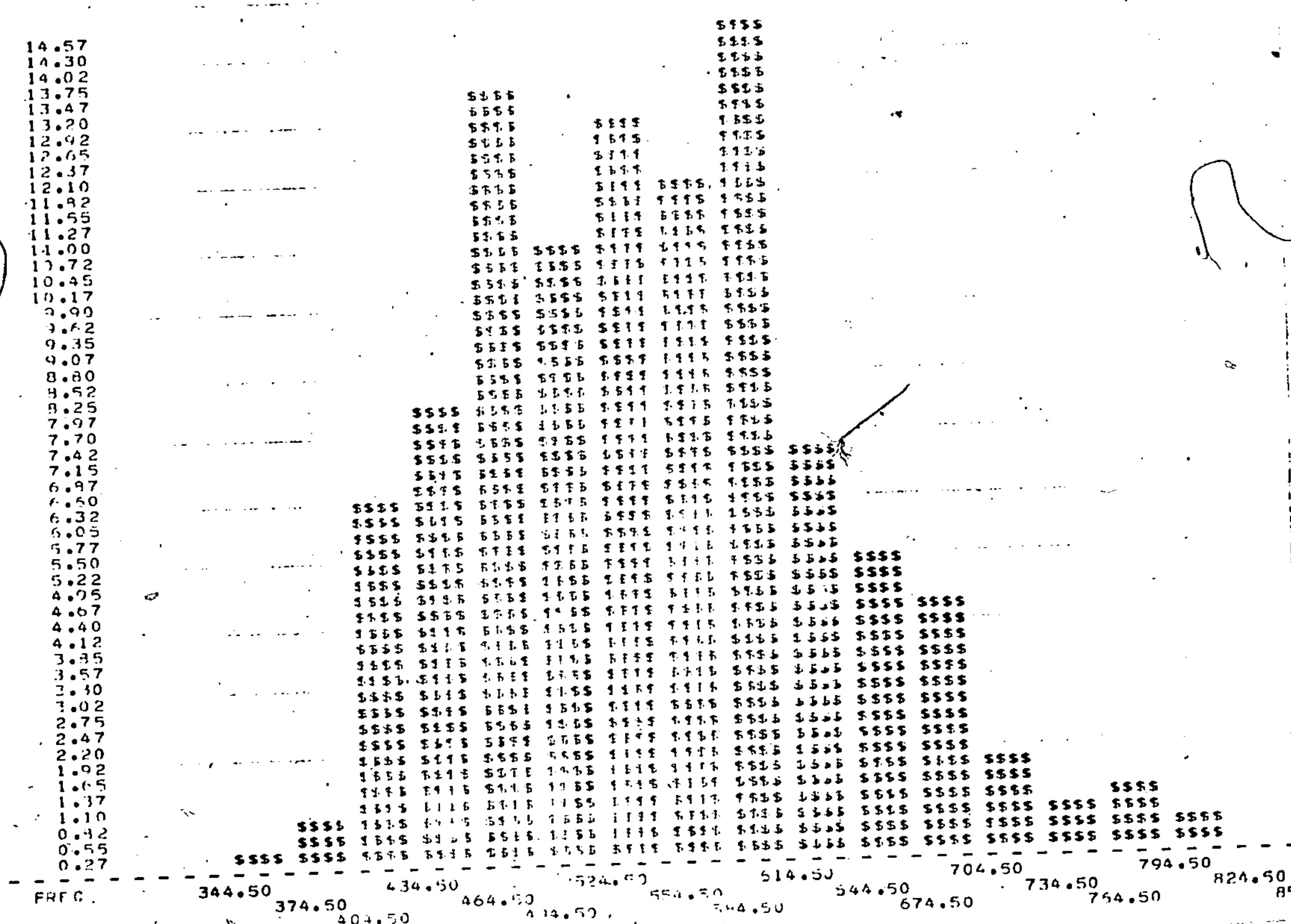
INT. NO.	EXACT LIMITS		MID-POINT	F	FX	D	FD	F*D**2	CUM F	- %
18	670 TO	899	884.50	3	0.86	11	33	363	350	100.00
17	840 TO	869	854.50	3	0.86	10	30	300	347	99.14
16	810 TO	839	824.50	3	0.86	9	27	243	344	98.29
15	780 TO	809	794.50	4	1.14	8	32	256	341	97.43
14	750 TO	779	764.50	6	1.71	7	42	294	337	96.29
13	720 TO	749	734.50	10	2.86	6	60	360	331	94.57
12	650 TO	719	704.50	17	4.86	5	85	425	321	91.71
11	660 TO	689	674.50	25	7.14	4	100	400	304	86.86
10	630 TO	659	644.50	15	4.29	3	45	135	279	79.71
9	600 TO	629	614.50	24	6.86	2	48	96	264	75.43
8	570 TO	599	584.50	11	8.96	1	31	31	240	68.57
7	540 TO	569	554.50	41	11.71	0	0	0	209	59.71
6	510 TO	539	524.50	38	10.86	-1	-38	38	168	48.00
5	480 TO	509	494.50	52	14.86	-2	-104	208	130	37.14
4	450 TO	479	464.50	38	10.86	-3	-114	342	78	22.29
3	420 TO	449	434.50	26	7.43	-4	-104	416	40	11.43
2	390 TO	419	404.50	13	3.71	-5	-65	325	14	4.00
1	360 TO	389	374.50	1	0.29	-6	-6	36	1	0.29
						SUMS =	102	4268		

REGROUPED FOR CHISQ TESTS TO GIVE 15 INTERVALS WITHFREQUENCIES OF

14 25 38 52 38 41 31 24 15 25 17 10 6 7 6

CHISQ NORMAL = 0.83194 CHISQ UNIFORM = 123.23

HISTOGRAM FOR THE CONDITION WHEN REACH=1, S.I.=2.58 BITS, R.I.=2.00 BITS.



FREQUENCY DISTRIBUTION FORTHE CONDITION WHEN REACH=1, S.I.=2.58 BITS, R.I.=2.00 BITS

MAXIMUM = 844 MINIMUM = 335 RANGE= 509 INTERVAL WIDTH = 30

MEAN = 537.97 IN INTERVAL 7. ST. DVN. = 85.535 MEDIAN = 532.50

INT. NO.	EXACT LIMITS	MID-POINT	F	F%	D	FD	F*D**2	CUM F	CUM %
18	840 TO 869	854.50	1	0.29	11	11	121	350	100.00
17	810 TO 839	824.50	0	0.00	10	0	0	349	99.71
16	780 TO 809	794.50	2	0.57	9	18	162	349	99.71
15	750 TO 779	764.50	4	1.14	8	32	256	347	99.14
14	720 TO 749	734.50	3	0.86	7	21	147	343	98.00
13	690 TO 719	704.50	6	1.71	6	36	216	340	97.14
12	660 TO 689	674.50	15	4.29	5	75	375	334	95.43
11	630 TO 659	644.50	18	5.14	4	72	288	319	91.14
10	600 TO 629	614.50	25	7.14	3	75	225	301	86.00
9	570 TO 599	584.50	51	14.57	2	102	204	276	78.86
8	540 TO 569	554.50	41	11.71	1	41	41	225	64.29
7	510 TO 539	524.50	45	12.86	0	0	0	184	52.57
6	480 TO 509	494.50	38	10.86	-1	-38	38	139	39.71
5	450 TO 479	464.50	47	13.43	-2	-94	188	101	28.86
4	420 TO 449	434.50	28	8.00	-3	-84	252	54	15.43
3	390 TO 419	404.50	22	6.29	-4	-88	352	26	7.43
2	360 TO 389	374.50	3	0.86	-5	-15	75	4	1.14
1	330 TO 359	344.50	1	0.29	-6	-6	36	1	0.29
					SUMS =	158	2976		

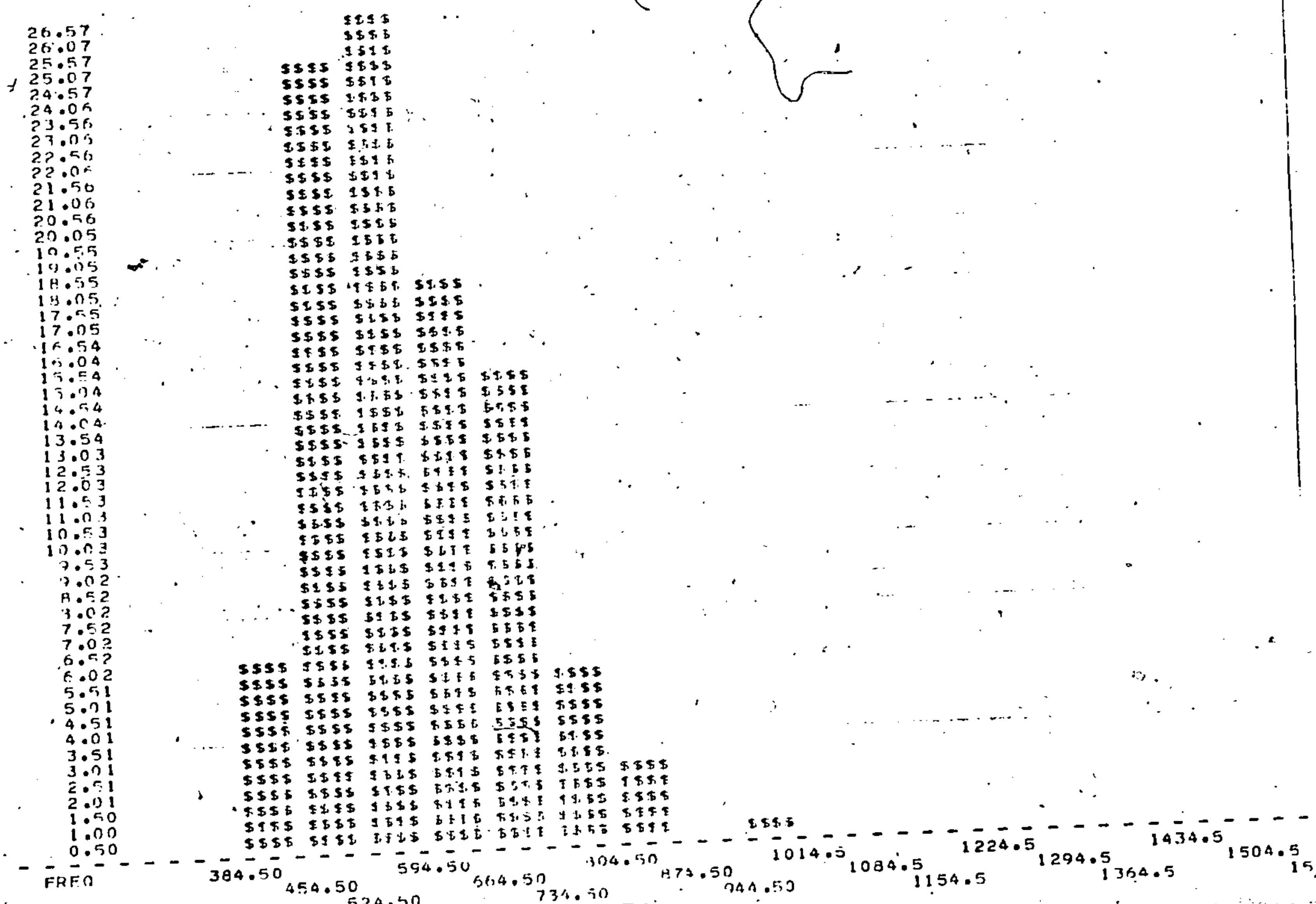
REGROUPED FOR CHISQ TESTS TO GIVE 12 INTERVALS WITHFREQUENCIES OF

26 23 47 38 45 41 51 25 19 13 [illegible] 7

CHISQ NORMAL = 0.79117 CHISQ UNIFORM = 86.251

191

HISTOGRAM FOR THE CONDITION WHEN REACH=2. S.I.=2.58 BITS, R.I.=2.00 BITS.



FREQUENCY DISTRIBUTION FORTHE CONDITION WHEN REACH=2, S.I.=2.58 BITS, R.I.=2.00 BITS.

MAXIMUM = 1670 MINIMUM = 391 RANGE= 1289 INTERVAL WIDTH = 70

MEAN = 560.48 IN INTERVAL 4. ST. DVN. = 130.85 MEDIAN = 539.50

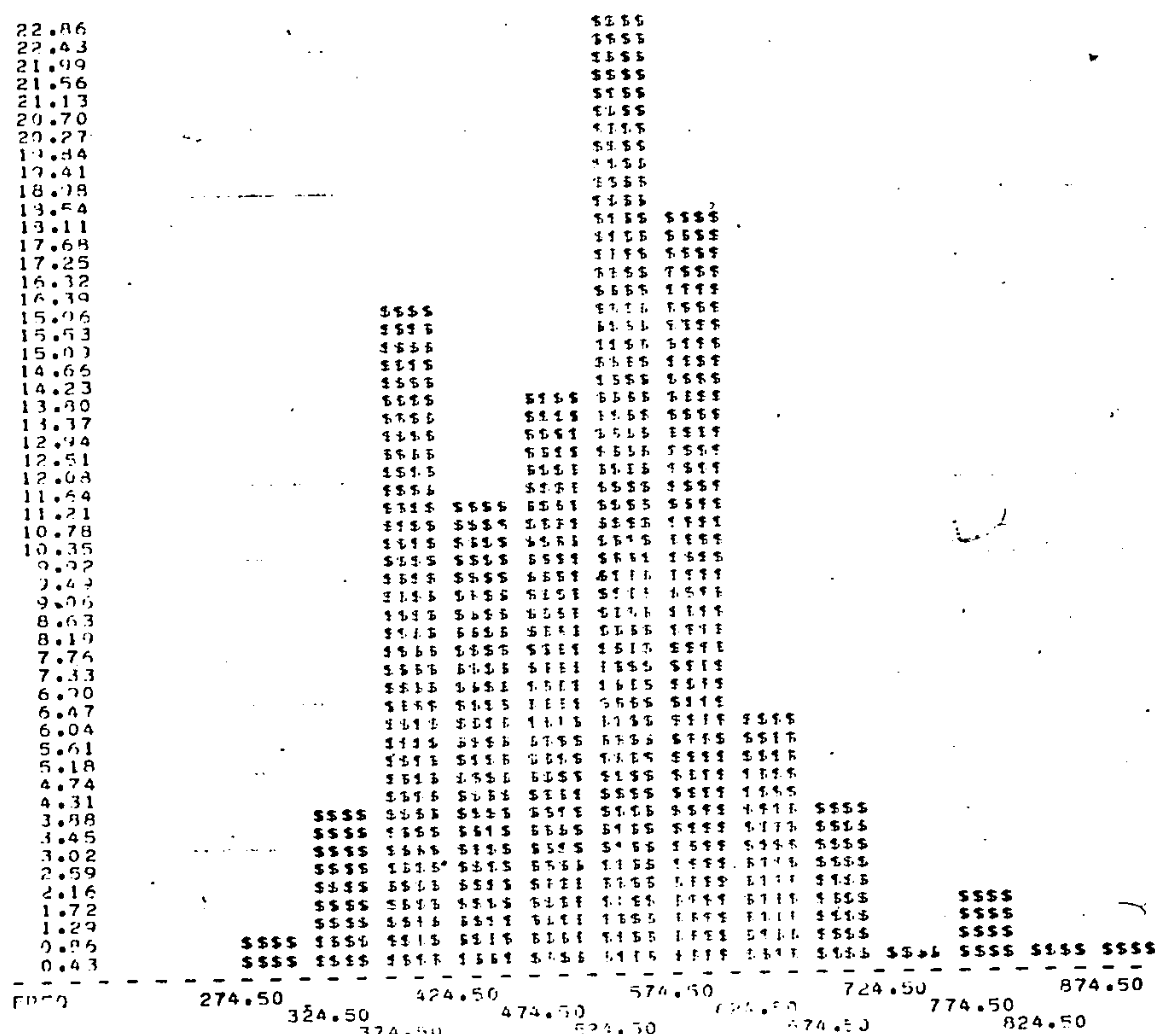
INT. NO.	EXACT LIMITS	MID-POINT.	F	FX	D	FD	FD**2	CUM F	%
19	1610 TO 1679	1644.5	1	0.29	15	15	225	350	100.00
18	1540 TO 1609	1574.5	1	0.29	14	14	196	349	99.71
17	1470 TO 1539	1504.5	0	0.00	13	0	0	348	99.43
16	1400 TO 1469	1434.5	0	0.00	12	0	0	348	99.43
15	1330 TO 1399	1364.5	0	0.00	11	0	0	348	99.43
14	1260 TO 1329	1294.5	0	0.00	10	0	0	348	99.43
13	1190 TO 1259	1224.5	0	0.00	9	0	0	348	99.43
12	1120 TO 1189	1154.5	0	0.00	8	0	0	348	99.43
11	1050 TO 1119	1084.5	0	0.00	7	0	0	348	99.43
10	980 TO 1049	1014.5	0	0.00	6	0	0	348	99.43
9	910 TO 979	944.50	2	0.57	5	10	50	348	99.43
8	840 TO 909	874.50	0	0.00	4	0	0	346	98.86
7	770 TO 839	804.50	9	2.57	3	27	81	346	98.86
6	700 TO 769	734.50	19	5.43	2	38	76	337	96.29
5	630 TO 699	664.50	53	15.14	1	53	53	318	90.86
4	560 TO 629	594.50	63	18.00	0	0	0	265	75.71
3	490 TO 559	524.50	93	26.57	-1	-93	93	202	57.71
2	420 TO 489	454.50	88	25.14	-2	-176	352	109	31.14
1	350 TO 419	384.50	21	6.00	-3	-63	189	21	6.00
					SUMS =	-175	1315		

REGROUPED FOR CHISQ TESTS TO GIVE 7 INTERVALS WITHFREQUENCIES OF

21 88 93 63 53 19 13

CHISQ NORMAL = 1.5522 CHISQ UNIFORM = 132.84

HISTOGRAM FOR THE CONDITION WHEN REACH=1, S.I.=2.58 BITS, P.I.=1.00 BIT.



FREQUENCY DISTRIBUTION FORTHE CONDITION WHEN REACH=1, S.I.=2.59 BITS, R.I.=1.00 BIT.

MAXIMUM = 889 MINIMUM = 278 RANGE= 611 INTERVAL WIDTH = 50

MEAN = 500.66 IN INTERVAL 6 ST. DVN. = 101.18 MEDIAN = 508.00

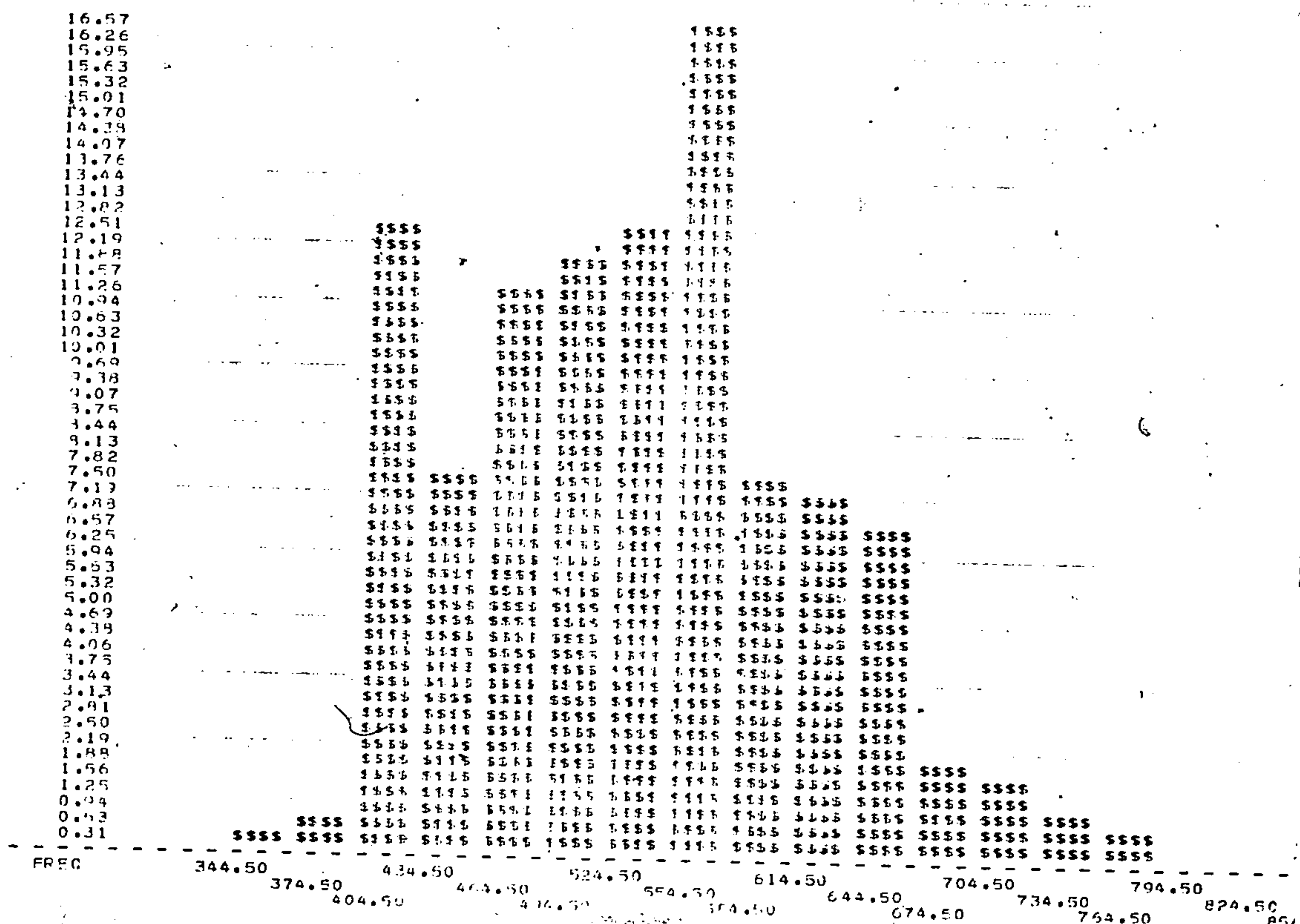
INT. NO.	EXACT LIMITS	MID-POINT	F	F%	D	FD	F*D**2	CUM F	CUM %
13	850 TO 899	874.50	1	0.29	7	7	49	350	100.00
12	800 TO 849	824.50	1	0.29	6	6	36	349	99.71
11	750 TO 799	774.50	6	1.71	5	30	150	348	99.43
10	700 TO 749	724.50	2	0.57	4	8	32	342	97.71
9	650 TO 699	674.50	14	4.00	3	42	126	340	97.14
8	600 TO 649	624.50	21	6.00	2	42	84	326	93.14
7	550 TO 599	574.50	64	18.29	1	64	64	305	87.14
6	500 TO 549	524.50	80	22.86	0	0	0	241	68.86
5	450 TO 499	474.50	49	14.00	-1	-49	49	161	46.00
4	400 TO 449	424.50	40	11.43	-2	-80	160	112	32.00
3	350 TO 399	374.50	56	16.00	-3	-168	504	72	20.57
2	300 TO 349	324.50	13	3.71	-4	-52	208	16	4.57
1	250 TO 299	274.50	3	0.86	-5	-15	75	3	0.86
					SUMS =	-165	1537		

REGROUPED FOR CHISQ TESTS TO GIVE 9 INTERVALS WITHFREQUENCIES OF

16 56 40 49 80 64 21 16 8

CHISQ NORMAL = 0.35661 CHISQ UNIFORM = 129.57

HISTOGRAM FOR THE CONDITION WHEN REACH=2, S.I.=2.58 BITS, R.I.=1.00 BIT.



FREQUENCY DISTRIBUTION FORTHE CONDITION WHEN REACH=2, S.I.=2.58 BITS, R.I.=1.00 BIT.

MAXIMUM = 879 MINIMUM = 346 RANGE= 533 INTERVAL WIDTH = 30

MEAN = 525.42 IN INTERVAL 7, ST. DVN. = 86.543 MEDIAN = 520.00

INT. NO.	EXACT LIMITS			MID-POINT	F	FX	D	FD	F*D**2	CUM F	- %
19	870	TO	899	884.50	1	0.29	12	12	144	350	100.00
18	840	TO	869	854.50	1	0.29	11	11	121	349	99.71
17	810	TO	839	824.50	0	0.00	10	0	0	348	99.43
16	780	TO	809	794.50	0	0.00	9	0	0	348	99.43
15	750	TO	779	764.50	2	0.57	8	16	128	348	99.43
14	720	TO	749	734.50	3	0.86	7	21	147	346	98.86
13	690	TO	719	704.50	6	1.71	6	36	216	343	98.00
12	660	TO	689	674.50	7	2.00	5	35	175	337	96.29
11	630	TO	659	644.50	23	6.57	4	92	368	330	94.29
10	600	TO	629	614.50	25	7.14	3	75	225	307	87.71
9	570	TO	599	584.50	26	7.43	2	52	104	282	80.57
8	540	TO	569	554.50	58	16.57	1	58	58	256	73.14
7	510	TO	539	524.50	44	12.57	0	0	0	198	56.57
6	480	TO	509	494.50	42	12.00	-1	-42	42	154	44.00
5	450	TO	479	464.50	39	11.14	-2	-78	156	112	32.00
4	420	TO	449	434.50	26	7.43	-3	-78	234	73	20.86
3	390	TO	419	404.50	44	12.57	-4	-176	704	47	13.43
2	360	TO	389	374.50	2	0.57	-5	-10	50	3	0.86
1	330	TO	359	344.50	1	0.29	-6	-6	36	1	0.29
							SUMS =	18	2908		

REGROUPED FOR CHISQ TESTS TO GIVE 12 INTERVALS WITHFREQUENCIES OF

47 26 39 42 44 58 26 25 23 7 6 7

CHISQ NORMAL = 1.3426 CHISQ UNIFORM = 110.59

APPENDIX G

ANOVA SUMS OF SQUARES OUTPUTS

1. For Pilot-Study (Performance Time).
2. For Major-Study (Performance Time).
3. For Major-Study (Pulse Rate Difference).

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M

MEANS

S	N	TIME
1	10	523.964000
2	10	631.480000
3	10	573.455000
4	10	571.480000
5	10	593.900000
6	10	577.093000
7	10	636.468000
8	10	635.405000
9	10	635.302000
10	10	513.417000

P	N	TIME
1	50	576.353800
2	50	602.019000

N	N	TIME
1	20	608.074000
2	20	605.559300
3	20	614.117500
4	20	587.156500
5	20	531.024500

OVERALL MEANS	100	589.186400

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M

ANALYSIS OF VARIANCE FOR VARIABLE TIME   MEAN 589.186400

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE
N	4	92666.134	23166.5335
P	1	16467.562	16467.5623
N*P	4	910.016	227.5040
S	9	190245.857	21138.4285
N*S	36	63300.224	1758.3396
P*S	9	4891.724	543.5248
N*P*S	36	25933.116	720.3643
CORRECTED TOTAL	99	394414.633	3983.9862

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M

MEANS

S	N	TIME
1	8	576.678750
2	8	626.393750
3	8	551.301250
4	8	557.833750
5	8	514.918750
6	8	575.036250
7	8	648.047500
8	8	609.691250
9	8	616.323750
10	8	467.106250

R	N	TIME
1	40	562.466250
2	40	586.200000

N	N	TIME
1	20	569.249500
2	20	567.666500
3	20	579.936500
4	20	580.480000

OVERALL MEANS	80	574.333125

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M

ANALYSIS OF VARIANCE FOR VARIABLE TIME   MEAN   574.333125

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE
N	3	81936.580	27312.1934
R	1	11265.818	11265.8178
N*R	3	954.763	318.2543
S	9	202024.728	22447.1920
N*S	27	51926.996	1923.2221
R*S	9	2243.837	249.3152
N*R*S	27	12092.505	447.8705
CORRECTED TOTAL	79	362445.228	4587.9143

STATISTICAL ANALYSIS SYSTEM

MEANS

S	N	TIME
1	6	438.366667
2	6	601.303333
3	6	533.003333
4	6	518.378333
5	6	511.181667
6	6	535.505000
7	6	639.190000
8	6	586.866667
9	6	579.593333
10	6	426.110000
R		
1	30	523.853333
2	30	550.038333
N		
1	20	548.502000
2	20	549.321000
3	20	513.014500
OVERALL MEANS	60	536.945833

STATISTICAL ANALYSIS SYSTEM

ANALYSIS OF VARIANCE FOR VARIABLE TIME MEAN 536.945833

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE
N	2	17187.969	8593.9845
R	1	10284.813	10284.8134
N*R	2	188.213	94.1065
S	9	251620.446	27957.8273
N*S	18	16183.992	899.1107
R*S	9	29227.354	3247.4838
N*R*S	18	8732.866	485.1592
CORRECTED TOTAL	59	333125.653	5651.2823

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M

MEANS

S	N	H
1	10	9.9000000
2	10	13.7000000
3	10	10.6000000
4	10	11.2000000
5	10	10.6000000
6	10	12.0000000
7	10	12.6000000
8	10	10.6000000
9	10	11.7000000

R	N	H
1	45	[illegible].0111111
2	45	12.3222222

N	N	H
1	18	14.0000000
2	18	12.0000000
3	18	10.6666889
4	18	10.2222222
5	18	[illegible].7222222

OVERALL MEANS 90 11.3666667

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M

ANALYSIS OF VARIANCE FOR VARIABLE H   MEAN 11.3666667

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE
N	4	208.40000	52.100000
R	1	190.67778	190.677778
N*R	4	10.26667	2.566667
S	8	14[illegible].00000	14.625000
N*S	32	44[illegible].00000	14.031250
R*S	8	33.[illegible]	4.162779
N*R*S	32	7[illegible].73333	2.[illegible]417
CORRECTED TOTAL	89	1118.90000	12.571910

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M

MEANS

S	N	H
1	8	11.6250000
2	8	12.5000000
3	8	11.7500000
4	8	12.5000000
5	8	10.3750000
6	8	13.1250000
7	8	11.7500000
8	8	10.1250000
9	8	12.0000000
R		
1	36	10.3611111
2	36	13.1388889
N		
1	18	14.1111111
2	18	12.1111111
3	18	10.5555556
4	18	10.2222222
OVERALL MEANS	72	11.7500000

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M

ANALYSIS OF VARIANCE FOR VARIABLE H   MEAN 11.7500000

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE
N	3	170.388889	56.796296
R	1	138.888889	138.888889
N*R	3	2.000000	0.666667
S	8	61.000000	7.625000
N*S	24	424.111111	17.671296
R*S	8	19.611111	2.451389
N*R*S	24	63.500000	2.645833
CORRECTED TOTAL	71	879.500000	12.387324

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M

MEANS

S	N	H
1	6	9.3333333
2	6	11.6666667
3	6	13.5000000
4	6	13.5000000
5	6	10.6666667
6	6	12.3333333
7	6	10.3333333
8	6	12.8333333
9	6	15.5000000

R	N	H
1	27	10.7777778
2	27	13.5925926

N	N	H
1	18	14.4444444
2	18	12.1666667
3	18	9.9444444

OVERALL MEANS	54	12.1851852

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M

1

ANALYSIS OF VARIANCE FOR VARIABLE H

MEAN 12.1851852

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE
N	2	182.259259	91.129630
R	1	106.962963	106.962963
N*R	2	0.703704	0.351852
S	8	174.148148	21.768519
N*S	16	235.740741	14.733795
R*S	8	13.703704	1.712963
N*R*S	16	72.629630	4.539352
CORRECTED TOTAL	53	786.148148	14.832984

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M

MEANS

P	N	TIME
1	12	571.201667
2	12	415.320000
3	12	503.116667
4	12	600.846667
5	12	522.983333
R		
1	30	504.816333
2	30	540.571000
N		
1	30	474.611667
2	30	570.775667
S		
1	20	483.575000
2	20	526.996500
3	20	557.509500
OVERALL MEANS	60	522.693667

S T A T I S T I C A L   A N A L Y S I S   S Y S T E M

ANALYSIS OF VARIANCE FOR VARIABLE TIME   MEAN 522.693667

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE
S	2	55218.534	27609.267
N	1	133712.723	133712.723
S*N	2	3422.228	1711.114
R	1	19175.943	19175.943
S*R	2	255.863	127.932
N*R	1	2818.913	2818.913
S*N*R	2	2261.402	1130.701
P	4	242635.655	60658.914
S*P	8	2766.698	345.837
N*P	4	16096.290	4024.072
S*N*P	8	12226.874	1528.359
R*P	4	3774.118	943.529
S*R*P	8	3884.032	485.504
N*R*P	4	2398.545	599.636
S*N*R*P	8	12297.655	1537.207
CORRECTED TOTAL	59	517945.473	8778.737

APPENDIX H

COMPUTER PROGRAMS

1. For Regression Analysis.

2. For Histograms.

```
$JOB    WATFIV  XXXXXXXXXX     HARJIT SINGH SETHI.
        IMPLICIT REAL*8 (A-H,O-Z)
        DIMENSION A(10,11),X(100),Y(100),R(100),ACY(100),C(100),ERROR(100
       1)
        I=5
        DO 1 ILH=1,I
        READ,X(ILH),Y(ILH)
    1   CONTINUE
        N=I
        NN=I-1
        DO 60 II=1,NN
        IA=II+1
        IB=II+2
        DO 10 I=1,IA
        DO 10 J=1,IA
        IF(I.EQ.1)GO TO 100
        IF(J.EQ.II+1)GO TO 100
  101   A(I,J)=A(I-1,J+1)
        GO TO 10
  100   A(I,J)=0
        DO 13 K=1,N
   13   A(I,J)=A(I,J)+X(K)**(I+J-2)
   10   CONTINUE
        DO 11 I=1,IA
        A(I,II+2)=0.
        DO 11 K=1,N
   11   A(I,II+2)=X(K)**(I-1)*Y(K)+A(I,II+2)
        DO 5 K=1,IA
        KK=K+1
        DO 15 J=KK,IB
   15   A(K,J)=A(K,J)/A(K,K)
        A(K,K)=1.
        DO 50 I=1,IA
        DO 49 J=1,IB
        IF(I.LE.K)GO TO 50
        IF(J.LE.K)GO TO 49
        A(I,J)=A(I,J)-A(K,J)*A(I,K)
   49   CONTINUE
        A(I,K)=0.0
   50   CONTINUE
    5   CONTINUE
        DO 43 K=1,II
        NK=IB-K
        DO 43 I=K,II
        NI=IA-I
   43   A(NI,IB)=A(NI,IB)-A(NI,NK)*A(NK,IB)
        DO 7 I=1,IA
    7   C(I)=A(I,II+2)
        DO 8 J=1,N
        ACY(J)=0
        DO 8 I=1,IA
    8   ACY(J)=C(I)*X(J)**(I-1)+ACY(J)
        Y2=0.0
        YY=0.0
        SUM=0.0
        ERR=0.0
        DO 9 I=1,N
        YY=YY+Y(I)
        Y2=Y2+Y(I)**2
        R(I)=ACY(I)-Y(I)
        ERROR(I)=R(I)/Y(I)*100.0
        ERRO=ERROR(I)
        ERR=ERR+DABS(ERRO)
    9   SUM=SUM+R(I)**2
        PRINT 200
        DO 21 I=1,IA
   21   PRINT,C(I)
        PRINT 202
        DO 20 I=1,N
   20   PRINT 41,X(I),Y(I),ACY(I),R(I) ,ERROR(I)
        YM=YY/N
        Y2M=Y2/N
        SS=Y2M-YM*YM
        SIG=DSQRT(SUM/(N-1))
        RH=1.0-SUM/SS/N
        RHI=DABS(RH)
        RHO=DSQRT(RHI)
        AERR=ERR/N
        STAN=SIG*100.0/YM
        PRINT 42,RHO,SIG,AERR
        PRINT 44,STAN
   44   FORMAT('0','PERCENT STANDARD ERROR =',F6.2)
  200   FORMAT('0',3X,'LEAST SQUARES FIT COEFFICIENTS')
   41   FORMAT(1X,11F12.5)
   42   FORMAT('0','CORRELATION COEFFICIENT = ',F12.6,6X,'SIG = ',F12.6,
       1 6X,'AVERAGE ERROR=',F6.2,' PERCENT')
  202   FORMAT('0',6X,'X(I)',8X,'Y(I)',8X,'ACY(I)',6X,'R(I)',4X,'PERCENT E
       1RROR')
   60   CONTINUE
        STOP
        END
```

```
//HISTO JOB (XXXXXXXXXX,5,...,2),'HARJIT',CLASS=A                          JOB  90
// EXEC WATFIV
//GO.SYSIN DD *
IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF373I STEP /GO      / START 75125.1203
IEF374I STEP /GO      / STOP  75125.1212 CPU  2MIN 12.14SEC MAIN   0K LCS 150K
IEF375I  JOB /HISTO   / START 75125.1203
IEF376I  JOB /HISTO   / STOP  75125.1212 CPU  2MIN 12.14SEC
```

```
$JOB
      DIMENSION A(350),TIME(7)
      INTEGER A,X,TIME
      REAL*4 TITLE(20)
      N=10
      DO 6 K=1,N
      II=0
      READ(5,1)TITLE
    1 FORMAT(20A4)
      DO 4 I=1,50
      READ(5,2)(TIME(KK),KK=1,7)
    2 FORMAT(1X,7(I6,4X))
      DO 4 IJ=1,7
      II=II+1
      A(II)=TIME(IJ)
    4 CONTINUE
      CALL SORT(350,A)
      CALL FOHINT(A,II,60,TITLE)
    6 CONTINUE
      STOP
      END
```

```
      SUBROUTINEFDHINT(X,N,NTYPE,TITLE)
CONVENTIONS FOR FDHINT/////////////////////////////////////////////////////
C       (1)--   X = THE INPUT VECTOR, ORDERED L TO H
C       (2)--   N = THE NUMBER OF OBSERVATIONS  < X(N) >
C       (3)--   NTYPE < 0 ==> FD TABLE GREATER THAN ZERO ==>FD TABLE&HIST
C       (4)--   TITLE = ONE CARD OF INFORMATION AS A HEADING
      COMMON/$FDHIT/JINT,F,MAX,MIN,RANGE,XINT,EMEAN,INTMEN,ESTDVN,EMED
      COMMON/FCHS$S/Y,CHID
      REALCHINMN(20),CHID(20),TITLE(20),CUMFP(20),LINE/'- - '/
      INTEGERF(20),D(20),FD(20),CUMF(20),FD2(20),CHINFQ(20),Y(20),GO,TOP
     *,BOT,RANGE,X(N),SUMFD,SUMFD2,FACTOR,CLINT1,XINT,B,INTVL(8)/1,2,3,5
     *,7,10,15,20/,EXCLS(20,2)
      INTEGERXXMAXX/Z7FFFFFFF/
      LOGICALJUMP
      SUMFD=0
      SUMFD2=0
      N2=N/2
      TOP=X(N)
      BOT=X(1)
      RANGE=TOP-BOT
      FACTOR=1
      I=1
CALCULATE INTERVAL WIDTH ==> 10 TO 20 INTERVALS, MAXIMIZED
      IF(RANGE.GT.19)GOTO10003
      INT=RANGE
      GOTO10005
10003 CLINT1=RANGE/FACTOR
      DO90004I=1,8
      INT=CLINT1/INTVL(I)
      IF(INT.EQ.0)GOTO10004
      IF(INT.GE.10.AND.INT.LT.19)GOTO10005
90004 CONTINUE
      FACTOR=FACTOR*10
      GOTO10003
10004 FACTOR=FACTOR/10
      IF(FACTOR.NE.0)GOTO10003
      PRINT50000
50000 FORMAT('-CAN''T COMPUTE SUITABLE INTERVAL WIDTH')
      RETURN
10005 JINT=INT+1
      XINT=INTVL(I)*FACTOR
CALCULATE STARTING VALUE FOR BOTTOM OF FIRST INTERVAL
      NBOT=BOT/XINT
      GO=XINT*NBOT
      IF(BOT.LT.0)GO=GO-XINT
      IF(FACTOR.GT.1)FACTOR=1
      IF(GO+XINT.LE.BOT)GO=GO+XINT
      EXCLS(1,1)=GO
      NXINT=XINT-1
      EXCLS(1,2)=GO+NXINT
      CHID(1)=GO+NXINT/2.
      IF(GO+XINT*JINT.LT.TOP)JINT=JINT+1
      DO90006K=2,JINT
      KM1=K-1
      EXCLS(K,1)=EXCLS(KM1,1)+XINT
      EXCLS(K,2)=EXCLS(KM1,2)+XINT
90006 CHID(K)=CHID(KM1)+XINT
CALCULATE FREQUENCIES IN THE INTERVALS
      K=1
      NCUMF=0
      PRCNT=100./N
C**********CALCULATION OF MEAN, ST. DEVN., AND MEDIAN ******************
      EMEAN=0.
      DO800I=1,N
800   EMEAN=EMEAN+X(I)
      EMEAN=EMEAN/N
      SUM=0.
      DO801I=1,N
801   SUM=SUM+(EMEAN-X(I))**2
      ESTDVN=SQRT(SUM/(N-1))
      EMED=X(N2+1)
      IF(N2*2.EQ.N)EMED=(EMED+X(N2))/2.
      MAX=0
      MIN=XXMAXX
      JUMP=.TRUE.
C********** FIT OBSERVATION INTO PROPER CLASS ****************************
      DO90008I=1,JINT
      B=EXCLS(I,2)
      IF(EMEAN.GT.B)INTMEN=I+1
      NFI=0
```

```
      DO90007J=K,N
      IF(X(J).GT.B)GOTO10008
90007 NFI=NFI+1
      IF(I.NE.JINT)NFI=0
10008 F(I)=NFI
      IF(NFI.GT.MAX)MAX=NFI
      IF(MIN.GT.NFI)MIN=NFI
      IF(NFI.LT.5)JUMP=.FALSE.
      K=J
      NCUMF=NCUMF+NFI
      CUMFP(I)=NCUMF*PRCNT
90008 CUMF(I)=NCUMF
      PRINT43,TITLE,TOP,BOT,RANGE,XINT,EMEAN,INTMEN,ESTDVN,EMED
C********** CALCULATE DEVIATION FROM MEAN, FD, FDSQUARED **************
      DO80001I=1,JINT
      IJ=I-INTMEN
      D(I)=IJ
      IJF=F(I)*IJ
      FD(I)=IJF
      SUMFD=SUMFD+IJF
      IJFIJ=IJF*IJ
      FD2(I)=IJFIJ
80001 SUMFD2=SUMFD2+IJFIJ
      WRITE(6,40005)(LINE,I=1,33)
      K=JINT+1
      DO80002I=1,JINT
      L=K-I
      FPRCT=F(L)*100./N
80002 PRINT40004,L,EXCLS(L,1),EXCLS(L,2),CMID(L),F(L),FPRCT,D(L),FD(L),F
     *D2(L),CUMF(L),CUMFP(L)
      PRINT40005,(LINE,I=1,33)
      PRINT40055,SUMFD,SUMFD2
      IF(JUMP)GOTO77777
      CALLCHIGPP(F,JINT,Y,NINT,CHINFQ)
      IF(NINT.NE.1)GOTO80003
      PRINT40021
      GOTO902
80003 PRINT46,NINT,(CHINFQ(I),I=1,NINT)
      GOTO779
77777 NINT=JINT
      DO777I=1,NINT
777   CHINFQ(I)=F(I)
779   J=1
      K=0
CALCULATION OF CHISQ TESTS
      DO708L=1,NINT
      XF=0.
      K=CHINFQ(L)+K
      DO707I=J,K
      XI=X(I)
      IF(XI.LT.EMEAN)INTMEN=L
C..........POSSIBLE ERROR HERE..........
  707 XF=XF+XI
      CHINMN(L)=XF/(K-J+1)
708   J=K+1
      MAXFQ=CHINFQ(INTMEN)
      FU=N*1./NINT
      CHINML=0.
      CHIUNF=0.
      DO901I=1,NINT
      IF=CHINFQ(I)
      XF=IF
      CHIXMN=CHINMN(I)
      XG=XF/MAXFQ*0.3989423
      XX=ABS(CHIXMN-EMEAN)/ESTDVN
      EN=0.3989423*EXP(-0.5*XX*XX)
      CHINML=CHINML+(XG-EN)**2/EN
901   CHIUNF=CHIUNF+(XF-EU)**2/EU
      PRINT491,CHINML,CHIUNF
902   IF(NTYPE.GT.0)CALLHISTGM(TITLE,NTYPE,N)
      RETURN
43    FORMAT('1FREQUENCY DISTRIBUTION FOR',20A4/'0   MAXIMUM =',I10,'
     * MINIMUM =',I10,'       RANGE=',I10,'      INTERVAL WIDTH =',I10/'0
     *MEAN =',G12.5,'  IN INTERVAL',I3,',      ST. DVN. =',G12.5,'      MED
     *IAN =',G12.5///'-INT. NO.',T25,'EXACT LIMITS',T49,'MID-POINT',T70,
     *'F',9X,'FX',10X,'D',9X,'FD',5X,'F*D**2',T122,'CUM F - X'/)
   46 FORMAT('0  REGROUPED FOR CHISQ TESTS TO GIVE',I3,' INTERVALS WITHF
     *REQUENCIES OF'/'0',6X,20I6)
  491 FORMAT('0  CHISQ NORMAL =',G12.5,'       CHISQ UNIFORM =',G12.5)
40004 FORMAT('0',I5,T13,4X,I10,' TO',1X,I10,7X,G12.5,3X,I8,3X,F8.2,3(3X,
```

```
     *I5),2X,I8,1X,F6.2)
40005 FORMAT(' ',33A4/)
40055 FORMAT(87X,'SUMS    =   ',I6,I11)
40021 FORMAT('-CHISQR TESTS BY-PASSED BECAUSE OF TOO FEW DATA POINTS')
      END

      SUBROUTINECHIGRP(F,JINT,Y,NINT,CHINFO)
      INTEGERF(JINT),Y(JINT),CHINFO(JINT)
      NINT=JINT
      DO 598 I=1,JINT
  598 Y(I)=F(I)
  597 IF(NINT.GT.3)GO TO 599
      IF(NINT.GT.2)GO TO 777
      IF(Y(1).LT.5.OR.Y(2).LT.5)GO TO 4
    2 DO 3 I=1,NINT
    3 CHINFO(I)=Y(I)
      RETURN
    4 NINT=1
      CHINFO(1)=Y(1)+Y(2)
      RETURN
  777 IF(Y(1).GE.5.AND.Y(2).GE.5.AND.Y(3).GE.5)GO TO 2
      IF(Y(1).LT.5)GO TO 6
      Y(2)=Y(2)+Y(3)
      IF(Y(2).LT.5)GO TO 4
    5 NINT=2
      GO TO 2
    6 Y(1)=Y(1)+Y(2)
      Y(2)=Y(3)
      IF(Y(2).LT.5.OR.Y(2).LT.5)GO TO 4
      GO TO 5
  599 IHALF=NINT/2
      KSPOT=2
      L=1
      M=Y(1)
  600 IF(M.GE.5)GO TO 601
      M=M+Y(KSPOT)
      KSPOT=KSPOT+1
      GO TO 602
  601 CHINFO(L)=M
      L=L+1
      M=Y(KSPOT)
      KSPOT=KSPOT+1
  602 IF(KSPOT.LE.IHALF)GO TO 600
      CHINFO(L)=M
      L=L+1
      J=L
      M=Y(NINT)
      KSPOT=NINT-1
  700 IF(M.GE.5)GO TO 701
      M=M+Y(KSPOT)
      KSPOT=KSPOT-1
      GO TO 770
  701 CHINFO(L)=M
      L=L+1
      M=Y(KSPOT)
      KSPOT=KSPOT-1
  770 IF(KSPOT.GT.IHALF)GO TO 700
      NMJK=J-1
      IF(M.GE.5.AND.CHINFO(NMJK).GE.5)GO TO 702
      KFSPOT=KSPOT+1
      IF(NMJK.NE.KFSPOT)GO TO 778
      M=Y(KFSPOT+1)
      L=L-1
  778 CHINFO(NMJK)=CHINFO(NMJK)+M
      L=L-1
      GO TO 703
  702 CHINFO(L)=M
  703 M=(L-NMJK)/2
      IF(IABS(M).EQ.0)GO TO 99999
      DO 704 I=1,M
      IK=L+1-I
      IM=NMJK+I
      NSKIP=CHINFO(IM)
      CHINFO(IM)=CHINFO(IK)
  704 CHINFO(IK)=NSKIP
99999 NINT=L
      IF(CHINFO(NMJK).GE.5)RETURN
      DO 705 I=1,L
  705 Y(I)=CHINFO(I)
      GO TO 597
      END
```

```
      SUBROUTINEHISTGM(TITLE,LINES,IN)
      INTEGERF(20),Y(20),JUNK(6)
      REALCMID(20),TITLE(20),LINE/'- - '/,BLANK/'  '/,$$$/'$$$$'/,GRAPH
     1(20)
      COMMON/$FDHIT/JINT,F,MAX,MIN,JUNK
      COMMON/FDH$$$/Y,CMID
      DO 333 III=1,20
  333 GRAPH(III)=BLANK
30000 WRITE(6,40006)TITLE
60002 IF(MIN.EQ.0)MIN=1
      NMAX=MAX-MIN+1
      SCALE=FLOAT(LINES-7)/FLOAT(NMAX)
      SC=1./SCALE
    4 DO 334 J=1,JINT
  334 Y(J)=(F(J)*SCALE+.5)
      N=LINES/30
      IF((LINES-N*30).LE.3*(N-1))N=N-1
      NSKIP=N*33+30-LINES
  297 IF(NSKIP.NE.0)PRINT40020,(I,I=1,NSKIP)
  298 K=(MAX*SCALE+1.5)
      FREQ=MAX*100./IN
      LINES=LINES-7
      DO 80005 I=1,LINES
      LL=K-I
      IF(LL.EQ.0)GO TO 60001
      DO 80004 J=1,JINT
80004 IF(Y(J).EQ.LL)GRAPH(J)=$$$
      WRITE(6,40007)FREQ,GRAPH
80005 FREQ=FREQ-SC*100./IN
      M=7+5*JINT/4
60001 WRITE(6,40005)(LINE,I=1,M)
      WRITE(6,40008)(CMID(M),M=1,JINT,3)
      WRITE(6,40009)(CMID(M),M=2,JINT,3)
      WRITE(6,40010)(CMID(M),M=3,JINT,3)
      LINES=LINES+7
50001 RETURN
40005 FORMAT(' ',33A4/)
40006 FORMAT('1HISTOGRAM FOR ',20A4//)
40007 FORMAT(F5.2,9X,20A5)
40008 FORMAT('    FREQ ',6X,7(G12.5,3X))
40009 FORMAT(' ',19X,7(G12.5,3X))
40010 FORMAT(' ',24X,7(G12.5,3X))
40020 FORMAT(' ',A1)
      END
$ENTRY
```

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