FINAL REPORT

CONTRACT NC. NAS8-18049

COMPUTER AND DATA PROCESSING SYSTEM WORKLOAD ANALYSIS

Submitted to
The George C. Marshall Space Flight Center
National Aeronautics and Space Administration
Huntsville, Alabama

By
The Department of Industrial Engineering
Auburn University
Auburn, Alabama

December 1966

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INTRODUCTION

This report presents the results of a workload analysis of data processing jobs executed on peripheral equipment at the George C. Marshall Space Flight Center, Huntsville, Alabama. The fundamental objectives of the report are to analyze data on peripheral equipment utilization, and to outline a workload mathematical simulation model that can be more fully analyzed in a later study for projected workloads. The Marshall Space Flight Center is replacing its so-called "second generation" data processing equipment with "third generation" equipment, and the conversion process requires recognition of those data processing jobs currently being processed on available peripheral equipment. The report presented herein is the result of an analysis of thirty-nine weeks' peripheral equipment utilization data for approximately 2,500 specific jobs. The report includes procedures followed throughout the study, data summaries made in the study, a description of the peripheral equipment workload mathematical simulation model outlined, and results of preliminary runs of the model.

STUDY PROCEDURES

This study consisted of the following steps:

1. Collection and organization of peripheral equipment utilization data for a thirty-nine week period for approximately 2,500 specific jobs.
2. Computation of the arithmetic average and standard deviation of peripheral equipment utilization time for each job.
3. Categorization and classification of jobs by processing frequency on the basis of computing autocorrelation coefficients.
4. Analysis of job classifications in order to determine, inasmuch as possible, the appropriate probability distributions for (a) frequency of processing, and (b) average processing time.
5. Outlining and initial application of a mathematical simulation model for jobs processed on peripheral equipment.

INITIAL SUMMARIES

General Comments. Before initial summaries were made, it was necessary to rearrange, correct, and resort all tapes on which initial data were stored. All records had to be converted to word sizes compatible with the Auburn University IBM 7040 computer. This phase of the study consumed a considerable amount of computer time.

Arithmetic Averages and Standard Deviations. For each of the approximately 2,500 jobs the arithmetic average and the standard deviation of processing time were computed according to the following respective formulas:

$$(1) \qquad \bar{X} = \sum_{i=1}^{n} X_i/n$$

$$(2) \qquad S = \sqrt{\frac{\sum_{i=1}^{n} X_i^2 - \left(\sum_{i=1}^{n} X_i\right)^2 / n}{n - 1}}$$

where X_i = the $i^{\underline{th}}$ processing time for a specific job

n = the number of times a specific job was processing during the thirty-nine week data availability period.

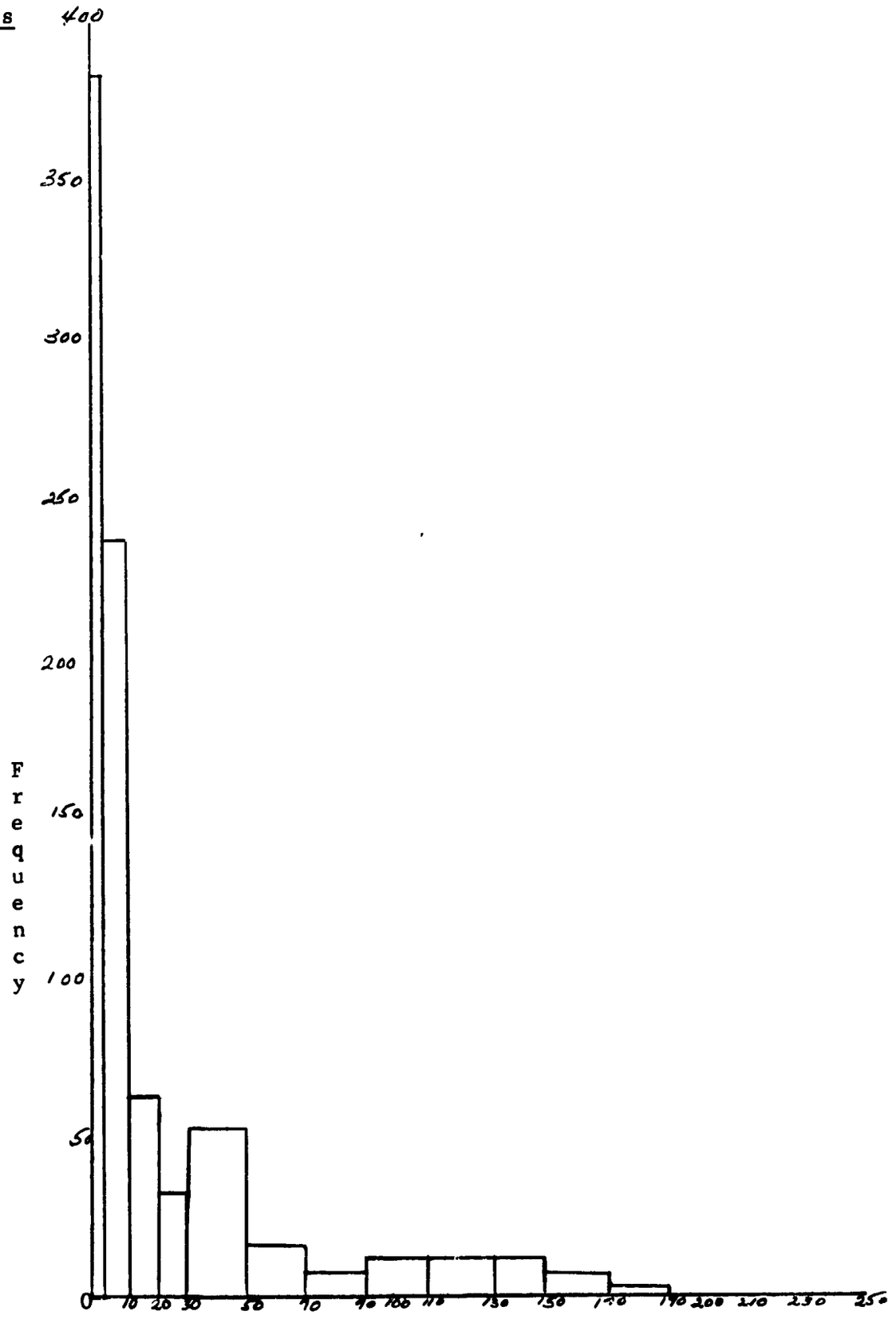
Results of these analyses appear under separate cover.

Categorization and Classification of Jobs. A system of grouping the approximately 2,500 specific jobs by utilizing information on their source and destination was devised. Eleven job groups, defined alphabetically as A, B, . . ., K, were established.

The number of times during the thirty-nine week data availability period that jobs in each job group required a particular number of minutes for processing is shown in the following set of figures. The last of the set of figures corresponds to a grouping of all job groups.

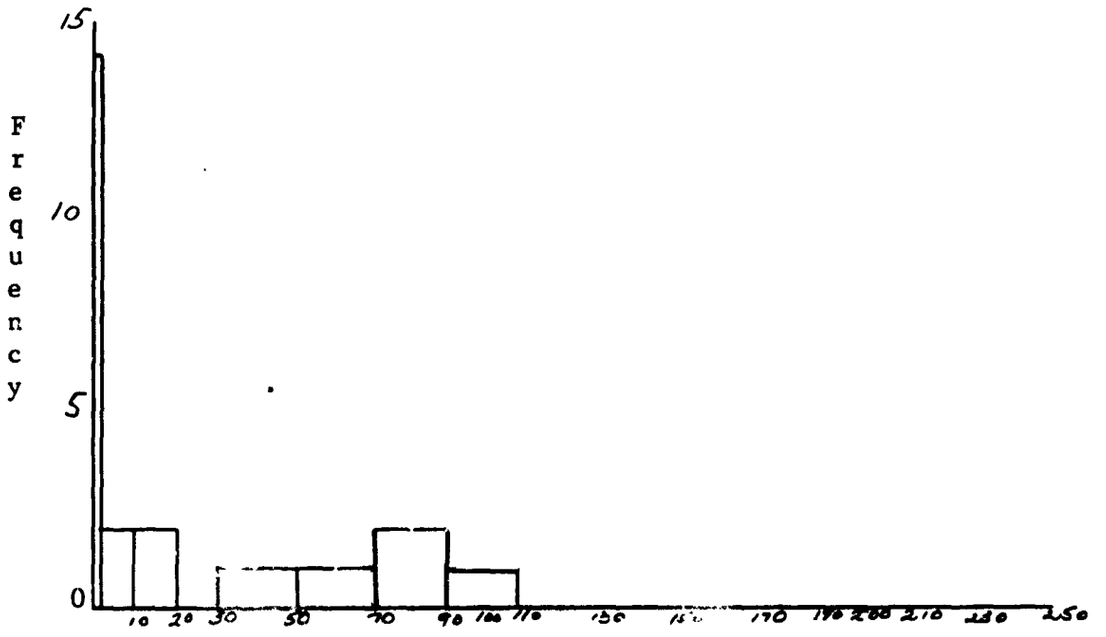
GROUP A

Minutes	Number of Jobs
0-1	387
2-10	238
11-20	63
21-30	33
31-50	53
51-70	14
71-90	5
91-110	7
111-130	7
131-150	7
151-170	5
171-190	1
191-210	0
211-230	0
231-252	0



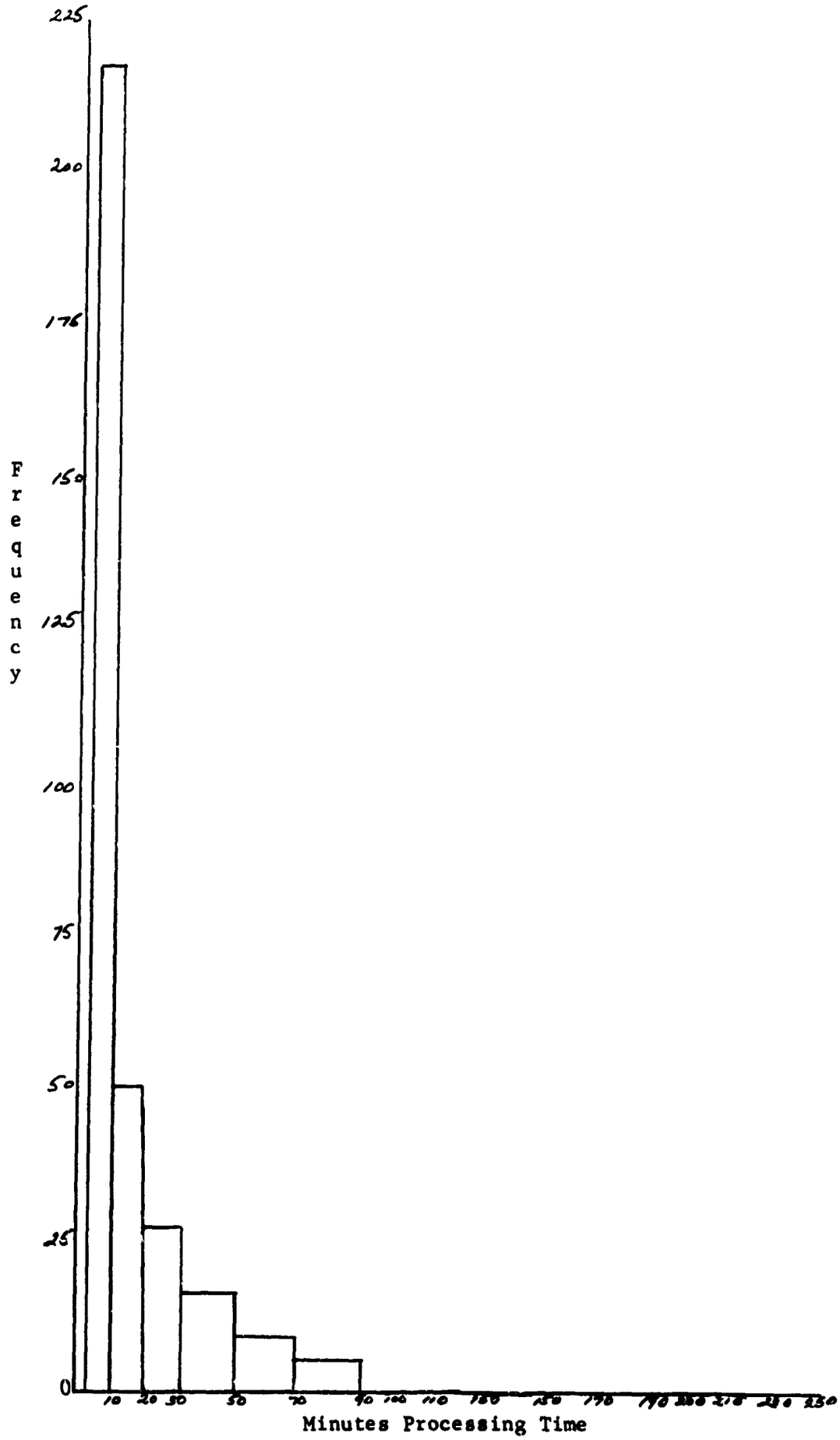
GROUP B

Minutes	Number of Jobs
0-1	14
2-10	2
11-20	2
21-30	0
31-50	1
51-70	1
71-90	2
91-110	1
111-130	0
131-150	0
151-170	0
171-190	0
191-210	0
211-230	0
231-252	0



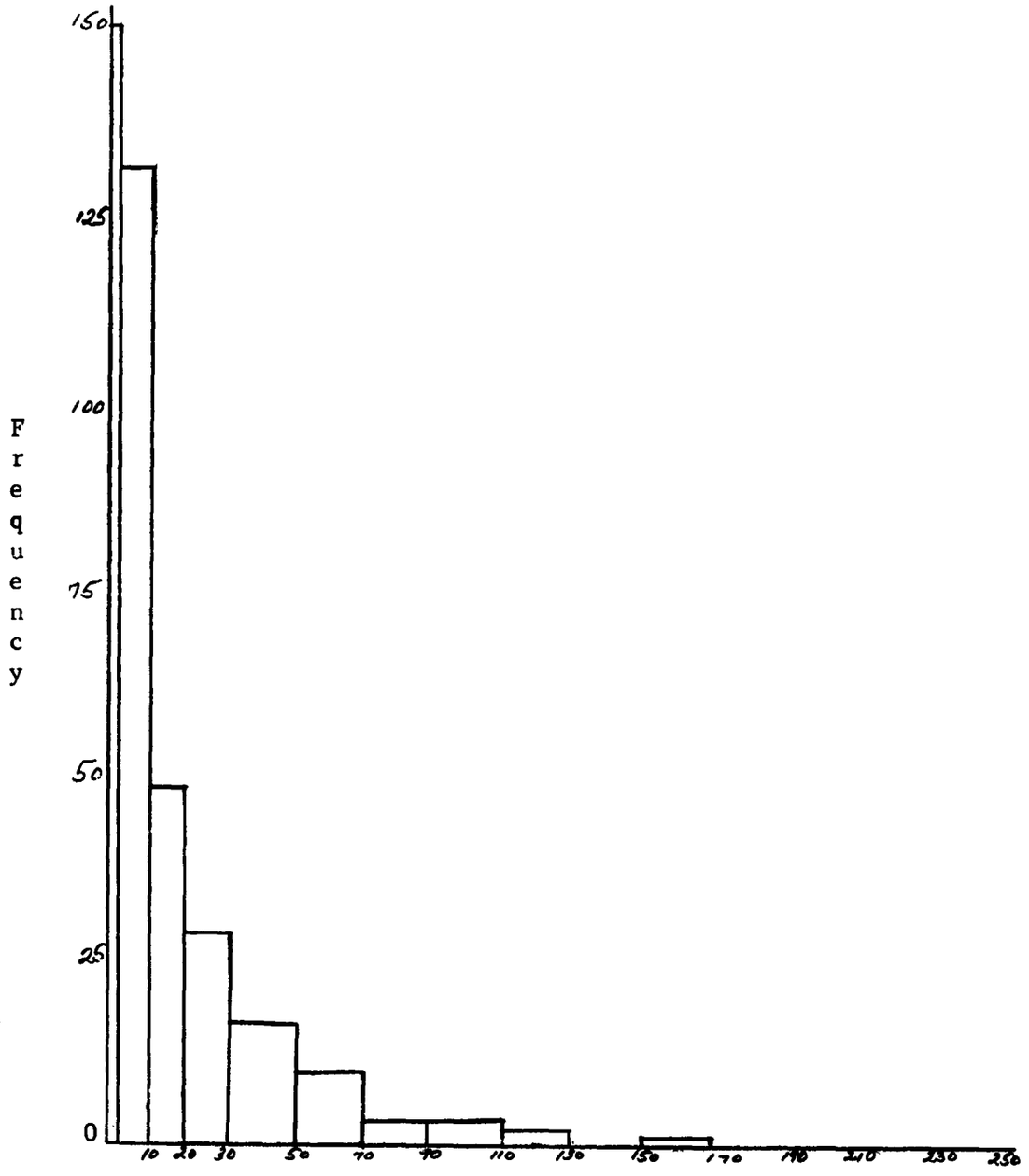
GROUP C

Minutes	Number of Jobs
0-1	167
2-10	217
11-20	49
21-30	27
31-50	15
51-70	8
71-90	4
91-110	0
111-130	0
131-150	0
151-170	0
171-190	0
191-210	0
211-230	0
231-252	0



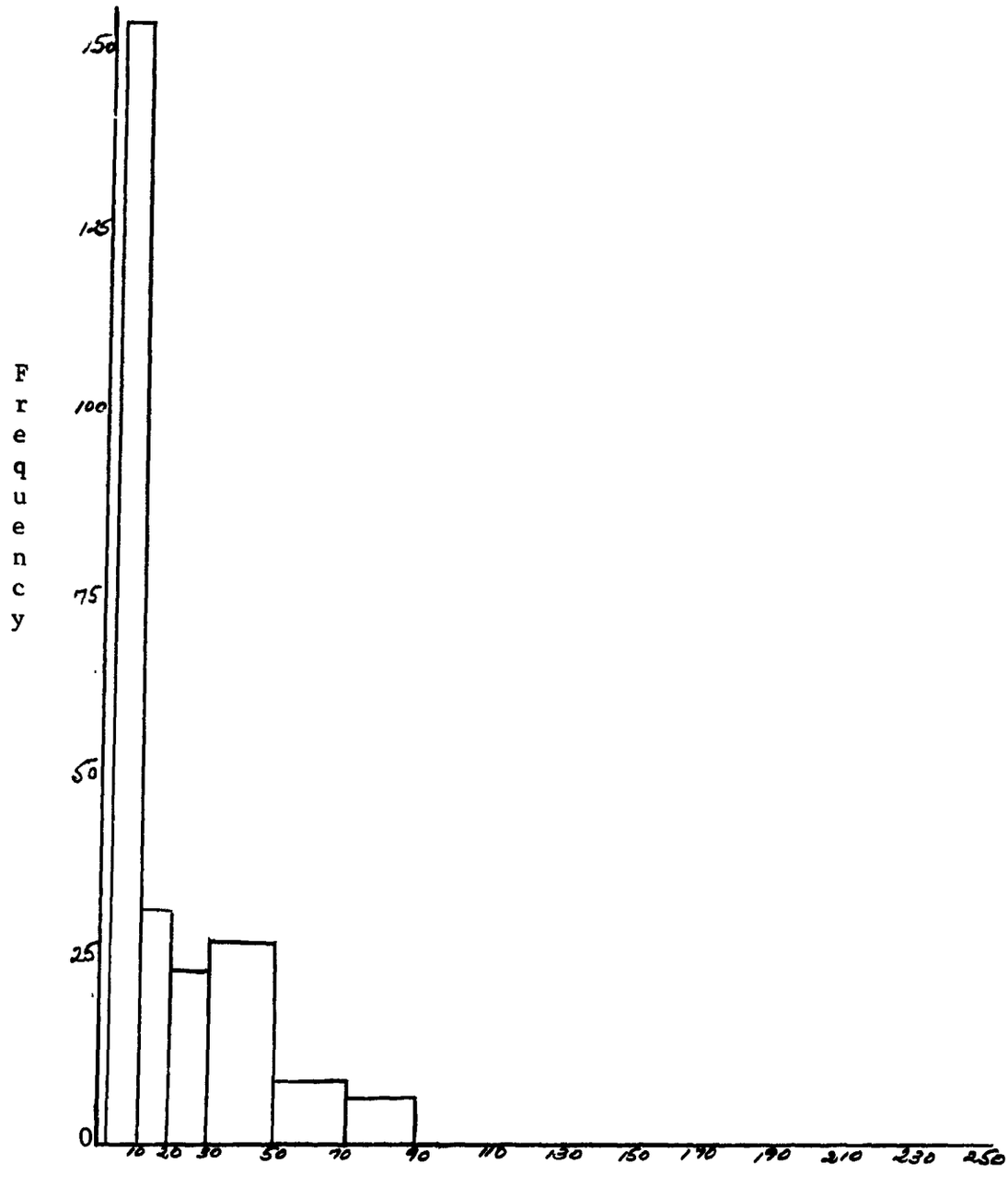
GROUP D

Minutes	Number of Jobs
0-1	152
2-10	133
11-20	49
21-30	28
31-50	15
51-70	10
71-90	3
91-110	3
111-130	2
131-150	0
151-170	1
171-190	0
191-210	0
211-230	0
231-252	0



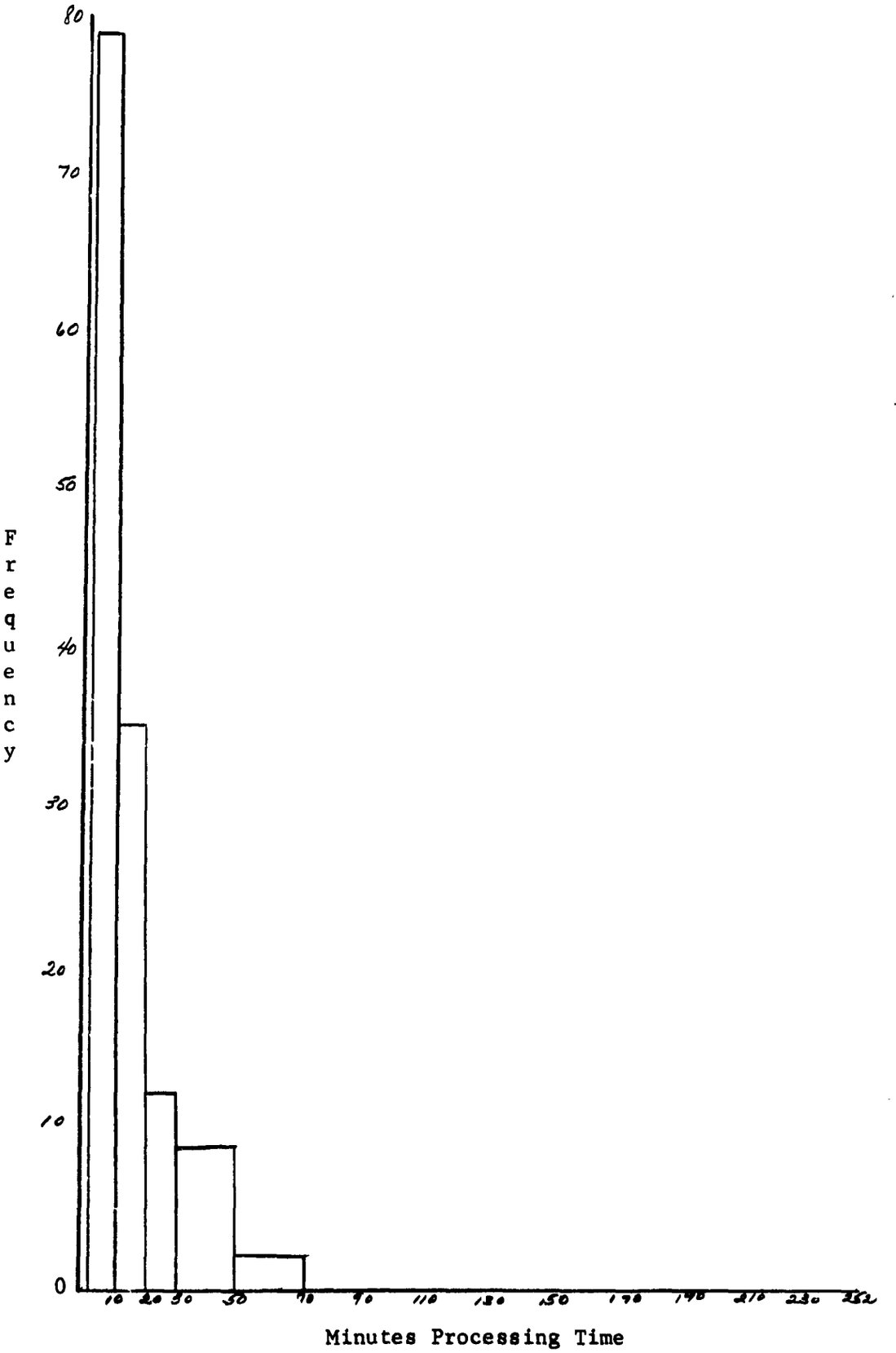
GROUP E

Minutes	Number of Jobs
0-1	125
2-10	153
11-20	32
21-30	23
31-50	27
51-70	8
71-90	6
91-110	0
111-130	0
131-150	0
151-170	0
171-190	0
191-210	0
211-230	0
231-252	0



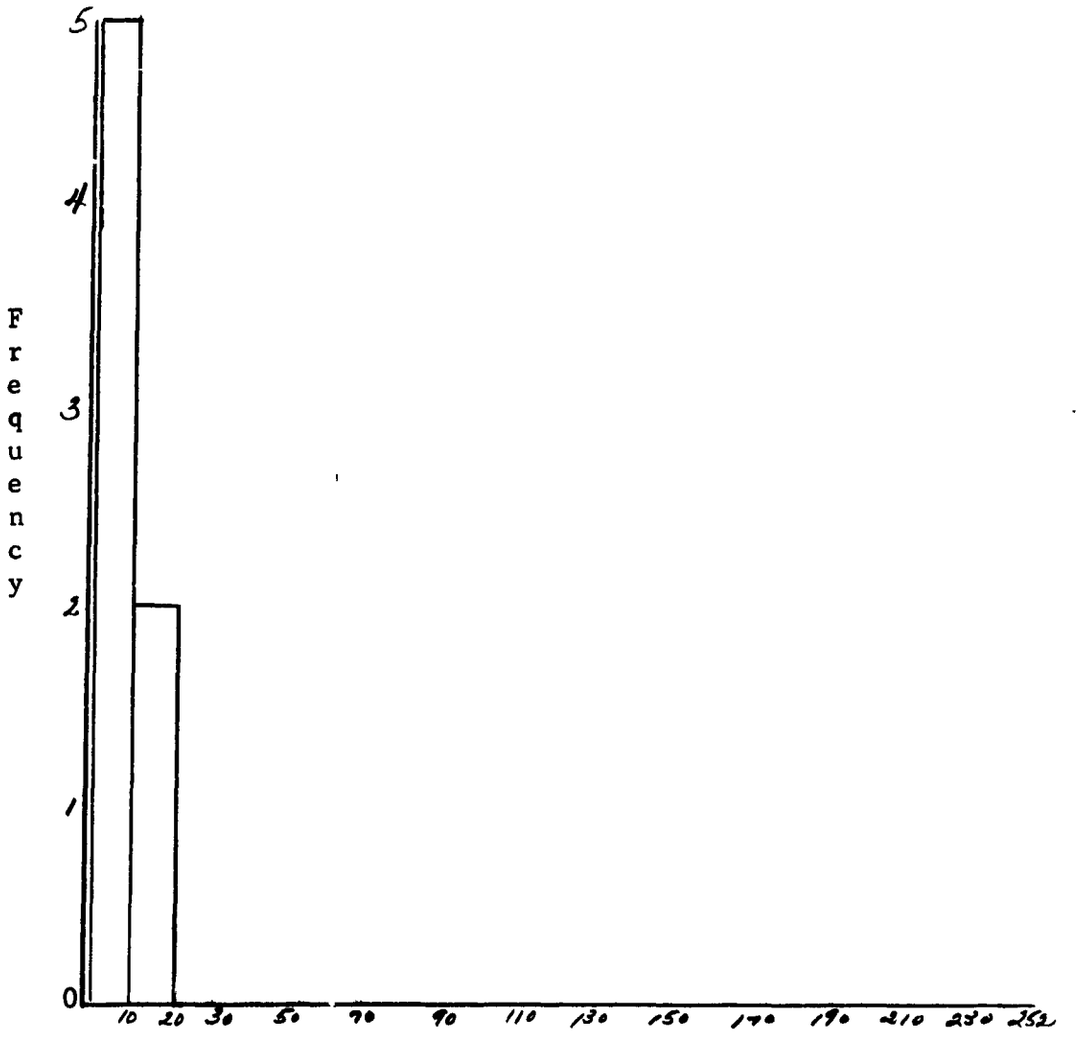
GROUP F

Minutes	Number of Jobs
0-1	59
2-10	78
11-20	35
21-30	12
31-50	9
51-70	2
71-90	0
91-110	0
111-130	0
131-150	0
151-170	0
171-190	0
191-210	0
211-230	0
231-252	0



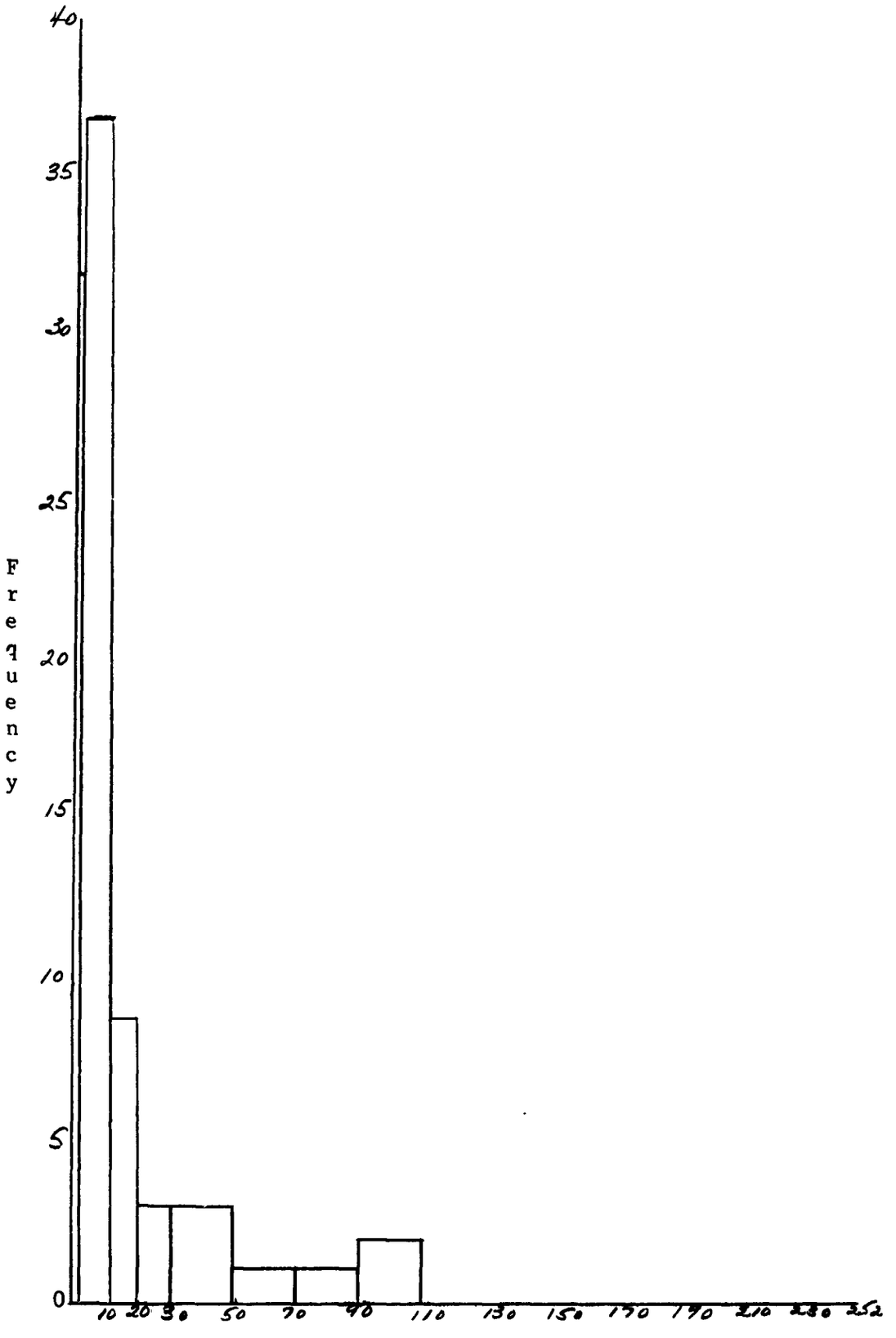
GROUP G

Minutes	Number of Jobs
0-1	1
2-10	5
11-20	2
21-30	0
31-50	0
51-70	0
71-90	0
91-110	0
111-130	0
131-150	0
151-170	0
171-190	0
191-210	0
211-230	0
231-252	0



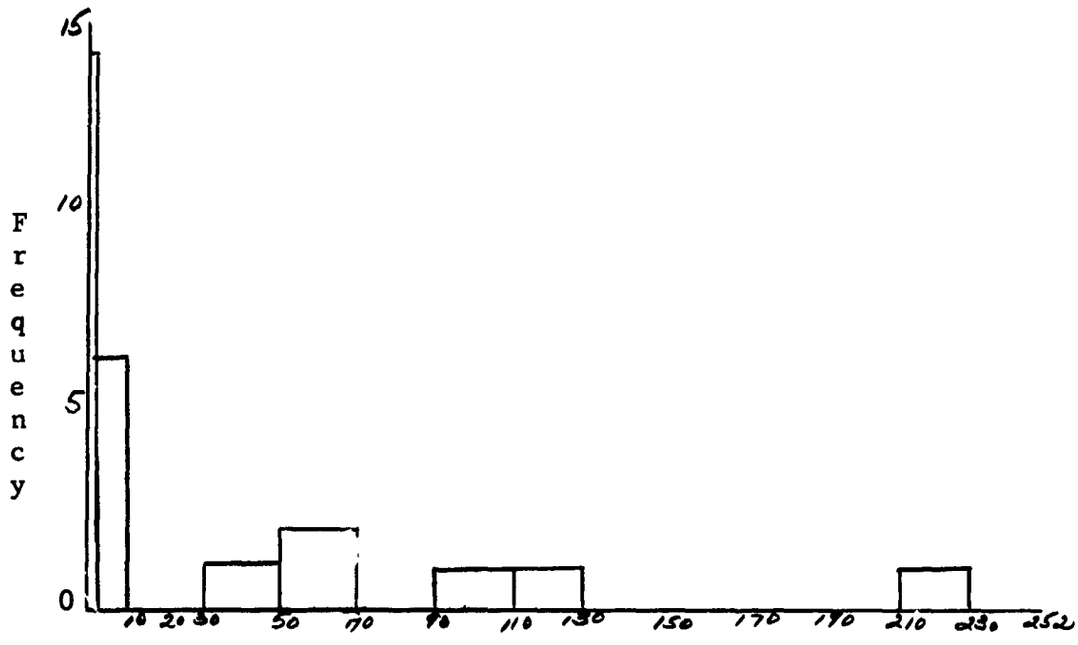
GROUP H

Minutes	Number of Jobs
0-1	32
2-10	37
11-20	9
21-30	3
31-50	3
51-70	1
71-90	1
91-110	2
111-130	0
131-150	0
151-170	0
171-190	0
191-210	0
211-230	0
231-252	0



GROUP I

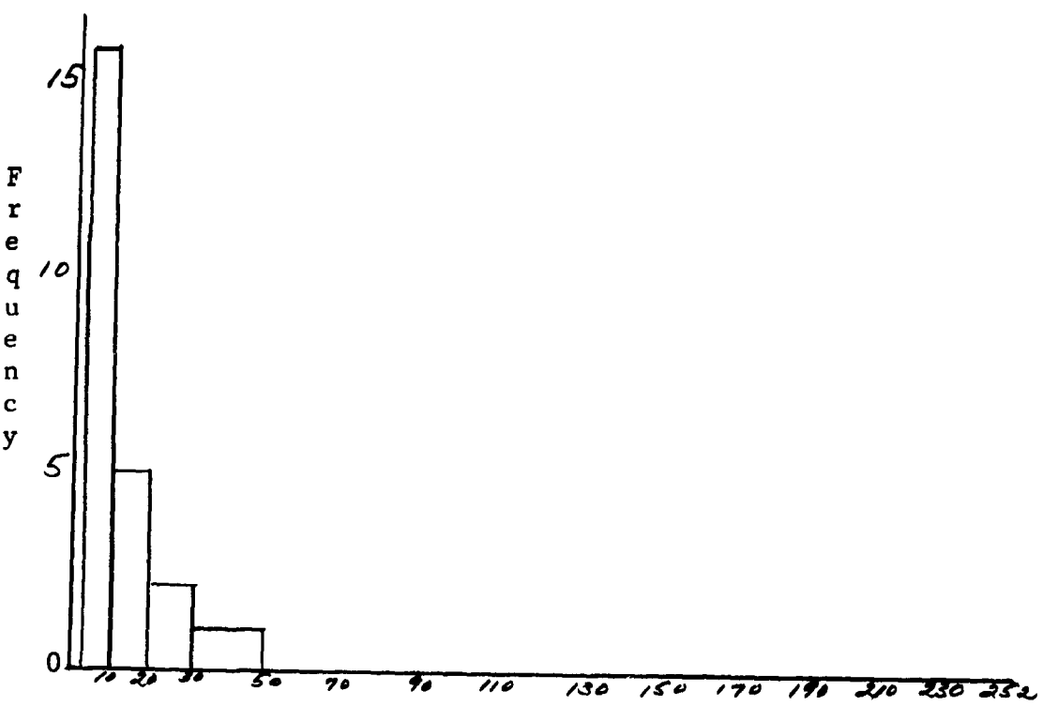
Minutes	Number of Jobs
0-1	14
2-10	6
11-20	0
21-30	0
31-50	1
51-70	2
71-90	0
91-110	1
111-130	1
131-150	0
151-170	0
171-190	0
191-210	0
211-230	1
231-252	0



Minutes Processing Time

GROUP K

Minutes	Number of Jobs
0-1	10
2-10	16
11-20	5
21-30	2
31-50	1
51-70	0
71-90	0
91-110	0
111-130	0
131-150	0
151-170	0
171-190	0
191-210	0
211-230	0
231-252	0



Minutes Processing Time

ALL GROUPS

Minutes	Number of Jobs
0-1	961
2-10	885
11-20	246
21-30	128
31-50	125
51-70	46
71-90	21
91-110	14
111-130	10
131-150	7
151-170	6
171-190	1
191-210	0
211-230	1
231-252	0

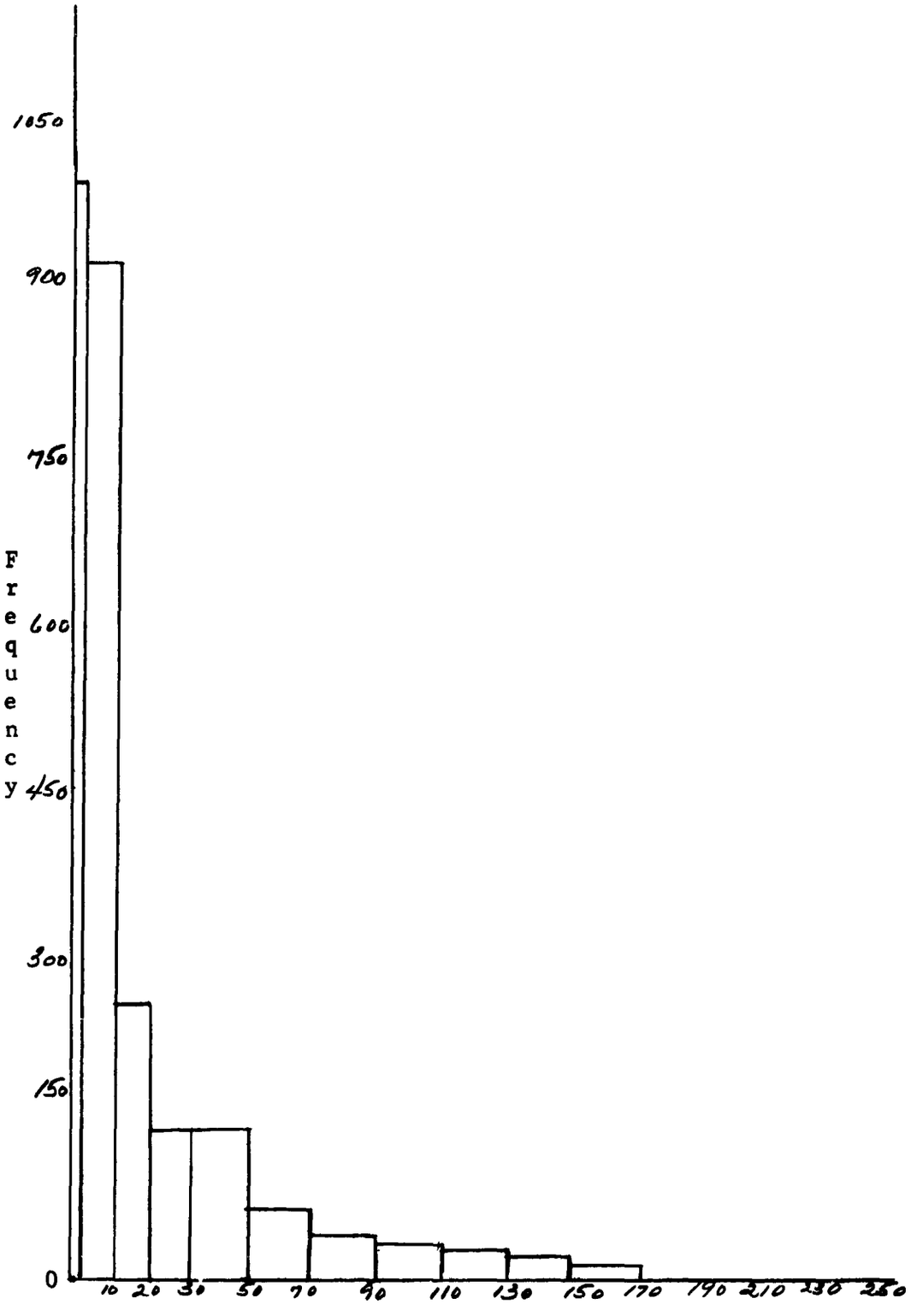


Table 1 identifies for each established job group (a) job group letter, (b) specific jobs within each group, (c) the source of jobs in each job group, and (d) the destination(s) of jobs in each group.

Table 1. Identification of Job Groups

Job Group	Job Numbers	Source[1/]	Destination(s)[2/]
A	A41010 A41020	4708	4708
"	A41051 A41060	"	"
"	A41070 A41080	"	"
"	A41111 A41112	"	"
"	A41120 A41401	"	"
"	A41450 A51300	"	"
B	All Other "A" Numbers	4723	4610,4708
C	DX100 through DX299	4485	4485
D	DX300 through DX499	4471	4249,4250
"	" " "	"	4353,4471
"	" " "	"	4483
E	DX500 through DX599	4471	4200,4201,4207
"	" " "	"	4312,4471,4666
F	DX600 through DX639	4491	4200,4491,Complex
G	DX640 through DX649	4723	4200,4723
H	DX650 through DX754	4491	4491
I	DX675 through DX689	4491	4491
J	DX700 through DX725	4723	4200,4723
K	DX726 through DX730	Not In Use	

Further subdivision of jobs was required, however, and a frequency of processing subdivision was selected. The data for jobs in each job group were evaluated in order to categorize each job according to its frequency of processing. The frequency of processing categories established are explained

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[1/] Location of support contractor unit.

[2/] Some output is delivered directly to the job sponsor, while some is delivered to the indicated support contractor unit and then to the sponsor. Also, some output on multilith must be sent first to the Army for reproduction, and then to support contractor unit, Bldg. 4491, or the job sponsor.

below. To accomplish the categorization, autocorrelation coefficients for frequency of processing were computed for each job according to the following formula:

$$(3) \quad \rho = R(n)/R(o)$$

where $R(o) = \frac{1}{N}\sum_{i=1}^{N}\left[f(t_i)\right]^2$

$$R(n) = \frac{1}{N-n}\sum_{i=1}^{N-n} f(t_i + n)\, f(t_i)$$

N = number of periods (days, weeks, months) considered

n = lag time (i.e., number of periods between successive comparisons)

$f(t_i)$ = actual average processing time for a particular job in the $i^{\underline{th}}$ period.

The computed autocorrelation coefficients are exhibited under separate cover. Each job in a job group was placed in one of five descriptive "frequency of processing" categories. Table 2 below presents the results of the categorization.

Table 2. Summary of Job Categorization According to Frequency of Processing

Job Category	Category Characteristics
Random I	Jobs Processed At Most Once During The Thirty-Nine Week Data Availability Period
Daily	Jobs Whose Autocorrelation Coefficients Exceeded .8 On A Daily Basis
Weekly	Jobs Whose Autocorrelation Coefficients Exceeded .8 On A Weekly Basis
Monthly	Jobs Whose Autocorrelation Coefficients Exceeded .8 On A Monthly Basis
Random II	Jobs Not Fitting Into The Above Categories

As a result of the job categorization, a specific job could be classified jointly by its job group letter and its job category. Hence, a job classification system was established, each job class being a combination of job group and job category. A total of fifty-five job classes were established.

PROBABILITY DISTRIBUTIONS FOR JOB CLASSIFICATIONS

General Comments. The basic structure of the mathematical simulation model to be described later depends on knowledge or estimates of (1) frequency of processing, and (2) average processing time for each job classification. Hopefully, a probability distribution could be ascertained for processing frequency and average processing time for each job classification. A total of one hundred ten probability distributions were required, two for each job classification. The basic time unit for simulation analysis purposes was selected as one week in order to confine the simulation model to a size that could be conveniently accommodated on the Auburn computer, and in order to cope with the considerable variability of data on frequency of processing and average processing time for job classes. Hence, each job classification was summarized by week for (1) frequency of processing, and (2) average processing time.

Procedures for Determination. For each job classification, an ordinary count was made to determine how many times jobs in each classification were processed each week of the thirty-nine week period. Similarly, for each job classification, the average processing time per job was computed for each week of the data availability period. It was assumed for simulation purposes that frequency of processing and average processing time per job were independent.[3/]

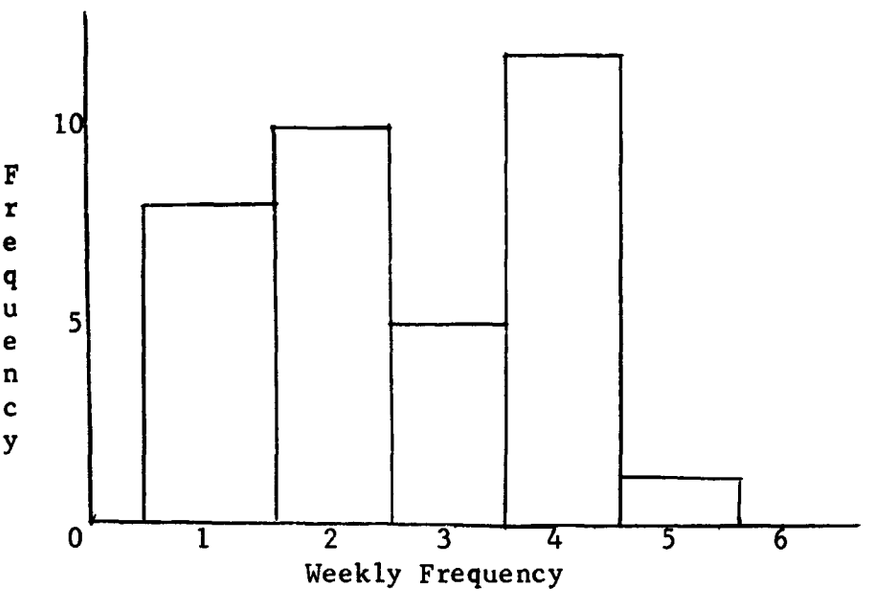
Frequency distributions were, from the weekly summaries, next constructed for (1) frequency of processing of jobs in a job classification, and (2) average processing time per job in a job classification. These appear in Appendix A. The frequency distributions were examined for the purpose of defining appropriate probability distributions associated with each. It was apparent,

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[3/] This assumption is supported by empirical evidence.

however, that even weekly summarizations of both job classification characteristics were not associated with commonly known probability distributions. For example, the following frequency distributions are for frequency of processing and average processing time of Group B, Weekly, jobs.

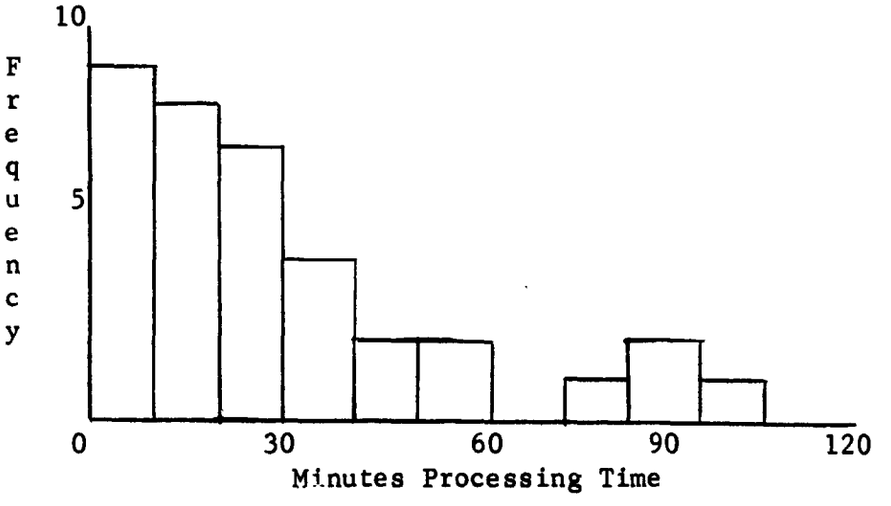
Weekly Frequency	Number of Jobs
1	8
2	10
3	5
4	12
5	1



Obviously, specification of appropriate, familiar probability distributions has little value. It was therefore decided that the original data for equipment utilization would be used in the simulation model instead of weak approximations to "true" probability distributions. The details concerning precisely how the original data will be utilized are described later.

Average Data Processing Time

Minutes	Number of Jobs
0 -10.4	9
10.5-20.9	8
21.0-31.4	7
31.5-41.9	4
42.0-52.4	2
52.5-62.9	2
63.0-73.4	
73.5-83.9	1
84.0-94.4	2
94.5-104.9	1



THE SIMULATION MODEL

The design and purpose of the mathematical simulation model is fundamentally to determine the optimal combination of number of peripheral equipment machines and daily shifts to employ under some assumed conditions in order to process a variable workload. The model was applied separately to two building locations, namely, building 4485 which will process all Group C jobs (i.e., jobs DX100-DX299), and building 4491 which will process all other jobs. The model was run under two assumed workload conditions which were called present load ("normal" load), and double load (twice "normal" load).

The basic time unit used for all simulation analyses was one week, and each model computer run involved a thirty-nine week period (the length of the data availability period). Inasmuch as familiar probability distributions for (1) frequency of processing, and (2) average processing time were unspecified for each job classification, the original data, summarized by week, were utilized.

Table 3 exhibits the original data used by the simulation model. The data are segregated by job group (i.e., A, B, . . ., K), and are listed by week. Each value in Table 3 is the actual total number of minutes of processing time for the corresponding job group and week.

The mathematical simulation model was developed to compute weekly total data processing costs, and also total periodic (i.e., thirty-nine week) data processing costs for specified combinations of (1) number of data processing machines, and (2) number of weekly shifts for buildings 4485 and 4491, assuming present workload and a double workload.

For building 4491 under the present workload, twenty simulation runs were made for combinations of one to five machines and one to four operators, while under a double workload thirty-two runs were made for combinations of

Table 3. Original Data Used In The Simulation Model

	Groups									
Week	A	B	C	D	E	F	G	H	I	K
1	145	4797	2248	9094	3972	335	0	45	71	0
2	184	5890	3750	6019	4237	2082	674	248	466	0
3	493	9808	3633	4865	4658	795	129	257	1152	0
4	273	6893	1733	7518	2214	292	0	220	666	0
5	762	8657	7595	6217	5502	560	78	346	456	1
6	531	8781	3653	5368	5626	852	453	879	905	31
7	429	10122	2853	4447	3697	2804	283	693	916	17
8	427	7791	3952	4431	3282	913	79	166	989	25
9	57	6460	1524	5717	2606	1870	146	199	510	23
10	649	6321	5978	6478	5764	328	309	789	686	46
11	79	5391	3412	5721	2765	181	278	169	437	50
12	149	8154	3934	3853	3442	524	123	283	631	77
13	276	4874	2359	4721	2924	444	148	164	457	80
14	424	7762	5943	6358	3880	1565	3	581	510	102
15	536	6385	3433	3721	3091	997	523	413	578	386
16	503	7504	2813	3237	4047	1907	24	301	740	78
17	132	3562	2416	1829	2141	1810	81	165	872	68
18	93	3711	1405	3956	2140	1443	28	149	429	160
19	244	4843	3857	3193	5743	1936	219	276	812	13
20	597	6081	4258	5718	3392	749	231	625	1002	60
21	656	7982	1775	4974	4323	608	166	252	978	101
22	208	4720	2717	5089	4341	1122	80	255	654	677
23	513	6098	4955	5172	5507	710	273	293	1572	279
24	620	6308	2276	4764	2919	837	855	803	840	272
25	119	5860	1380	5809	2861	604	55	161	613	46
26	334	6136	1334	3108	4768	810	219	113	905	144
27	249	7871	3331	7174	5289	1927	589	312	994	136
28	465	7455	1656	4248	2772	1525	163	136	681	0
29	529	8601	1617	3913	3758	1308	10	303	845	8
30	729	7366	1703	3335	1864	1323	73	195	966	52
31	569	8325	2829	4555	3054	964	220	225	849	306
32	69	7218	2924	5652	5524	2347	175	178	716	136
33	668	7133	1533	3617	4544	829	386	651	612	0
34	391	9420	603	4204	4279	842	231	326	712	293
35	382	7180	2026	7317	5243	838	218	342	661	133
36	536	8569	4662	4841	3139	1169	227	613	361	277
37	332	7363	1761	4820	4278	1449	745	297	812	174
38	380	12416	1293	3279	4107	887	644	148	744	126
39	482	7437	1213	2085	1954	1098	411	110	578	181

one to eight machines and one to four operators. For building 4485 under each of present and double workload conditions, twelve simulation runs were made, for combinations of one to three machines and one to four operators. The following individual costs and conditions were assumed for the simulation model:

1. Each machine in buildings 4485 and 4491 costs $10 per hour when operating.
2. Hourly total cost of machines required for "overload" work is $40 per hour.
3. Each machine operator costs $100 per week per shift.
4. Each machine operator can operate simultaneously at most two machines.
5. The maximum number of weekly shifts is four.[4/]
6. All work due for processing during a week must be processed in the week; carry-over of work from one week to the next is not allowed.
7. Machine utilization is 75 per cent efficient. That is on the average for every hour which processing occurs, only forty-five minutes are utilized for actual processing, or 4/3 hour of total time is required for each hour of actual processing time.

The simulation model involves an analysis of the following mathematical cost expression:

$$(4) \quad \text{Total Periodic Cost} = \sum_{i=1}^{39} \Big[(\text{Number of Machines})\ (\$10)\ \left(\tfrac{4}{3}\right) (\text{Number of Weekly Processing Hours Excluding "Overload" Hours}) + (\$100)\ (\text{Number of Operators Per Shift})\ (\text{Number of Daily Shifts}) + (\$40)\ (\text{Number of Hours of "Overload" Hours Per Week}) \Big]$$

"Overload" hours for any week occurred whenever

$$\left(\tfrac{4}{3}\right) (\text{Actual Number of Weekly Processing Hours}) > (\text{Number of Machines})\ (40)$$

[4/] Each shift is forty weekly hours.

The simulation model was run for combinations (1) number of machines, and (2) number of daily shifts for, individually, buildings 4485 and 4491. Results of the simulation model runs are, for each building location, (1) weekly costs, and (2) total periodic costs for the combinations mentioned above. A listing of the simulation model computer program, written in FORTRAN IV, appears in Appendix B.

RESULTS AND CONCLUSIONS

Table 4 shows the weekly and periodic results obtained from one simulation run, namely, that for building 4491 under present workload conditions when one machine and one operator are employed. Other simulation run results appear under separate cover, and are fundamentally of the type exhibited in Table 4, page 25.

For convenience of summary and presentation, all simulation results have been condensed into four tables listed below as Tables 5, 6, 7, and 8. Each table shows the total periodic costs associated with various combinations of number of machines and shifts.

Table 5. Building 4485 Present Workload Summary

Number of Machines	Number of Shifts	Total Periodic Cost
1	3	$34,130.22
2	2	$27,633.78
3	1	$30,230.22

Table 6. Building 4491 Present Workload Summary

Number of Machines	Number of Shifts	Total Periodic Cost
1	4	$478,420.38
2	4	$296,915.51
3	4	$200,396.62
4	4	$191,177.96
5	3	$195,077.96

Table 4. Building 4491 Present Workload Simulation Results For One Machine and One Operator

Week	Hours Run	"Carry Over" Hours	Total Run Hours	Costs
1	40.00	370.20	400.00	$ 15,308.00
2	40.00	400.00	400.00	16,500.00
3	40.00	452.38	400.00	18,595.11
4	40.00	361.69	400.00	14,967.56
5	40.00	461.76	400.00	18,970.22
6	40.00	480.58	400.00	19,723.11
7	40.00	480.18	400.00	19,707.11
8	40.00	362.29	400.00	14,991.55
9	40.00	350.84	400.00	14,533.78
10	40.00	434.89	400.00	17,895.55
11	40.00	294.91	400.00	12,296.44
12	40.00	343.02	400.00	14,220.89
13	40.00	273.07	400.00	11,422.67
14	40.00	430.78	400.00	17,731.11
15	40.00	329.56	400.00	13,682.22
16	40.00	367.58	400.00	15,203.11
17	40.00	196.89	400.00	8,375.56
18	40.00	229.09	400.00	9,663.56
19	40.00	343.98	400.00	14,259.11
20	40.00	370.11	400.00	15,304.44
21	40.00	405.33	400.00	16,713.33
22	40.00	341.02	400.00	14,140.89
23	40.00	413.71	400.00	17,048.44
24	40.00	364.84	400.00	15,093.78
25	40.00	318.40	400.00	13,236.00
26	40.00	327.49	400.00	13,599.56
27	40.00	505.36	400.00	20,714.22
28	40.00	347.67	400.00	14,406.67
29	40.00	388.33	400.00	16,033.33
30	40.00	313.40	400.00	13,036.00
31	40.00	383.71	400.00	15,848.44
32	40.00	449.22	400.00	18,468.89
33	40.00	369.78	400.00	15,291.11
34	40.00	419.96	400.00	17,298.22
35	40.00	455.87	400.00	18,734.67
36	40.00	398.49	400.00	16,439.55
37	40.00	410.44	400.00	16,917.78
38	40.00	465.13	400.00	19,105.33
39	40.00	278.58	400.00	11,643.11
		Total Periodic Cost		$607,120.37

Table 7. Building 4485 Double
Workload Summary

Number of Machines	Number of Shifts	Total Periodic Cost
1	4	$77,623.10
2	4	$55,267.55
3	2	$60,460.44

Table 8. Building 4491 Double
Workload Summary

Number of Machines	Number of Shifts	Total Periodic Cost
1	4	$1,128,440.73
2	4	$ 941,240.75
3	4	$ 769,889.66
4	4	$ 593,831.02
5	4	$ 471,007.94
6	4	$ 385,193.25
7	4	$ 382,355.92
8	4	$ 382,355.92

From Tables 5, 6, 7, and 8 are obtained the optimum combinations of number of machines and weekly shifts. The optimum combination for each building and workload condition is that for which total periodic cost is minimum. Table 9 shows the optimum results.

Table 9. Optimum Combinations of Number of
Machines and Weekly Shifts

Building	Workload	Number of Machines	Number of Weekly Shifts	Total Periodic Cost
4485	Present	2	2	$ 34,130.22
4491	Present	4	4	$191,177.96
4485	Double	2	4	$ 55,267.55
4491	Double	7	4	$382,355.92
4491	Double	8	4	$382,355.92

Under present workload conditions for building 4491, four machines and four weekly shifts are specified yielding a total periodic cost of $191,177.96. The optimum combination generated from the simulation model is exactly that combination currently being employed in building 4491 at the Space Flight Center. Optimum results obtained for building 4485 from the simulation model are slightly in error because some jobs assumed by the simulation model to be processed in this building are, in fact, processed elsewhere.

Analysis of the machine utilization data for each job showed that several jobs required on the average more than 180 minutes (three hours) of processing time. These jobs are listed in Table 10.

Table 10. Jobs Requiring An Average Of More Than 180 Minutes Processing Time

A4002B	A4101S	A41024
A52057	A5121G	A5324A
A61360	D41064	D30403
D42057	D45034	D53206
D5120F	D53062	D5320G
D5144V	D53200	D53209
D5606M	D5606D	D6115S
D66170	D6700A	

Even though these jobs represented only approximately one per cent of all jobs studied, they involve a considerable amount of data processing time. Hence, further examination of each is recommended for the purpose of possibly reducing data processing time. In addition, it is recommended that all Random I jobs be investigated. These are jobs that were processed at most once during the data availability period. For convenience of scheduling and allocating data processing time, additional knowledge of Ramdom I jobs might be very useful.

APPENDIX A

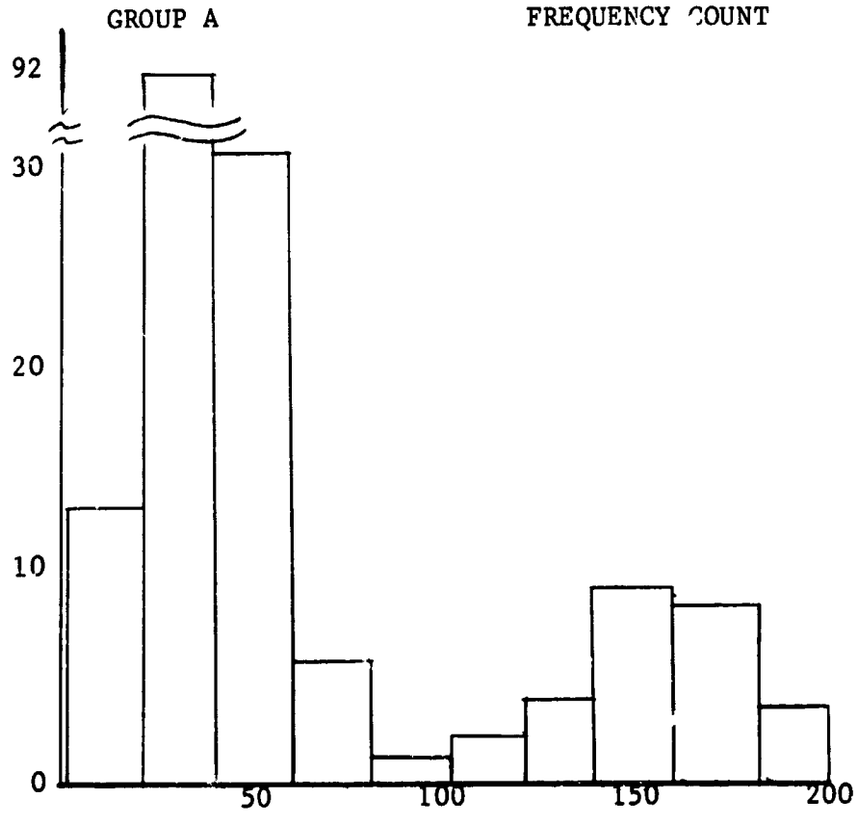
FREQUENCY DISTRIBUTIONS FOR PROCESSING FREQUENCY AND AVERAGE PROCESSING TIME BY JOB CLASSIFICATION

TOTAL

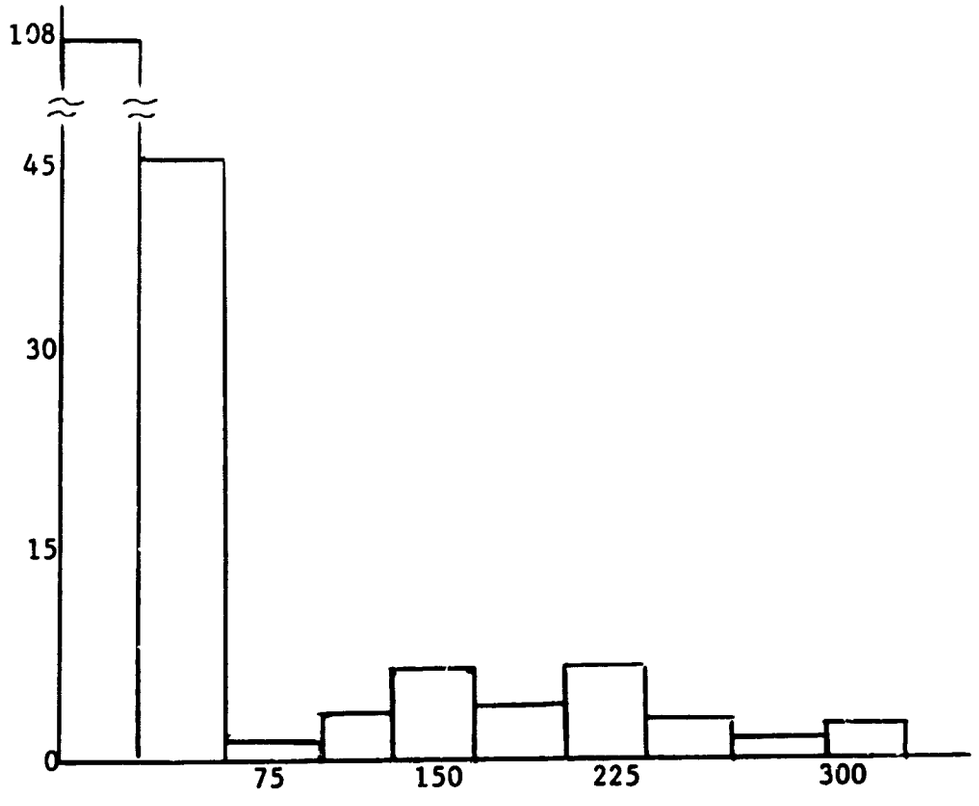
GROUP A

FREQUENCY COUNT

Number of Jobs	
1-20	14
21-40	92
41-60	31
61-80	6
81-100	1
101-120	2
121-140	4
141-160	10
161-180	9
181-200	4

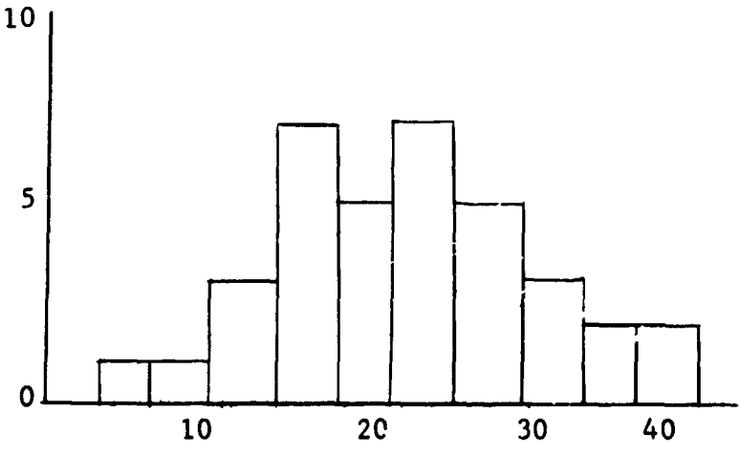


Average Running Times	
0-32	109
33-65	44
66-98	1
99-131	2
132-164	5
165-197	4
198-230	5
231-263	2
264-296	1
297-329	2

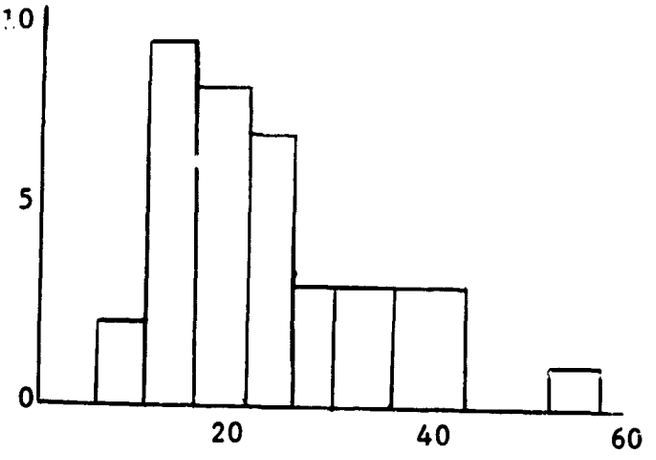


RANDOM GROUP A FREQUENCY COUNT

Number of Jobs	
3-6	1
7-10	1
11-14	3
15-18	7
19-22	5
23-26	7
27-30	5
31-34	3
35-38	2
39-42	2



Average Running Times	
5 -10.2	2
10.3-15.5	9
15.6-20.8	8
20.9-26.1	7
26.2-31.4	3
31.5-36.7	3
36.8-42.0	3
42.1-47.3	
47.4-52.6	
52.7-57.9	1

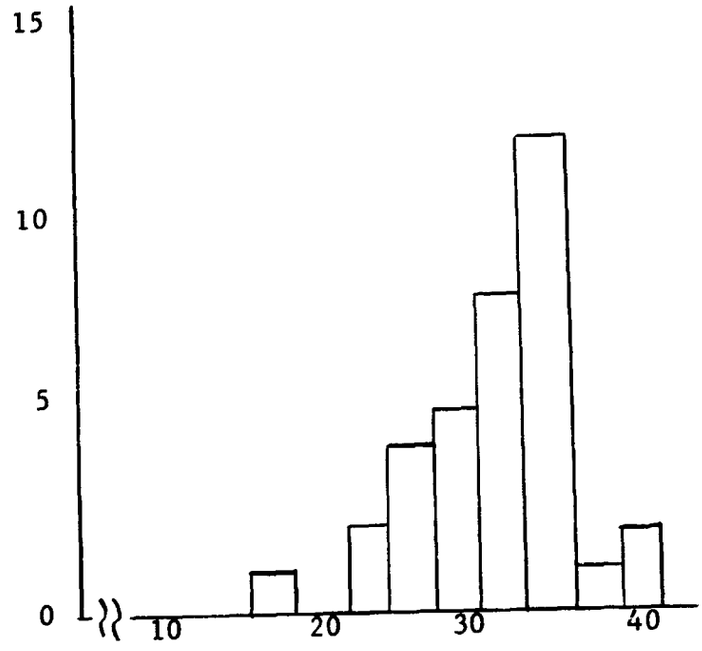


DAILY

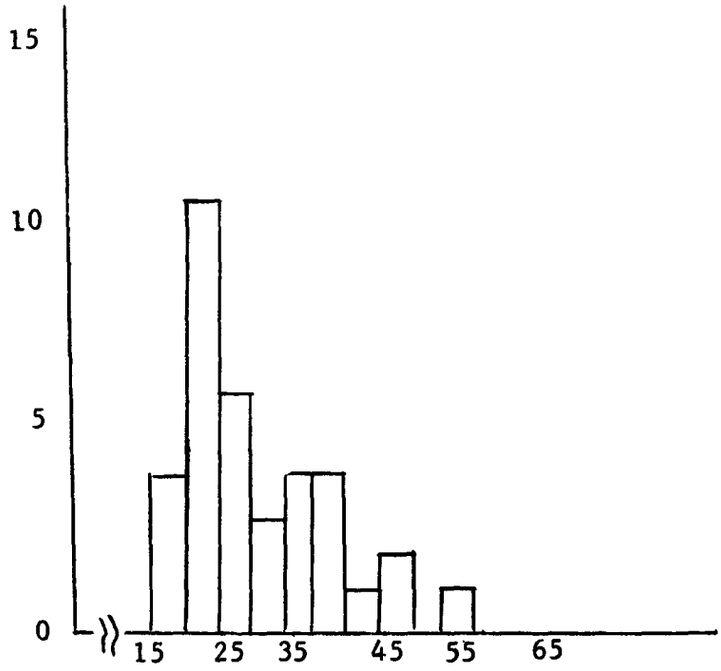
GROUP A

FREQUENCY COUNT

Number of Jobs	
13-15	
16-18	1
19-21	
22-24	2
25-27	4
28-30	5
31-33	8
34-36	12
37-39	1
40-42	2

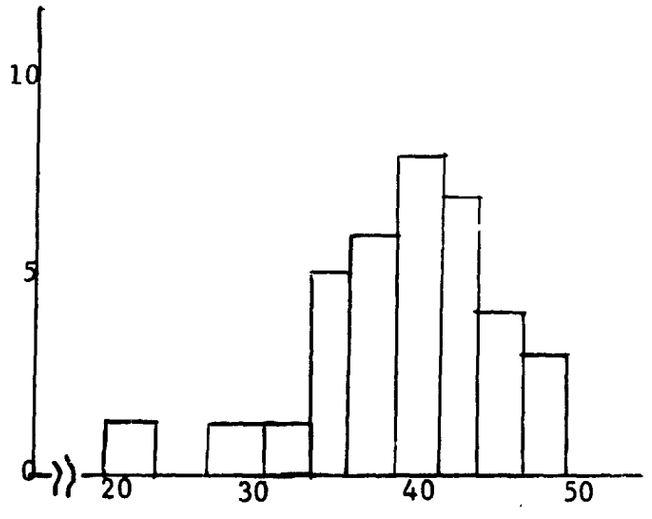


Average Running Times	
15.4-19.5	4
19.6-23.7	11
23.8-27.9	6
28.0-32.1	3
32.2-36.3	4
36.4-40.5	4
40.6-44.7	1
44.8-48.9	2
49.0-53.1	
53.2-57.3	1

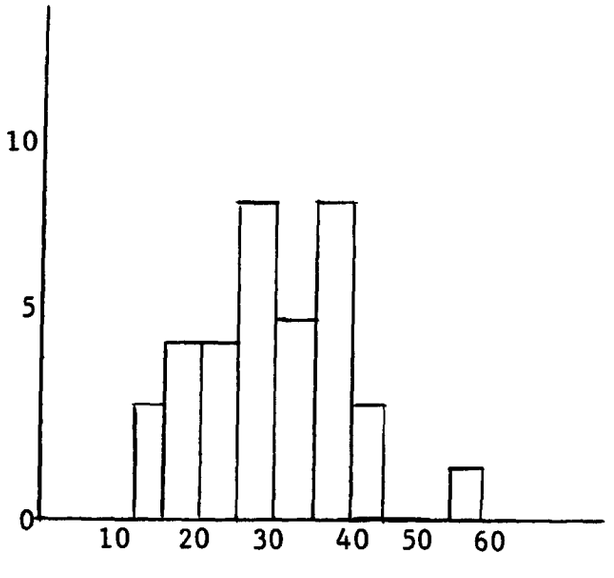


WEEKLY GROUP A FREQUENCY COUNT

Number of Jobs	
20-23	1
24-26	
27-29	1
30-32	1
33-35	5
36-38	6
39-41	8
42-44	7
45-47	4
48-50	3

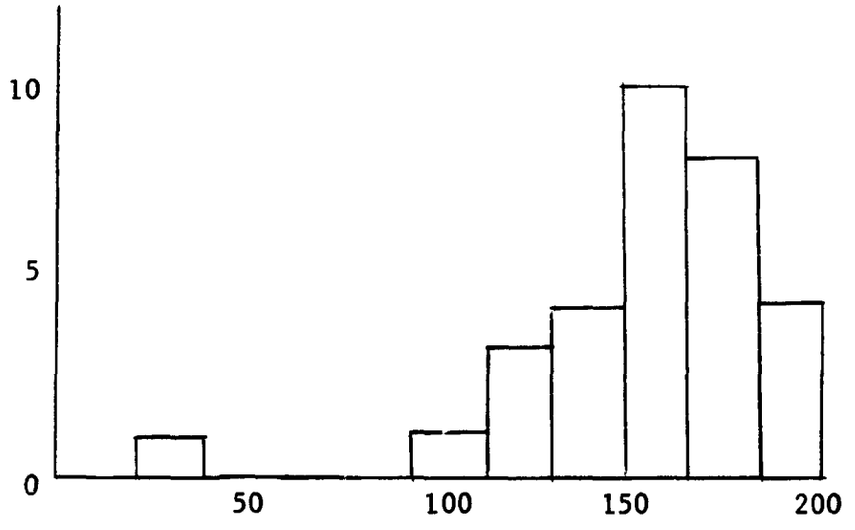


Average Running Times	
13.4-17.8	3
17.9-22.3	4
22.4-26.8	4
26.9-31.3	8
31.4-35.8	5
35.9-40.3	8
40.4-44.8	3
44.9-49.3	
49.4-53.8	
53.9-58.3	1

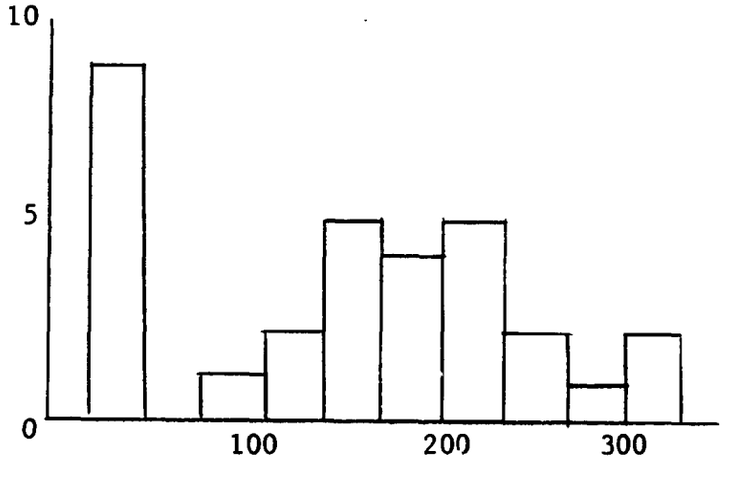


MONTHLY GROUP A FREQUENCY COUNT

Number of Jobs	
21-38	1
39-56	
57-74	
75-92	
93-110	1
111-128	3
129-146	4
147-164	10
165-182	8
183-200	4



Average Running Times	
15-45.9	9
46-76.9	
77-107.9	1
108-138.9	2
139-169.9	5
170-200.9	4
201-231.9	5
232-262.9	2
263-293.9	1
294-324.9	2

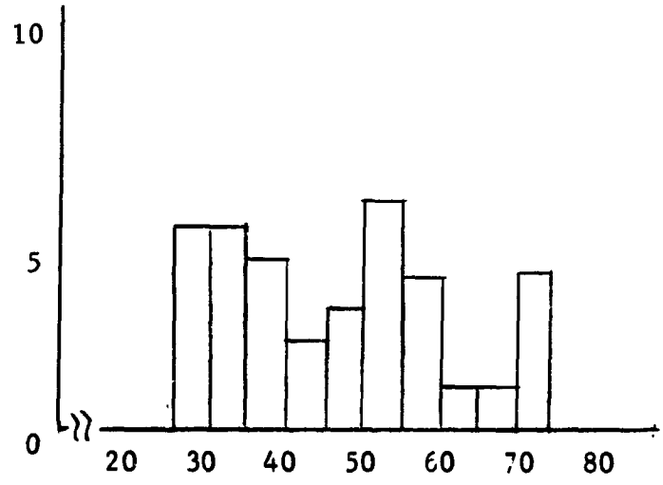


OTHERS

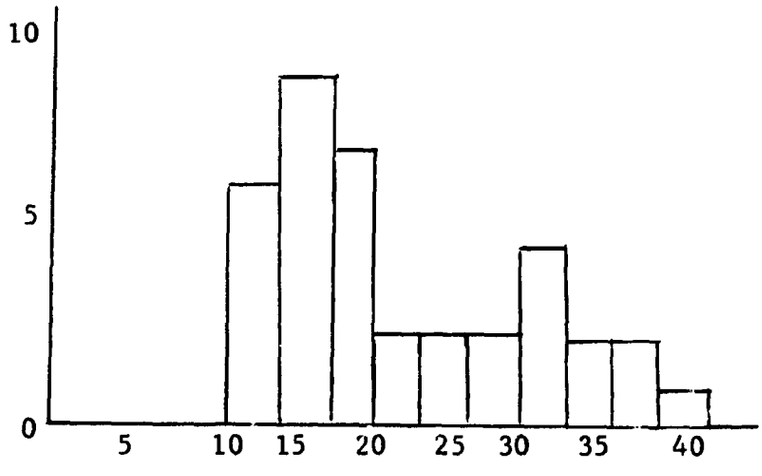
GROUP A

FREQUENCY COUNT

Number of Jobs	
25-29	5
30-34	5
35-39	4
40-44	[illegible]
45-49	3
50-54	6
55-59	4
60-64	1
65-69	1
70-75	4

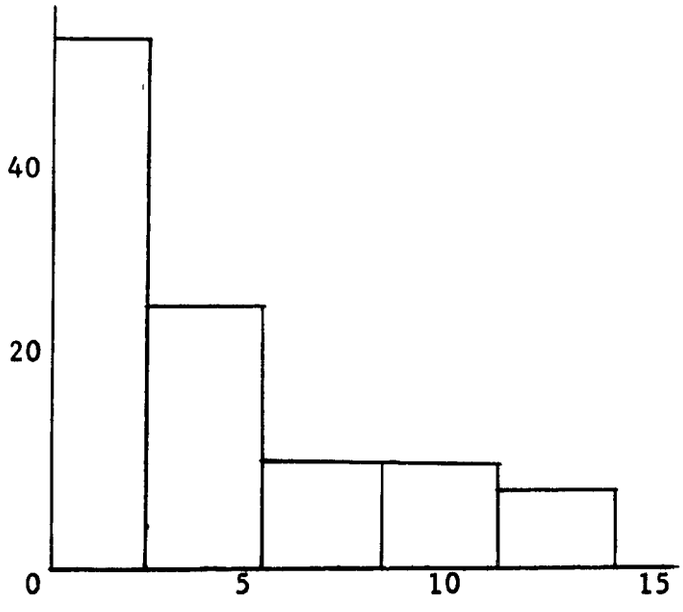


Average Running Times	
11.0-14.0	6
14.1-17.1	8
17.2-20.2	7
20.3-23.3	2
23.4-26.4	2
26.5-29.5	2
29.6-32.6	4
32.7-35.7	2
35.8-38.8	2
38.9-41.9	1

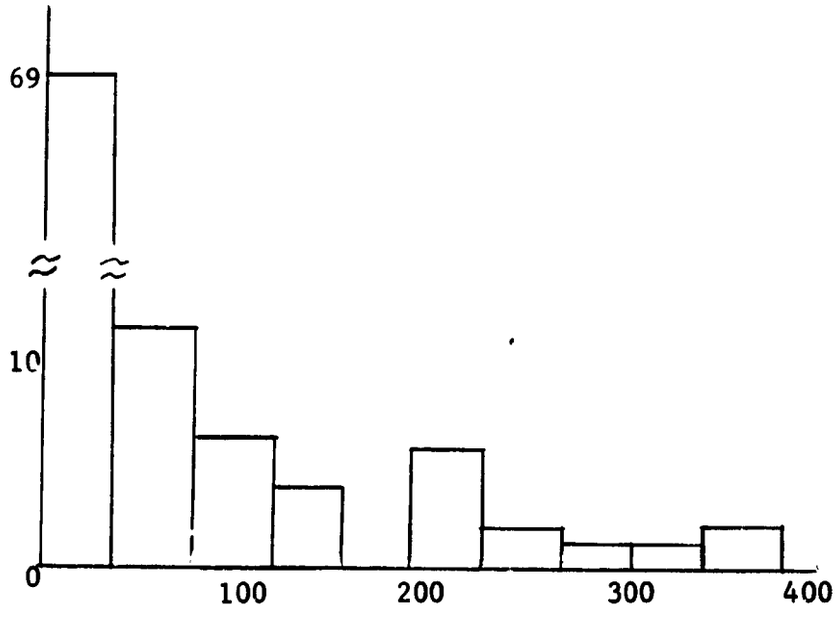


TOTAL GROUP B FREQUENCY COUNT

Number of Jobs	
0-2	53
3-5	25
6-8	9
9-11	9
12-14	7

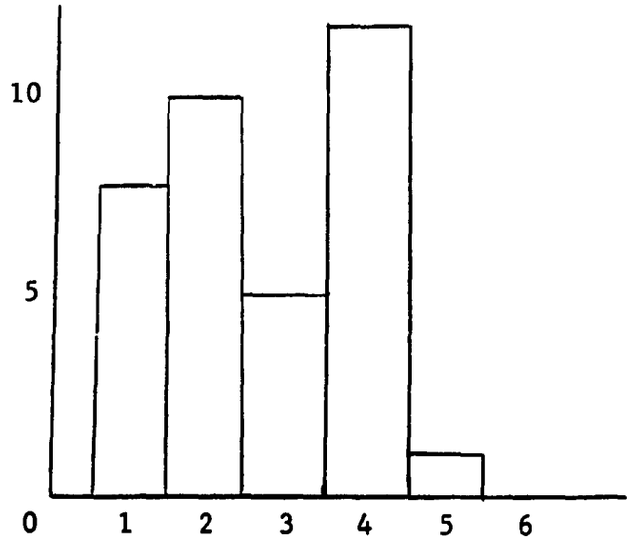


Average Running Times	
0-37	69
38-75	12
76-113	6
114-151	4
152-189	
190-227	6
228-265	2
266-303	1
304-341	1
342-379	2

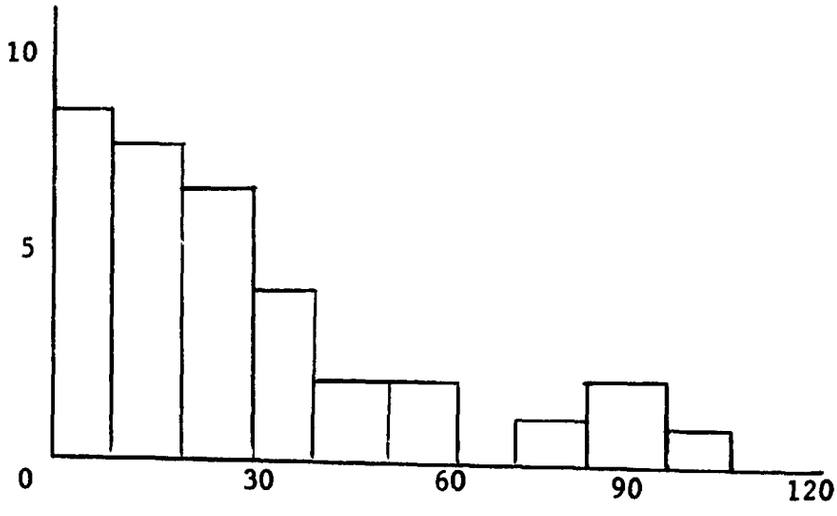


WEEKLY GROUP B FREQUENCY COUNT

Number of Jobs	
1	8
2	10
3	5
4	12
5	1

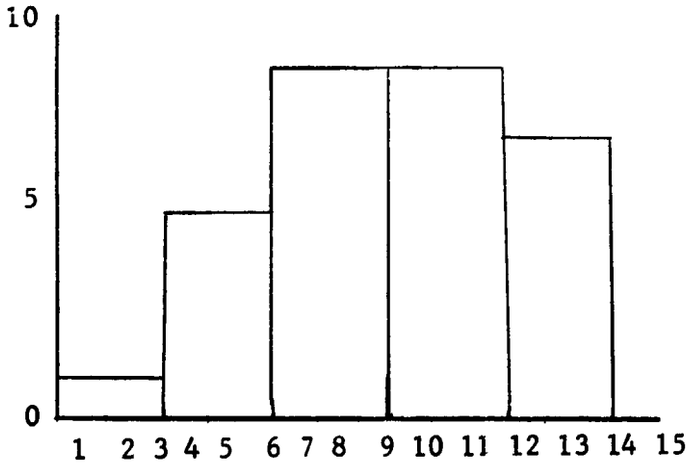


Average Running Times	
0 -10.4	9
10.5-20.9	8
21.0-31.4	7
31.5-41.9	4
42.0-52.4	2
52.5-62.9	2
63.0-73.4	
73.5-83.9	1
84.0-94.4	2
94.5-104.9	1

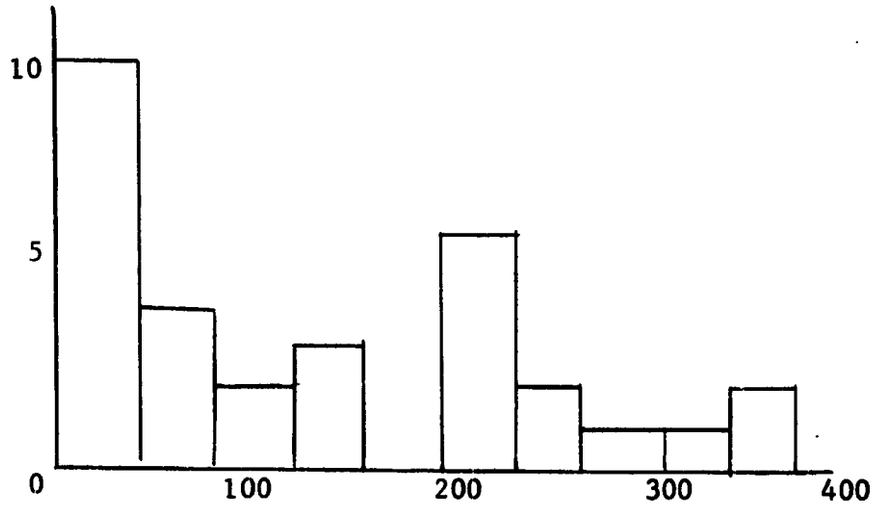


MONTHLY GROUP B FREQUENCY COUNT

Number of Jobs	
0-2	1
3-5	5
6-8	9
9-11	9
12-14	7

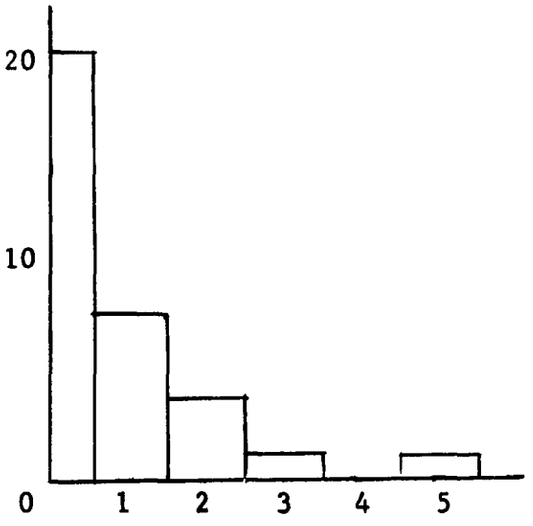


Average Running Times	
0-37.9	10
38-75.9	4
76-113.9	2
114-151.9	3
152-189.9	
190-227.9	6
228-265.9	2
266-303.9	1
304-341.9	1
342-379.9	2

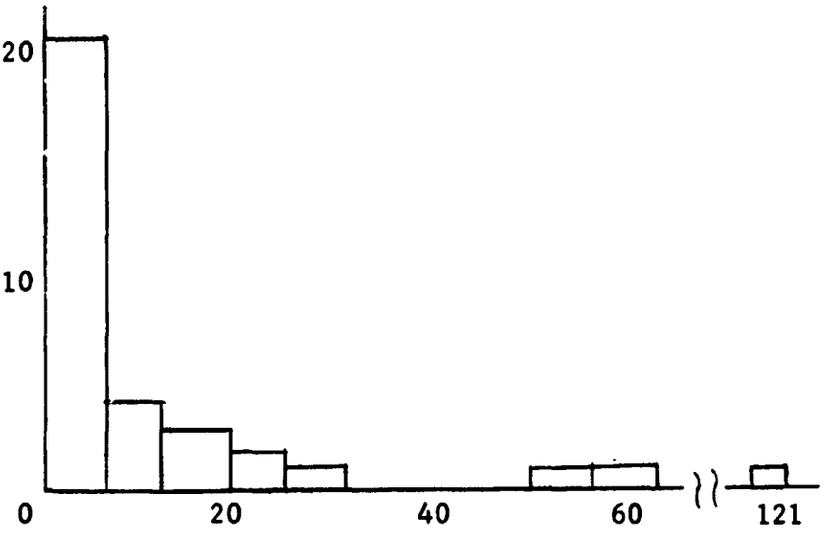


OTHERS GROUP B FREQUENCY COUNT

Number of Jobs	
0	22
1	8
2	4
3	1
4	
5	1

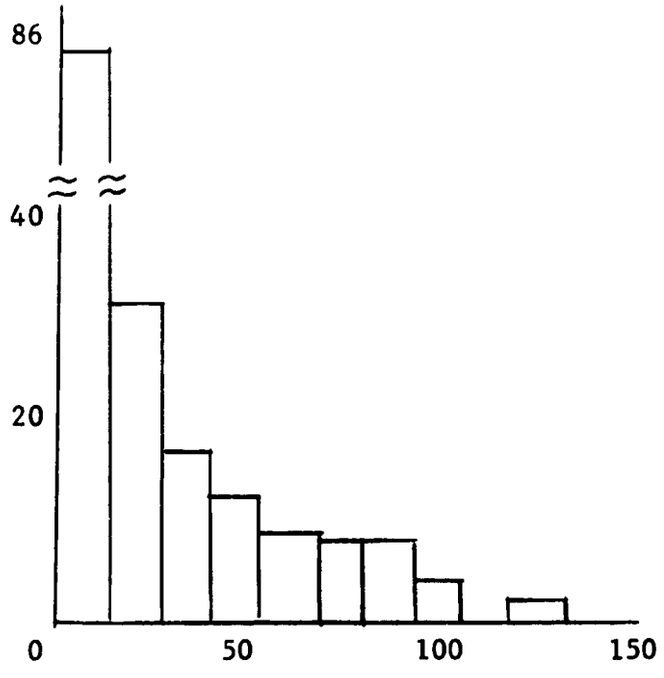


Average Running Times	
0 -6.2	23
6.3-12.5	4
12.6-18.8	3
18.9-25.1	2
25.2-31.4	1
31.3-37.7	
37.8-44.0	
44.1-50.3	
50.4-56.6	1
56.7-62.9	1
121.0	1

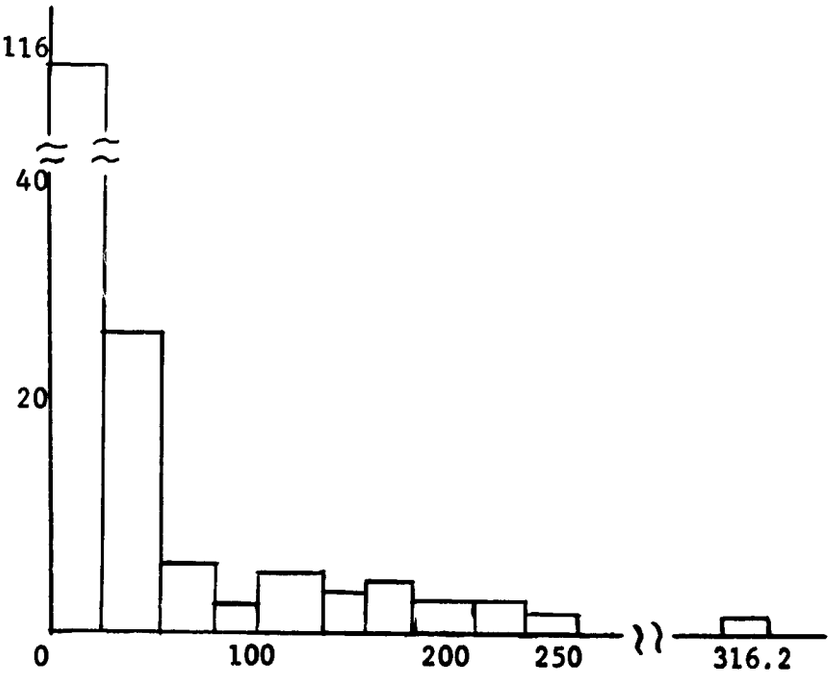


TOTAL GROUP C FREQUENCY COUNT

Number of Jobs	
0-12	86
13-25	32
26-38	17
39-51	11
52-64	9
65-77	8
78-90	8
91-103	3
104-116	
117-129	1

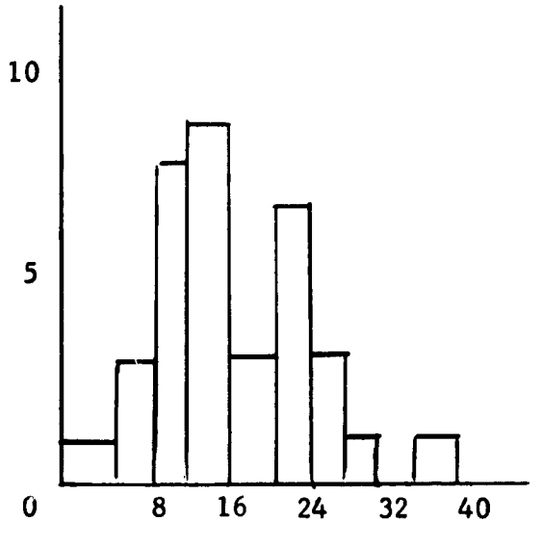


Average Running Times	
0 -26.4	116
26.5-52.9	30
53.0-79.4	6
79.5-105.9	2
106.0-132.4	5
132.5-158.9	3
159.0-185.4	4
185.5-211.9	3
212.0-238.4	3
238.5-264.9	2
316.2	1

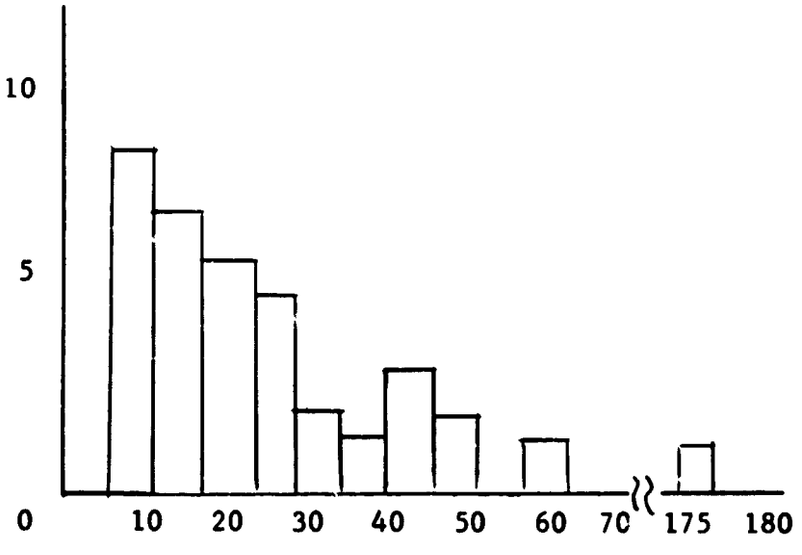


RANDOM GROUP C FREQUENCY COUNT

Number of Jobs	
0-4	1
5-8	3
9-12	8
13-16	9
17-20	3
21-24	7
25-28	3
29-32	1
33-36	
37-40	1

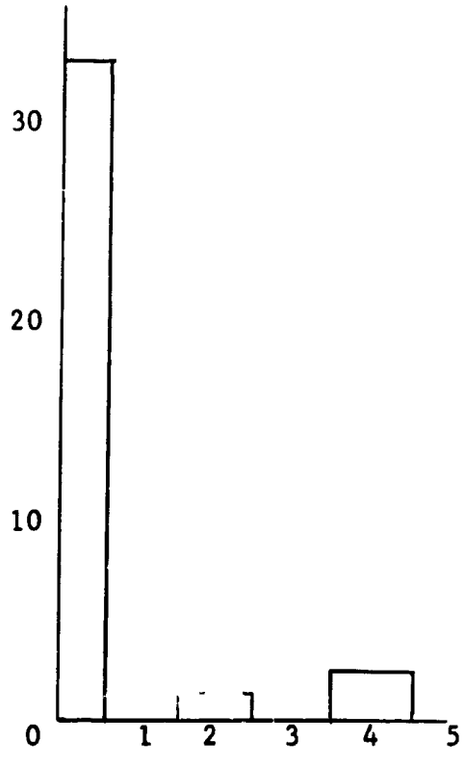


Average Running Times	
3-9.9	9
10-15.9	7
16-21.9	6
22-27.9	4
28-33.9	2
34-39.9	1
40-45.9	3
46-51.9	2
52-57.9	
58-63.9	1
175.4	1

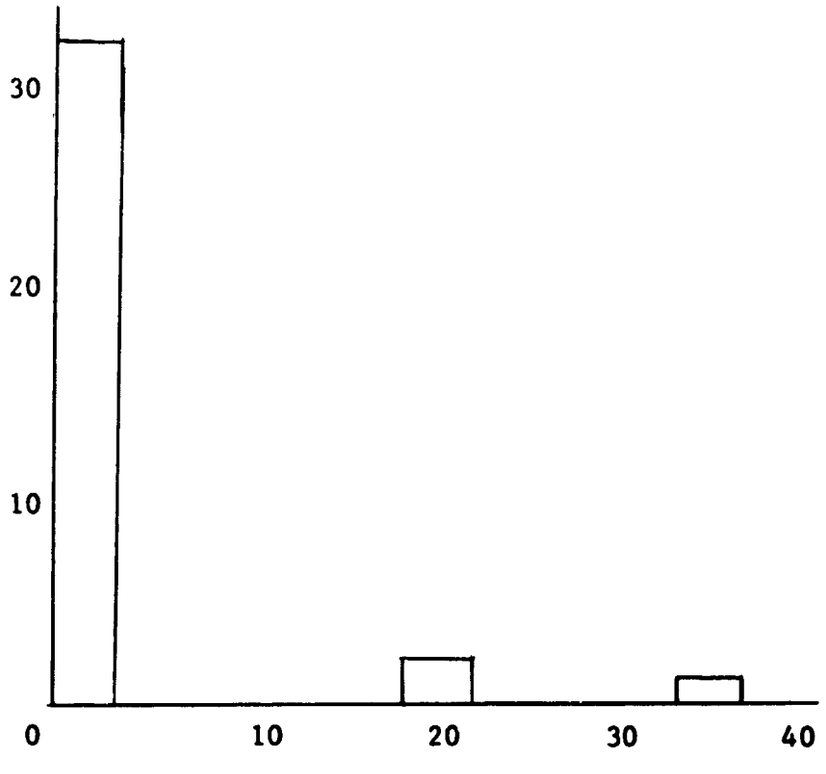


DAILY GROUP C FREQUENCY COUNT

Number of Jobs	
0	33
1	
2	1
3	
4	2

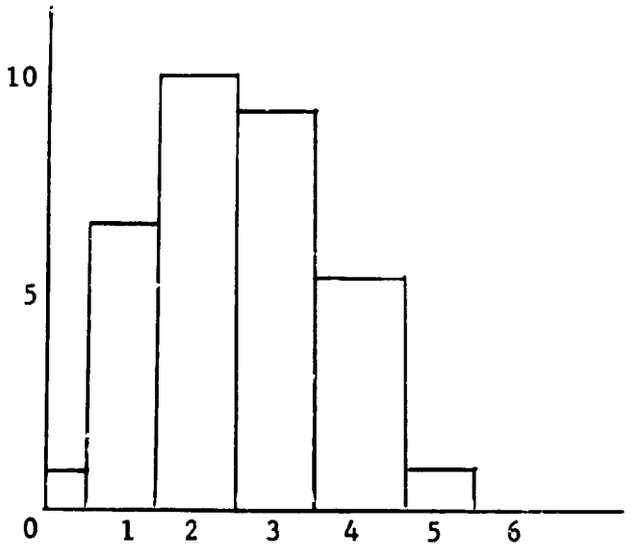


Average Running Times	
0 -3.5	33
3.6-7.1	
7.2-10.7	
10.8-14.3	
14.4-17.9	
18.0-21.5	2
21.6-25.1	
25.2-28.7	
28.8-32.3	
32.4-35.9	1

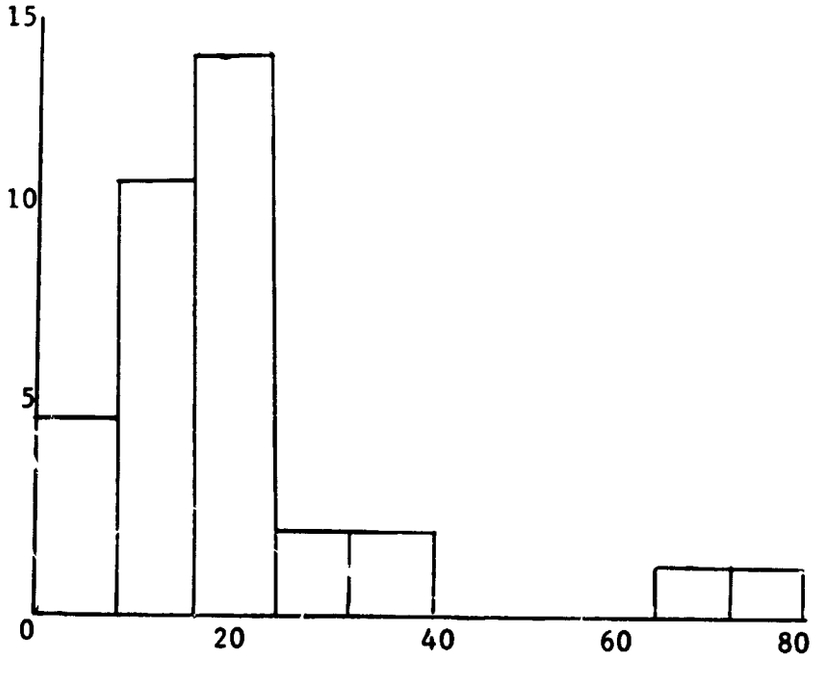


WEEKLY GROUP C FREQUENCY COUNT

Number of Jobs	
0	1
1	7
2	11
3	10
4	6
5	1

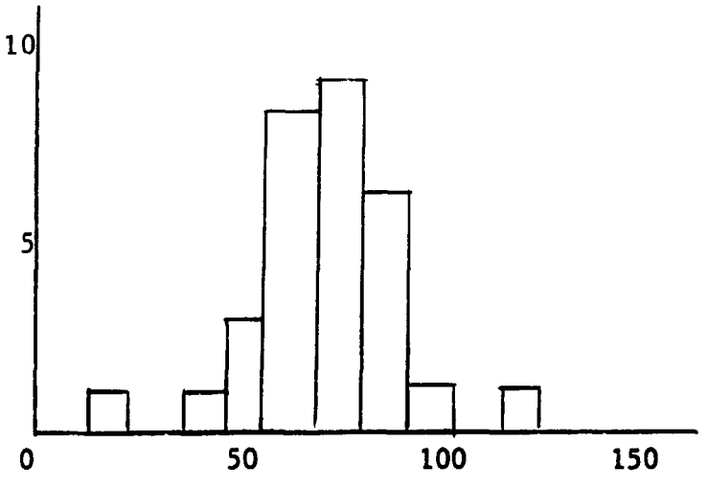


Average Running Times	
0-7.9	5
8-15.9	11
16-23.9	14
24-31.9	2
32-39.9	2
40-47.9	
48-55.9	
56-63.9	
64-71.9	1
72-79.9	1

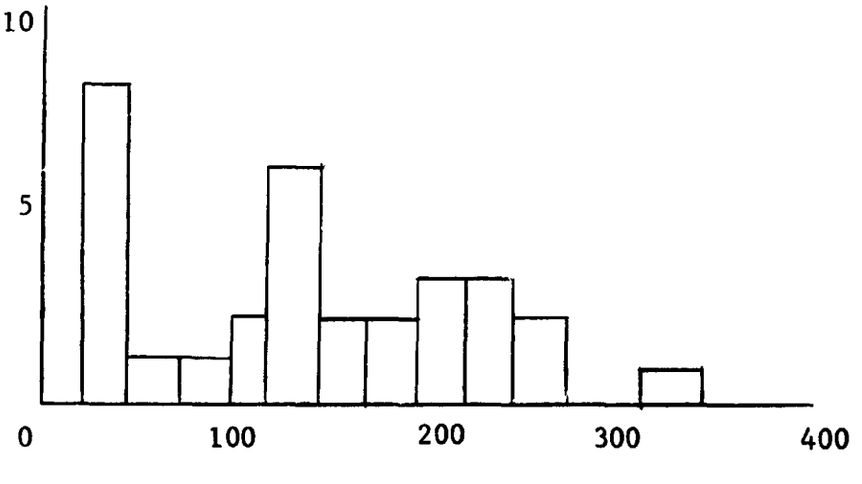


MONTHLY GROUP C FREQUENCY COUNT

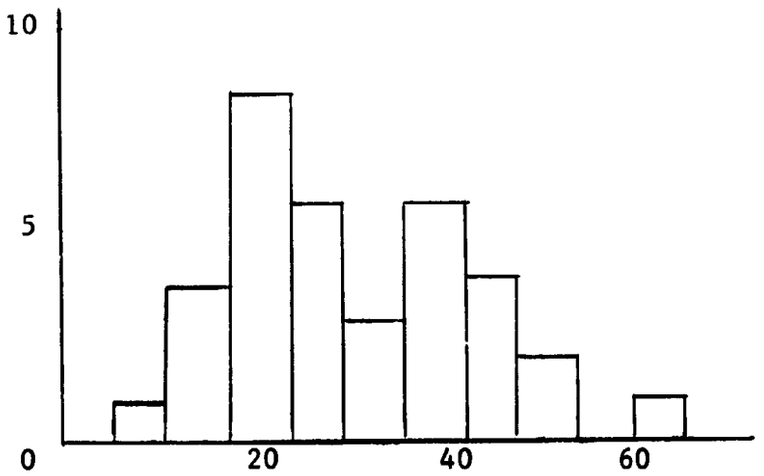
Number of Jobs	
11-22	1
23-34	
35-46	1
47-58	4
59-70	8
71-82	9
83-94	6
95-106	1
107-118	
119-130	1



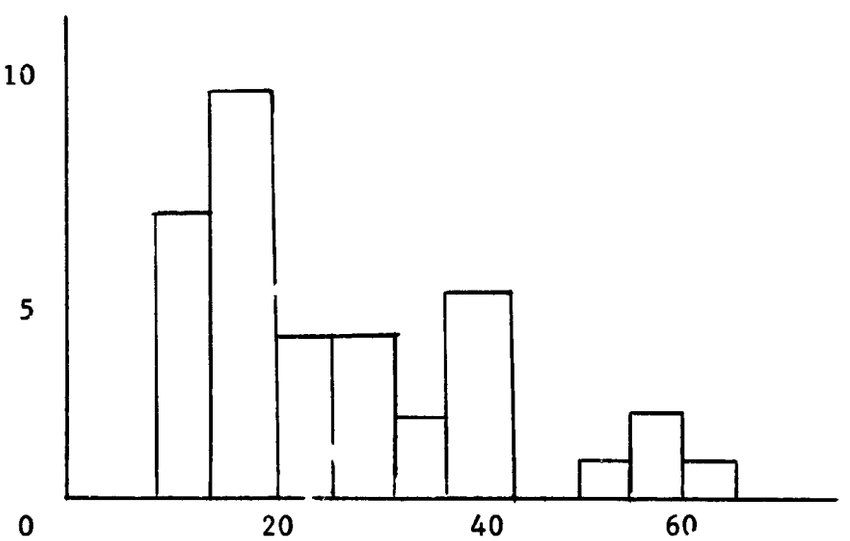
Average Running Times	
15-39.9	8
40-64.9	1
65-89.9	1
90-114.9	2
115-139.9	6
140-164.9	2
165-189.9	2
190-214.9	3
215-239.9	3
240-264.9	2
316.2	1



Number of Jobs	
6-11	1
12-17	4
18-23	9
24-29	6
30-35	3
36-41	6
42-47	4
48-53	2
54-59	
60-65	1

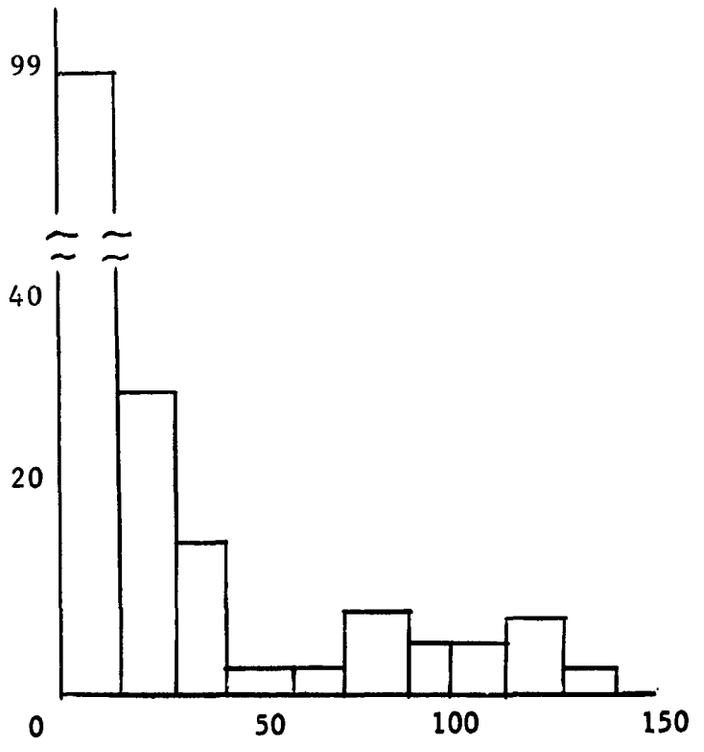


Average Running Times	
7-12.9	7
13-18.9	10
19-24.9	4
25-30.9	4
31-36.9	2
37-42.9	5
43-48.9	
49-54.9	1
55-60.9	2
61-66.9	1

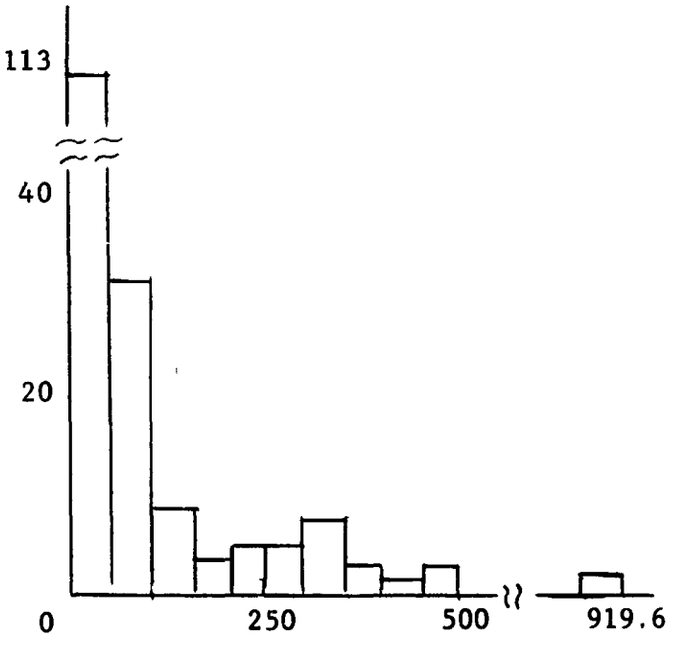


TOTAL GROUP D FREQUENCY COUNT

Number of Jobs	
0-13	99
14-27	30
28-41	14
42-55	2
56-69	2
70-83	8
84-97	5
98-111	5
112-125	7
126-139	2

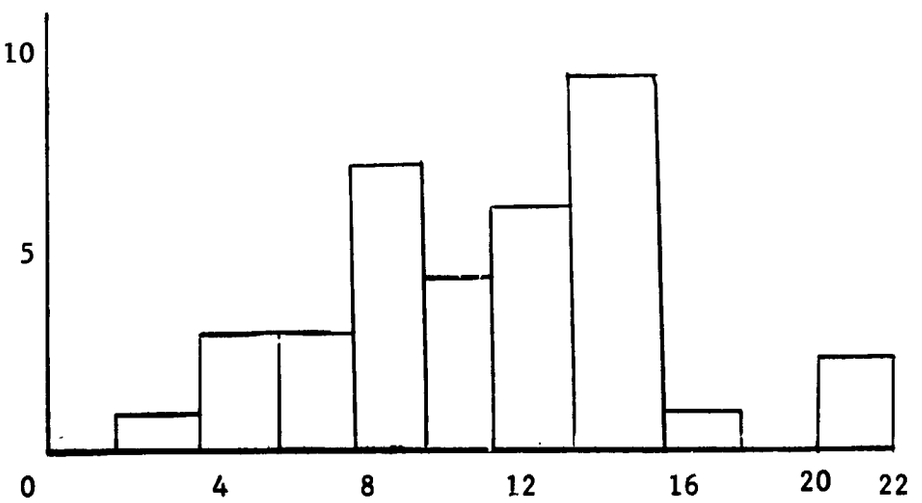


Average Running Times	
0-49	113
50-99	31
100-149	9
150-199	2
200-249	4
250-299	4
300-349	6
350-399	2
400-449	1
450-499	2
919.6	1

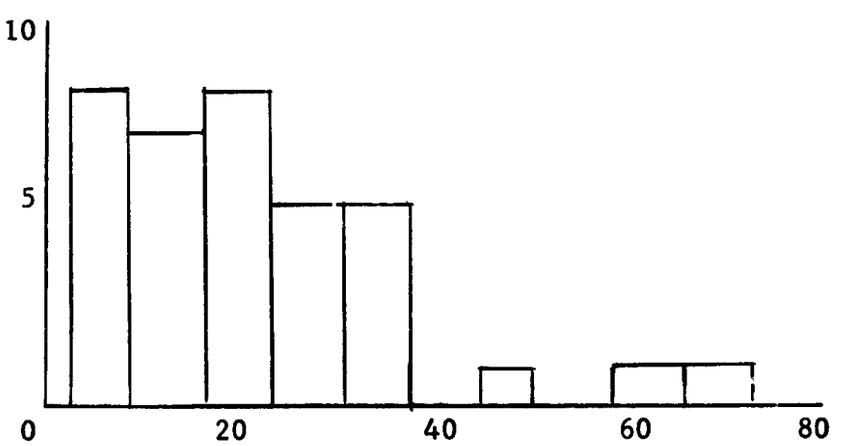


RANDOM GROUP D FREQUENCY COUNT

Number of Jobs	
2-3	1
4-5	3
6-7	3
8-9	7
10-11	4
12-13	6
14-15	9
16-17	1
18-19	
20-22	2

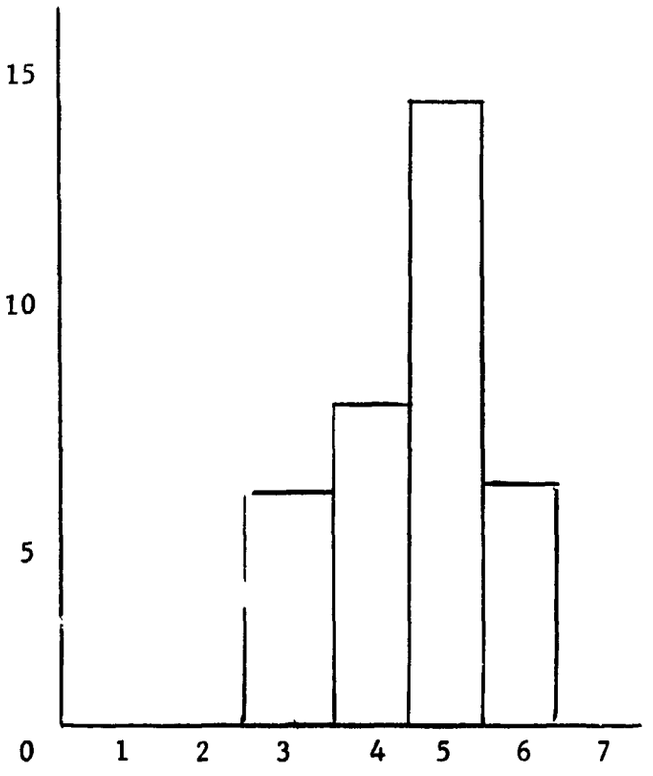


Average Running Times	
2-8.9	8
9-15.9	7
16-22.9	8
23-29.9	5
30-36.9	5
37-43.9	
44-50.9	1
51-57.9	
58-64.9	1
65-71.9	1

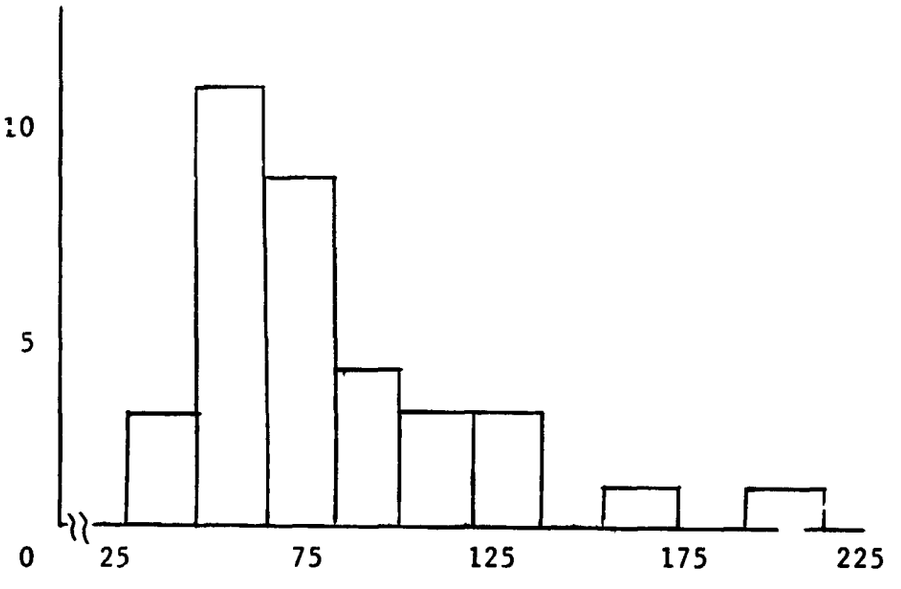


DAILY GROUP D FREQUENCY COUNT

Number of Jobs	
3	6
4	8
5	16
6	6

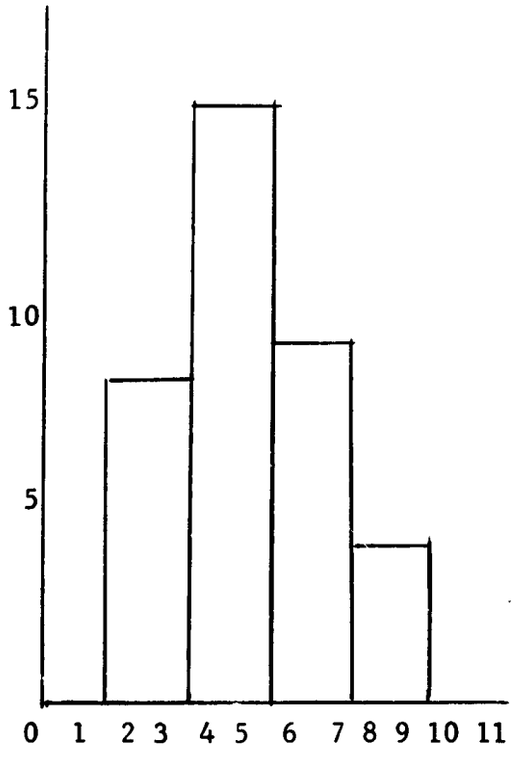


Average Running Times	
29-46.9	3
47-64.9	12
65-82.9	9
83-100.9	4
101-118.9	3
119-136.9	3
137-154.9	
155-172.9	1
173-190.9	
191-208.9	1

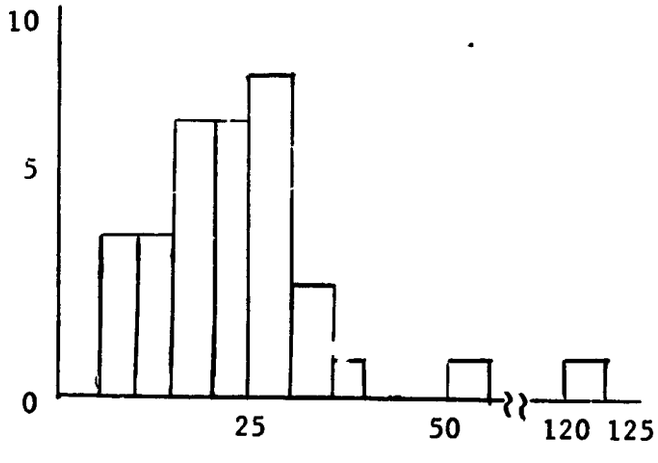


WEEKLY GROUP D FREQUENCY COUNT

Number of Jobs	
0-1	
2-3	8
4-5	15
6-7	9
8-9	4

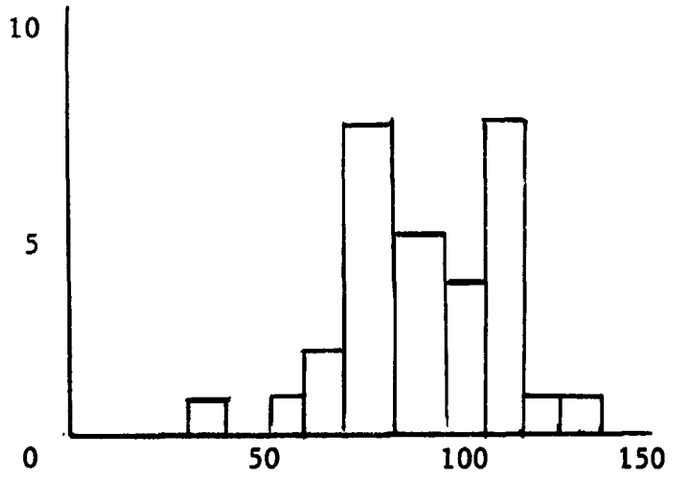


Average Running Times	
5-9.9	4
10-14.9	4
15-19.9	7
20-24.9	7
25-29.9	6
30-34.9	3
35-39.9	1
40-44.9	
45-49.9	
50-54.9	1
121.5	1

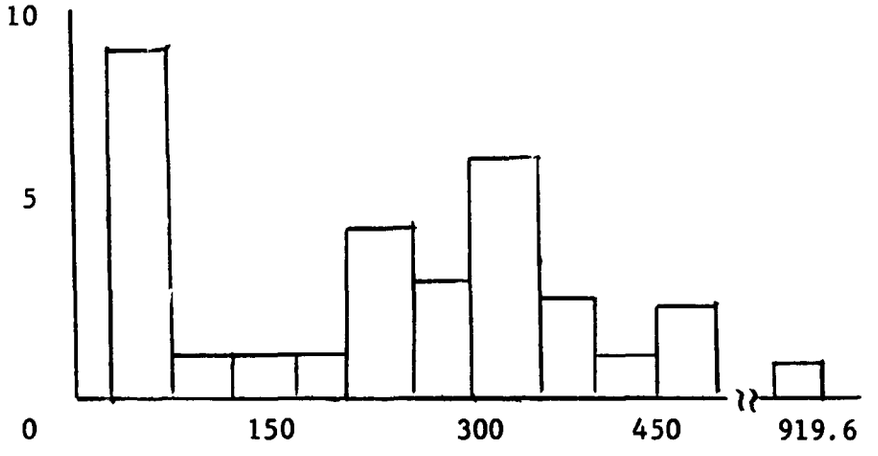


MONTHLY GROUP D FREQUENCY COUNT

Number of Jobs	
30-40	1
41-51	
52-62	1
63-73	2
74-84	8
85-95	5
96-106	4
107-117	8
118-128	1
129-139	1

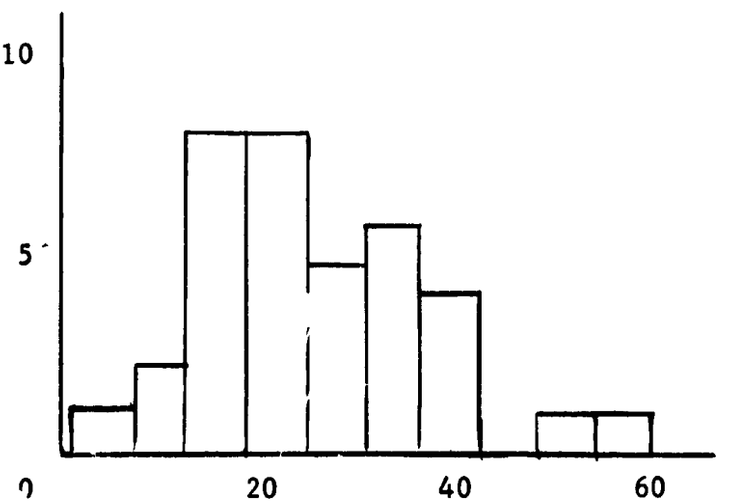


Average Running Times	
23-69.9	9
70-116.9	1
117-163.9	1
164-210.9	1
211-257.9	4
258-304.9	3
305-351.9	6
352-398.9	2
399-445.9	1
446-492.9	2
919.6	1

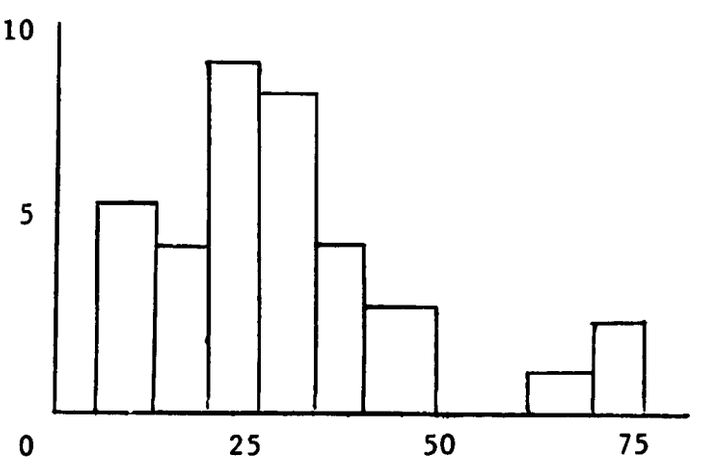


OTHERS GROUP D FREQUENCY COUNT

Number of Jobs	
1-6	1
7-12	2
13-18	8
19-24	8
25-30	5
31-36	6
37-42	4
43-48	
49-54	1
55-60	1

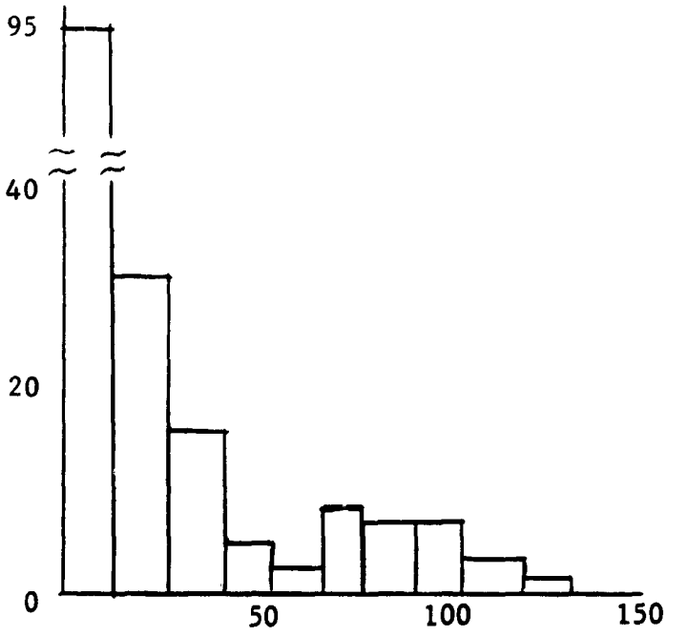


Average Running Times	
6-12.9	5
13-19.9	4
20-26.9	9
27-33.9	8
34-40.9	4
41-47.9	3
48-54.9	
55-61.9	
62-68.9	1
69-75.9	2

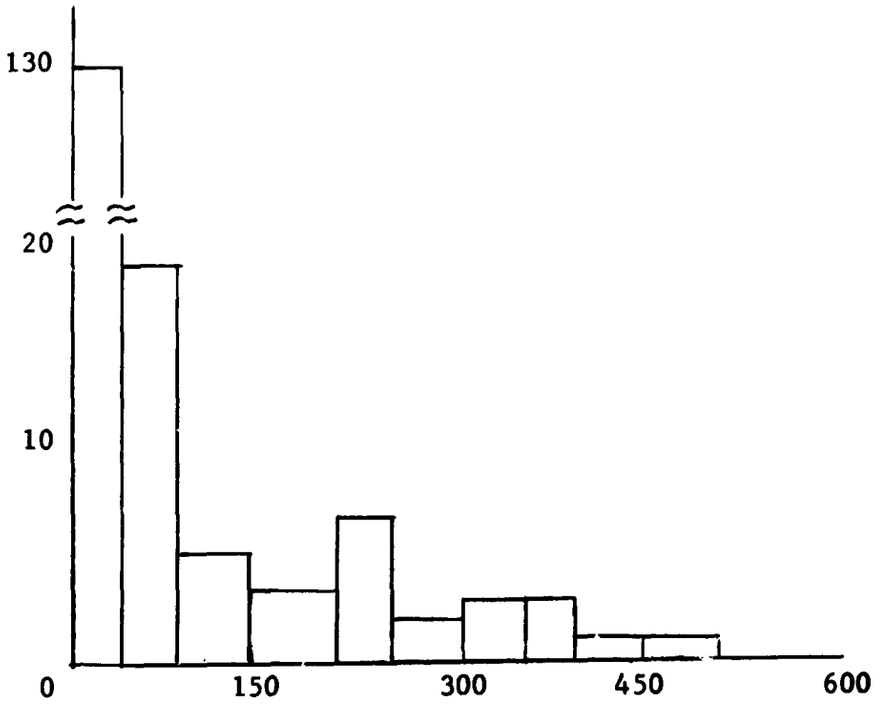


TOTAL GROUP E FREQUENCY COUNT

Number of Jobs	
0-12	95
13-25	32
26-38	15
39-51	4
52-64	3
65-77	8
78-90	7
91-103	7
104-116	3
117-129	1

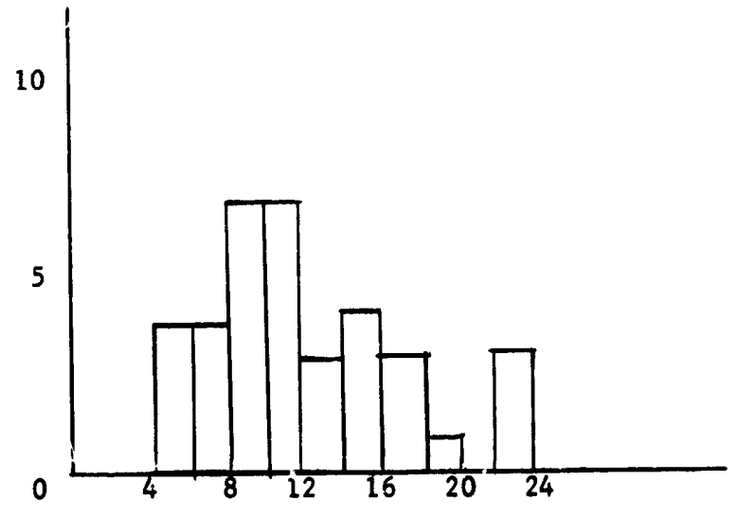


Average Running Times	
0-49	130
50-99	20
100-149	4
150-199	3
200-249	8
250-299	2
300-349	3
350-399	3
400-449	1
450-499	1

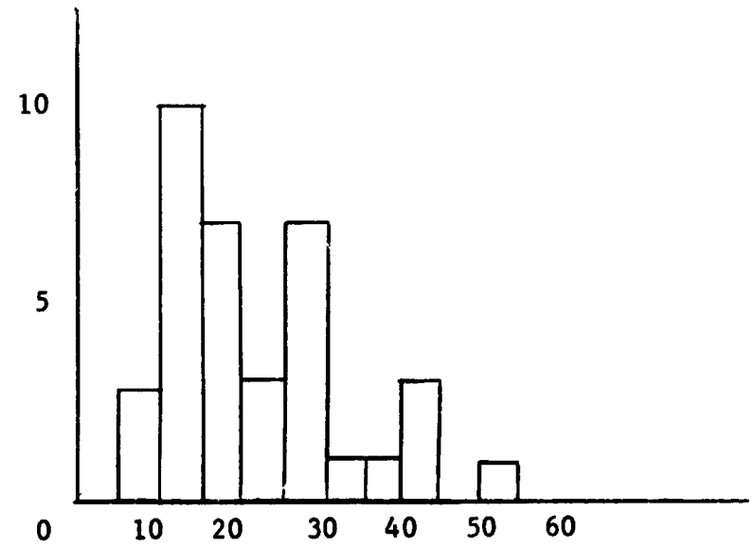


RANDOM GROUP E FREQUENCY COUNT

Number of Jobs	
4-5	4
6-7	4
8-9	7
10-11	7
12-13	3
14-15	4
16-17	3
18-19	1
20-21	
22-23	3

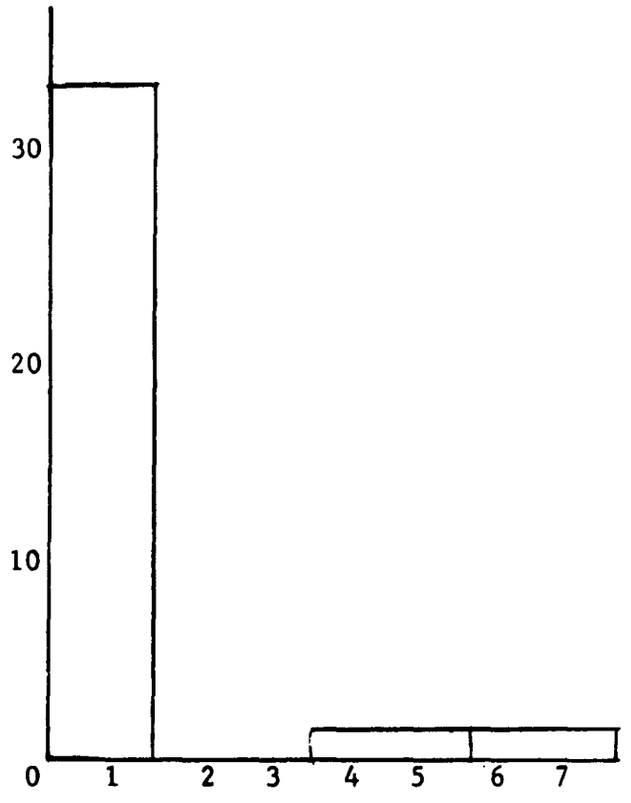


Average Running Times	
4.7-9.8	3
9.9-15.0	10
15.1-20.2	7
20.3-25.4	3
25.5-30.6	7
30.7-35.8	1
35.9-41.0	1
41.1-46.2	3
46.3-51.4	
51.5-56.7	1

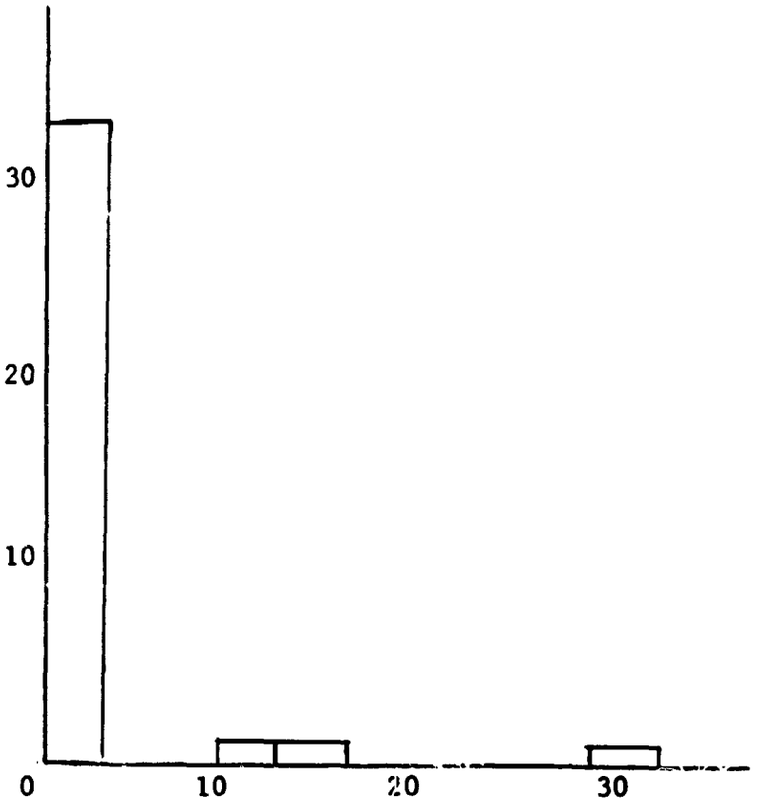


DAILY GROUP E FREQUENCY COUNT

Number of Jobs	
0-1	34
2-3	
4-5	1
6-7	1

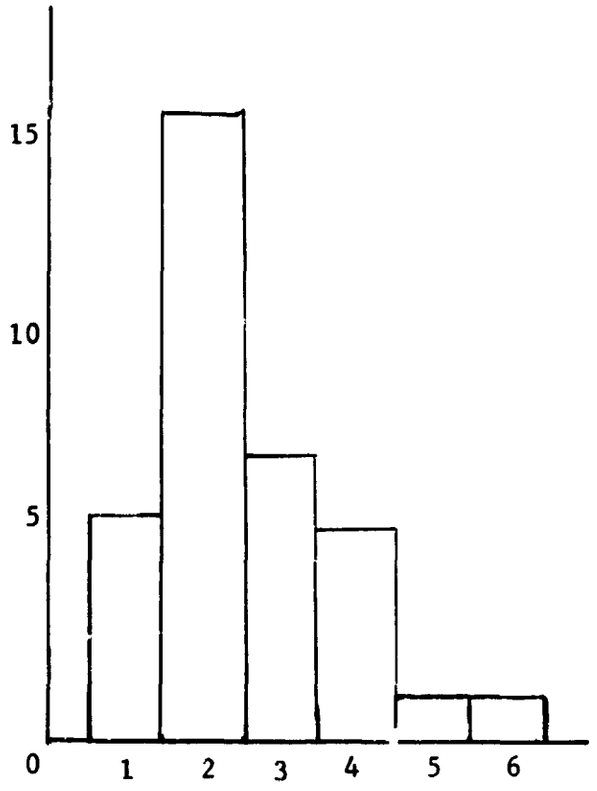


Average Running Times	
0 -3.1	33
3.2-6.3	
6.4-9.5	
9.6-12.7	1
12.8-15.9	1
16.0-19.1	
19.2-22.3	
22.4-25.5	
25.6-28.7	
28.8-31.9	1

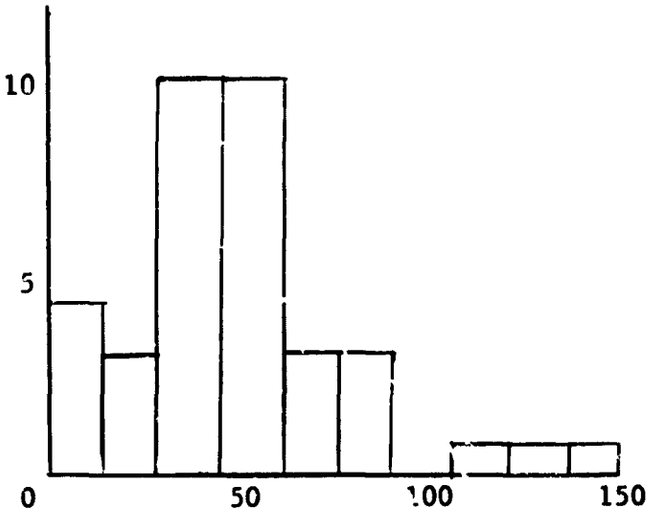


WEEKLY GROUP E FREQUENCY COUNT

Number of Jobs	
1	6
2	16
3	7
4	5
5	1
6	1

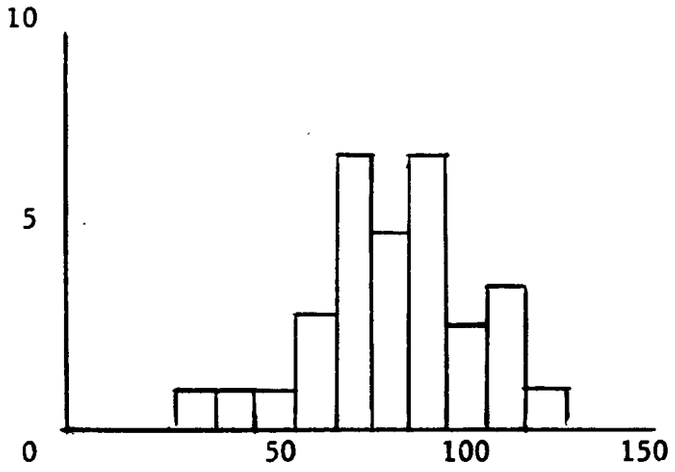


Average Running Times	
0-14.9	4
15-29.9	3
30-44.9	10
45-59.9	10
60-74.9	3
75-89.9	3
90-104.9	
105-119.9	1
120-134.9	1
135-149.9	1

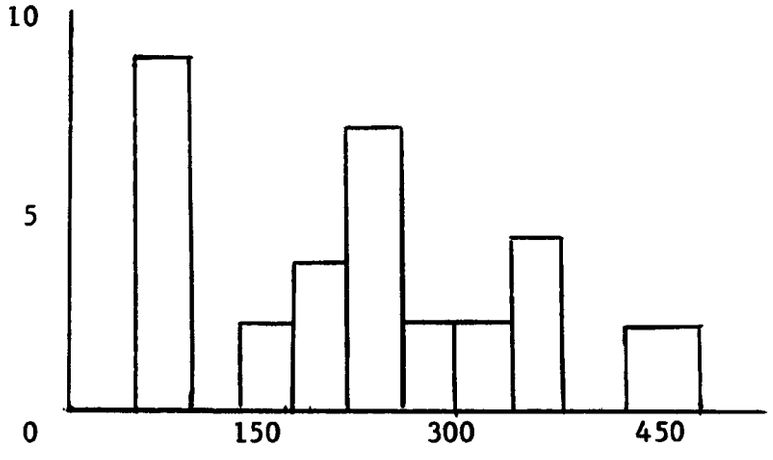


MONTHLY GROUP E FREQUENCY COUNT

Number of Jobs	
27-36	1
37-46	1
47-56	1
57-66	3
67-76	7
77-86	5
87-96	7
97-106	2
107-116	3
117-126	1

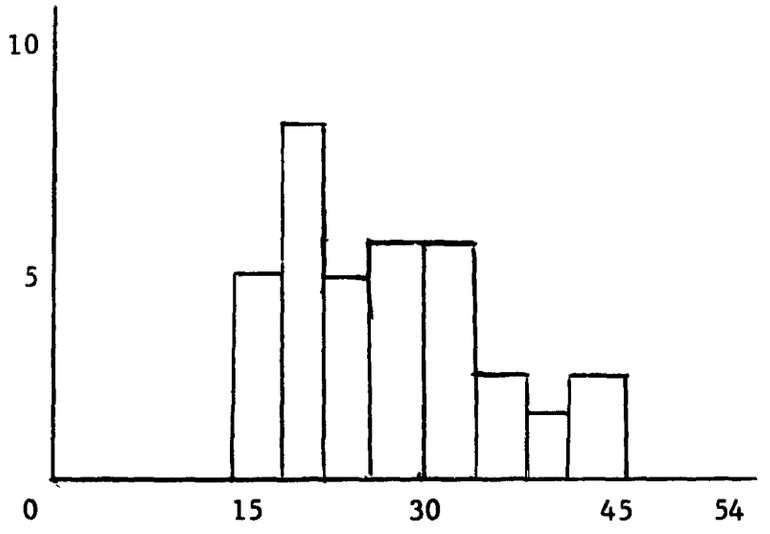


Average Running Times	
36 -79.1	9
79.2-122.3	
122.4-165.5	2
165.6-208.7	3
208.8-251.9	7
252.0-295.1	2
295.2-338.3	2
338.4-381.5	4
381.6-424.7	
424.8-467.9	2

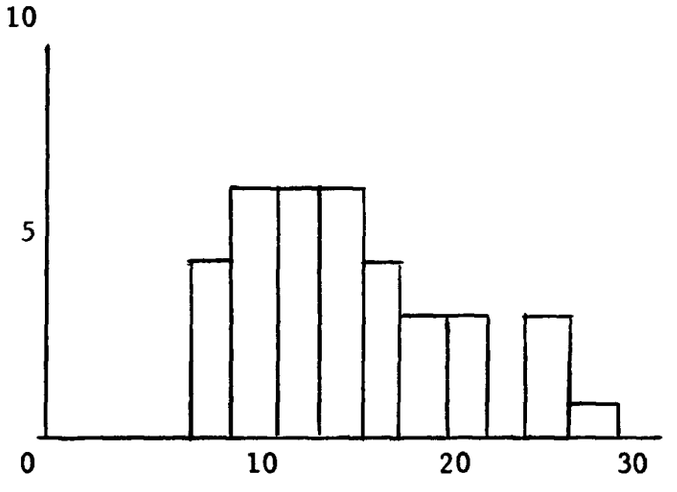


OTHERS GROUP E FREQUENCY COUNT

Number of Jobs	
10-13	
14-17	5
18-21	9
22-25	5
26-29	6
30-33	6
34-37	2
38-41	1
42-45	2
46-49	



Average Running Times	
7 -9.1	4
9.2-11.3	6
11.4-13.5	6
13.6-15.7	6
15.8-17.9	4
18.0-20.1	3
20.2-22.3	3
22.4-24.5	
24.6-26.7	3
26.8-28.9	1

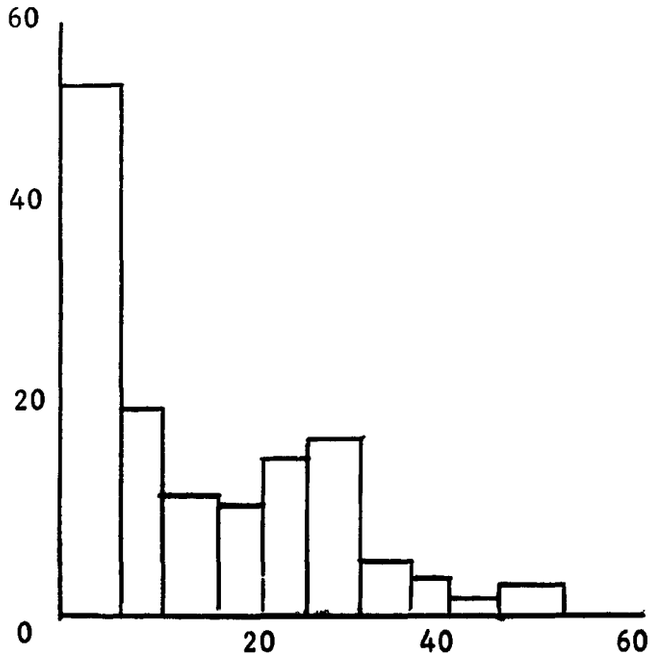


TOTAL

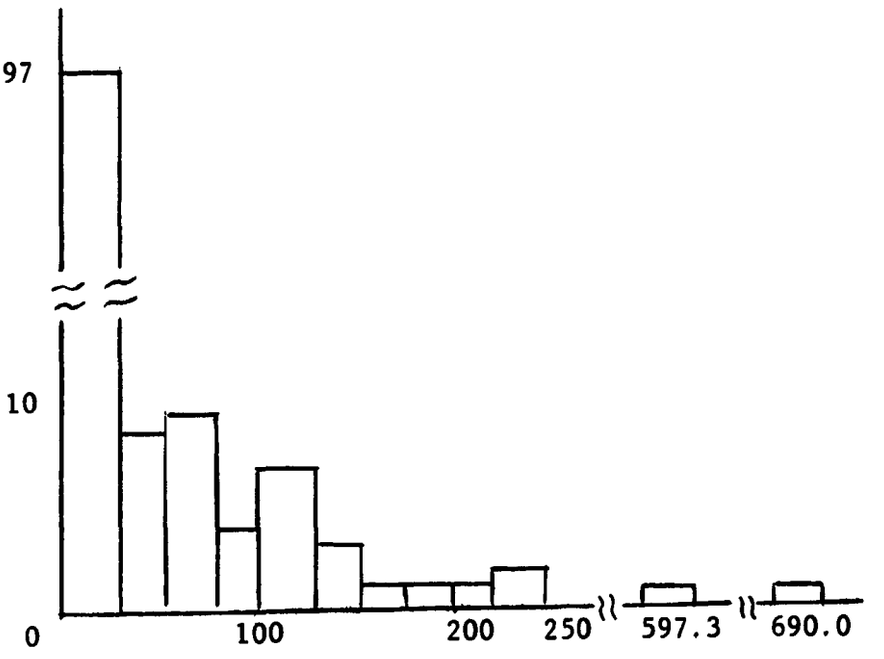
GROUP F

FREQUENCY COUNT

Number of Jobs	
0-4	53
5-9	20
10-14	11
15-19	10
20-24	14
25-29	15
30-34	5
35-39	3
40-44	1
45-49	2

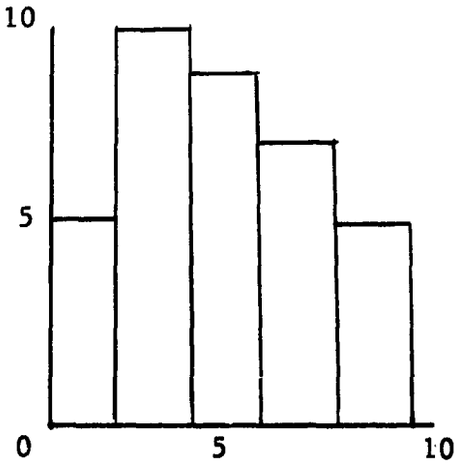


Average Running Times	
0-23	97
24-47	9
48-71	10
72-95	4
96-119	7
120-143	3
144-167	1
168-191	1
192-215	1
216-239	2
597.3	1
690.0	1

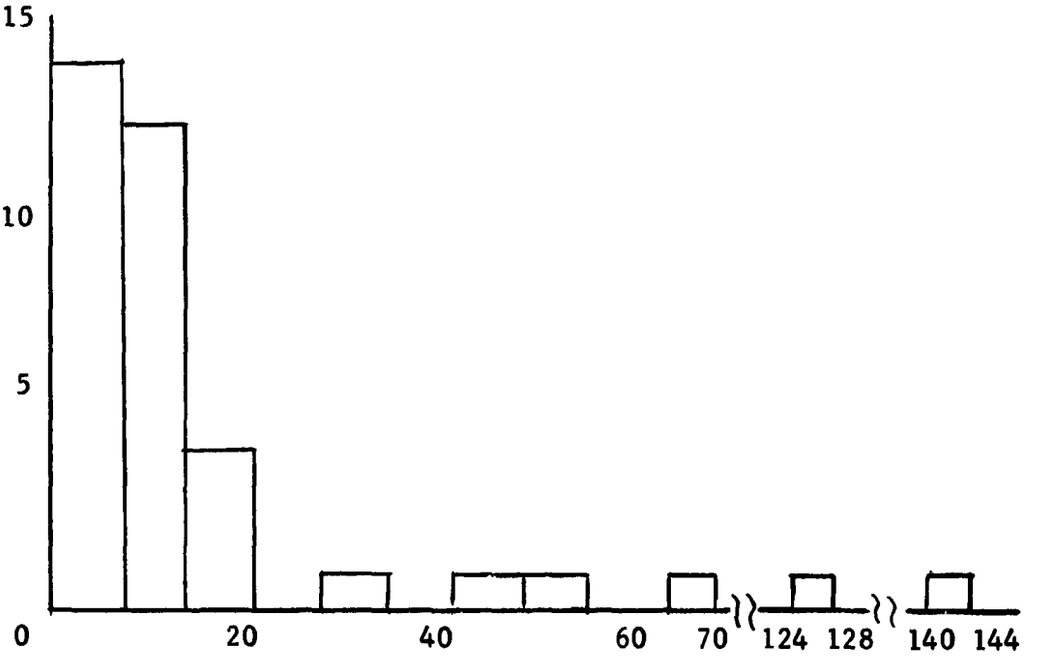


RANDOM GROUP F FREQUENCY COUNT

Number of Jobs	
0-1	5
2-3	10
4-5	9
6-7	7
8-9	5

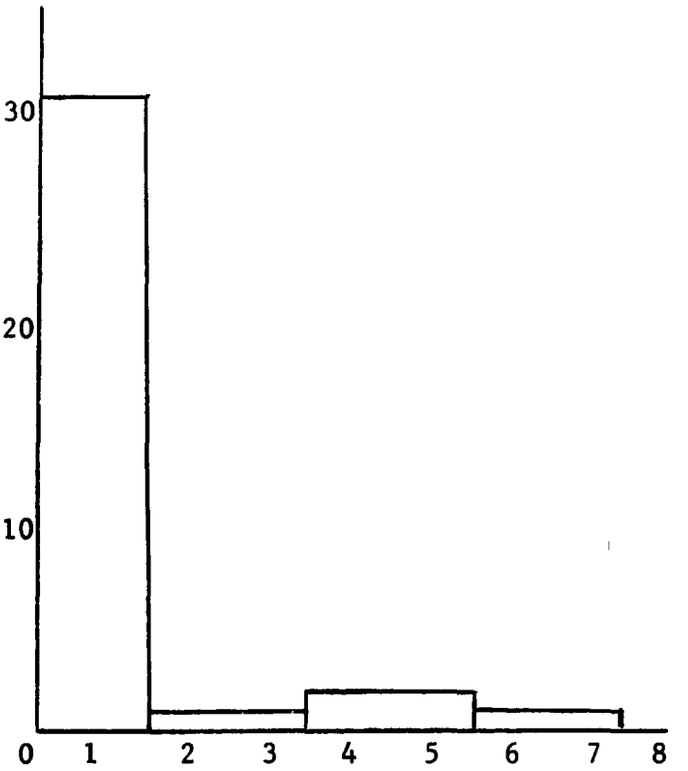


Average Running Times	
0-6.9	14
7-13.9	12
14-20.9	4
21-27.9	
28-34.9	1
35-41.9	
42-48.9	1
49-55.9	1
56-62.9	
63-69.9	1
126.8	1
143.5	1

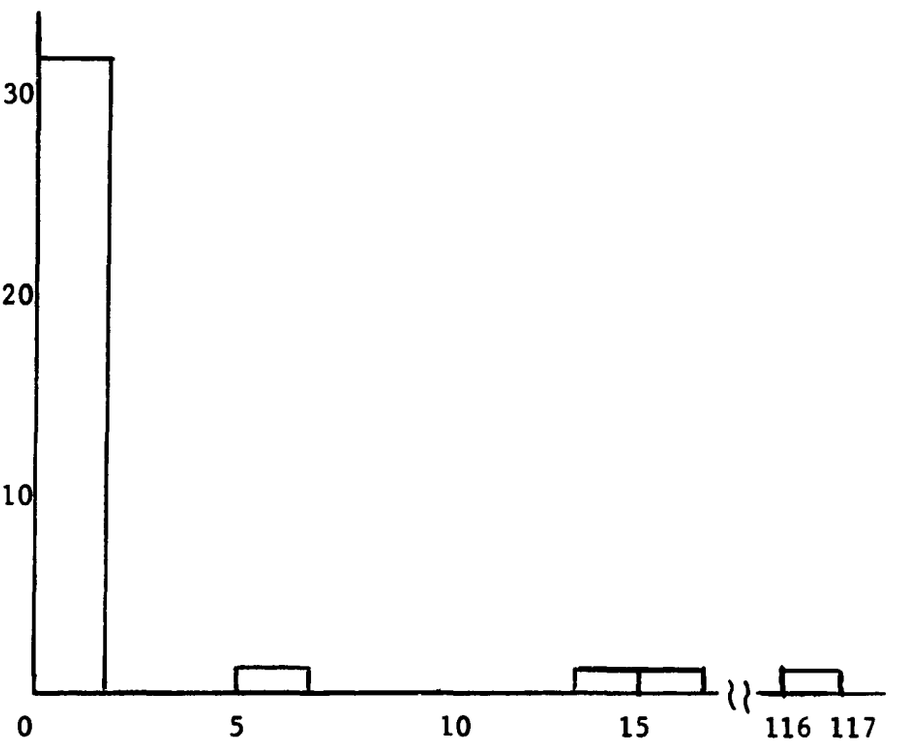


DAILY GROUP F FREQUENCY COUNT

Number of Jobs	
0-1	32
2-3	1
4-5	2
6-7	1

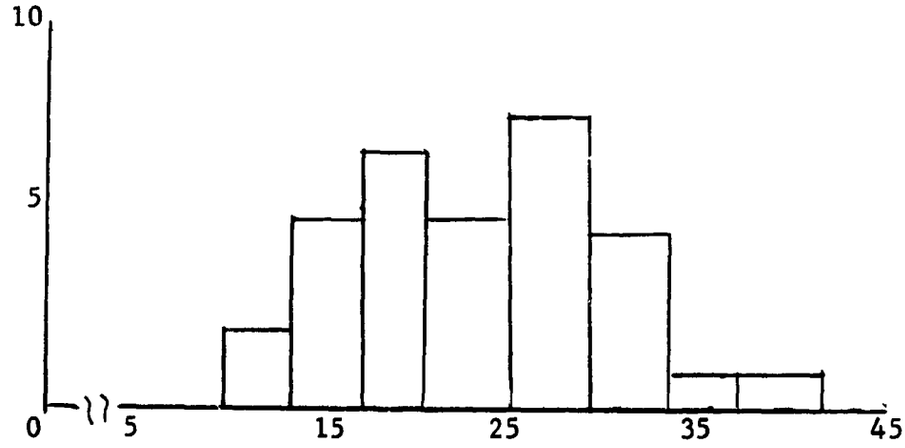


Average Running Times	
0 -1.6	32
1.7-3.3	
3.4-5.0	
5.1-6.7	1
6.8-8.4	
8.5-10.1	
10.2-11.8	
11.9-13.5	
13.6-15.2	1
15.3-16.9	1
116.5	1

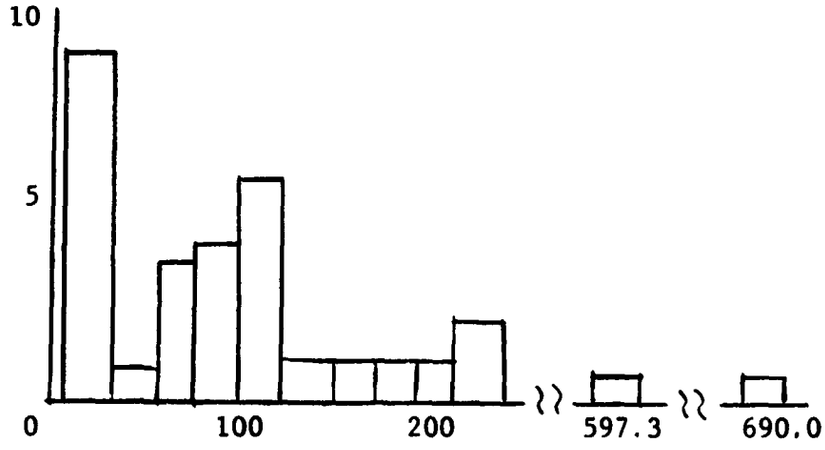


MONTHLY GROUP F FREQUENCY COUNT

Number of Jobs	
6-9	
10-13	2
14-17	5
18-21	6
22-25	5
26-29	7
30-33	4
34-37	1
38-41	1
42-45	

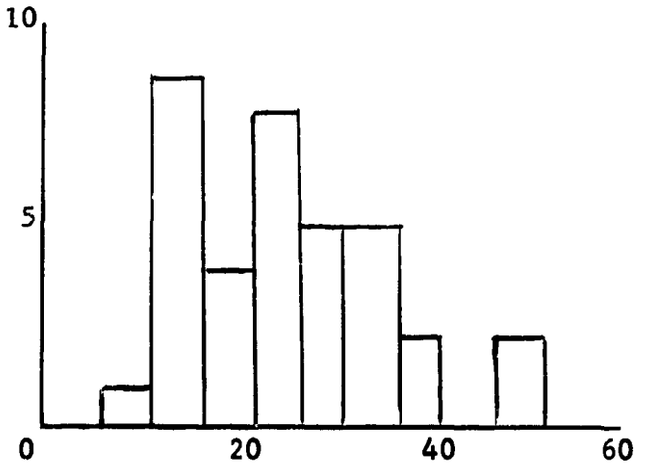


Average Running Times	
6-28.9	9
29-51.9	1
52-74.9	3
75-97.9	4
98-120.9	6
121-143.9	1
144-166.9	1
167-189.9	1
190-212.9	1
213-234.9	2
597.3	1
690.0	1

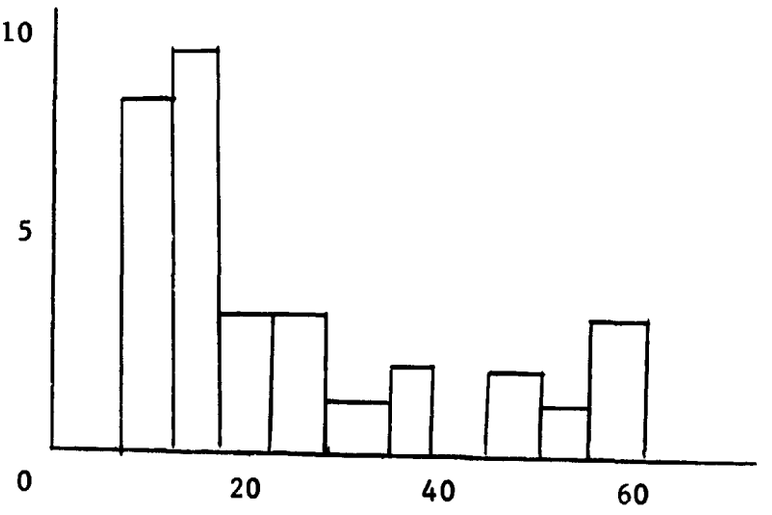


OTHERS GROUP F FREQUENCY COUNT

Number of Jobs	
5-10	1
11-15	9
16-20	4
21-25	8
26-30	5
31-35	5
36-40	2
41-45	
46-50	2
51-55	

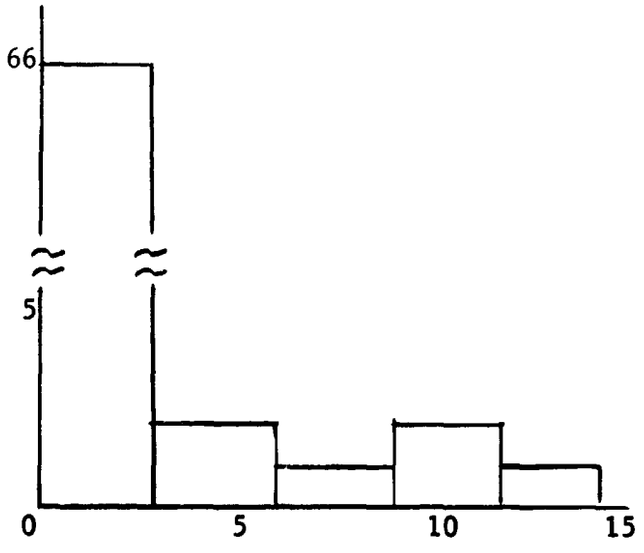


Average Running Times	
6 -11.4	9
11.5-16.9	10
17.0-22.4	4
22.5-27.9	4
28.0-33.4	1
33.5-38.9	2
39.0-44.4	
44.5-49.9	2
50.0-55.4	1
55.5-61.0	3

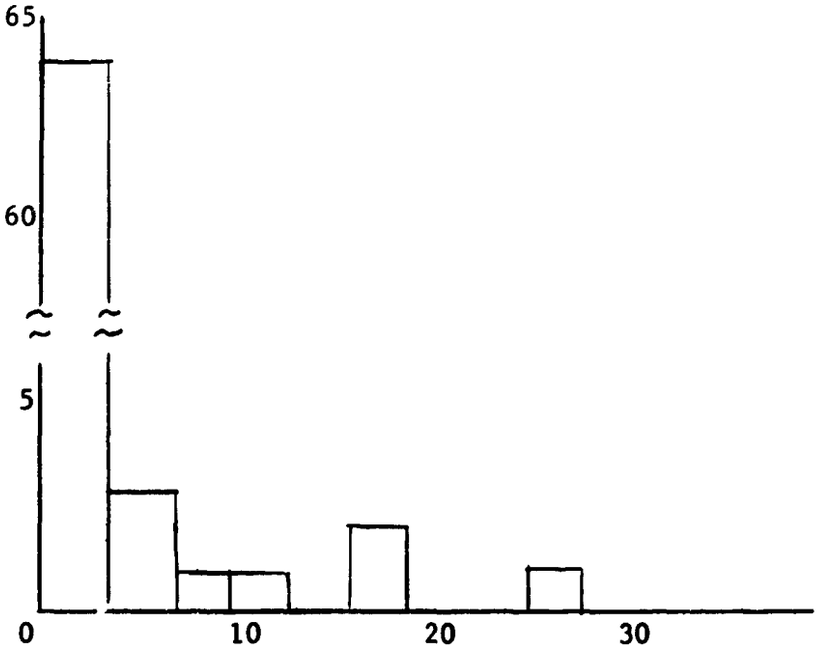


TOTAL GROUP G FREQUENCY COUNT

Number of Jobs	
0-2	66
3-5	2
6-8	1
9-11	2
12-14	1

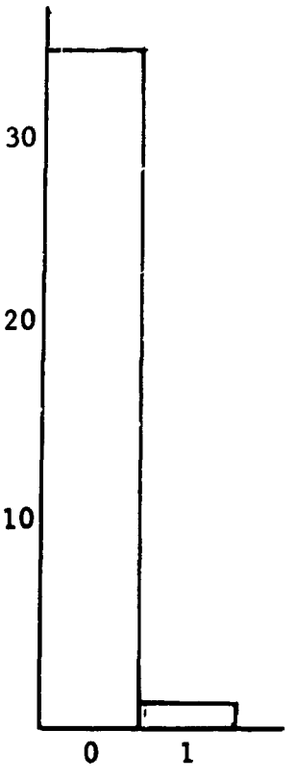


Average Running Times	
0-2.9	64
3-5.9	3
6-8.9	1
9-11.9	1
12-14.9	
15-17.9	2
18-20.9	
21-23.9	
24-26.9	1
27-29.9	

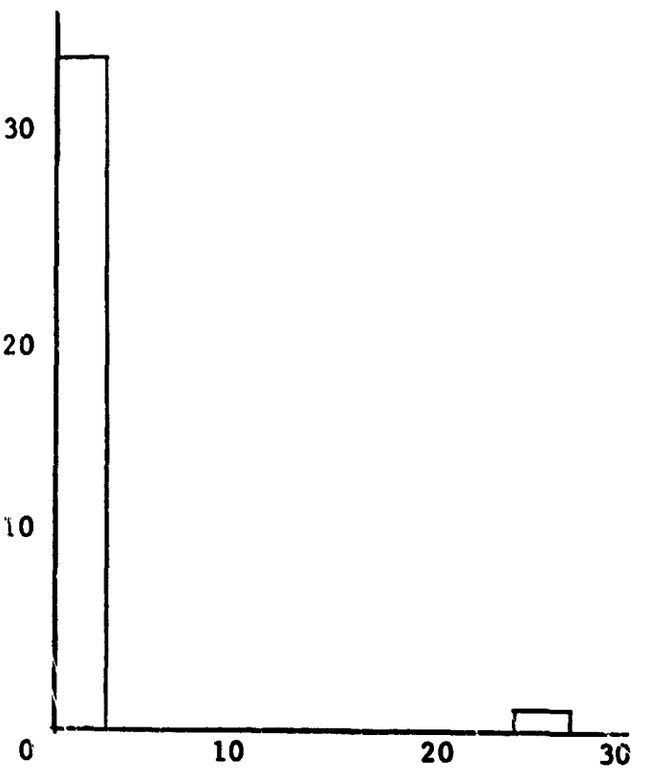


RANDOM GROUP G FREQUENCY COUNT

Number of Jobs	
0	35
1	1

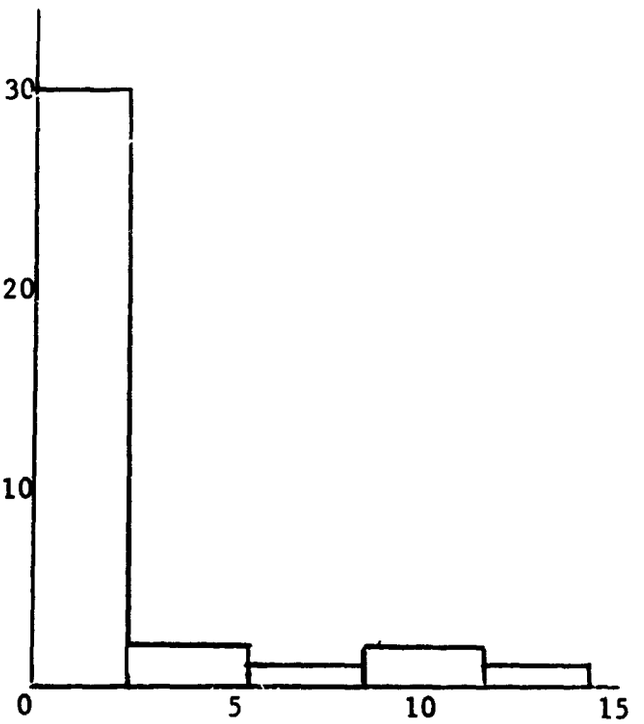


Average Running Times	
0-2.9	35
3-5.9	
6-8.9	
9-11.9	
12-14.9	
15-17.9	
18-20.9	
21-23.9	
24-26.9	1
27-29.9	

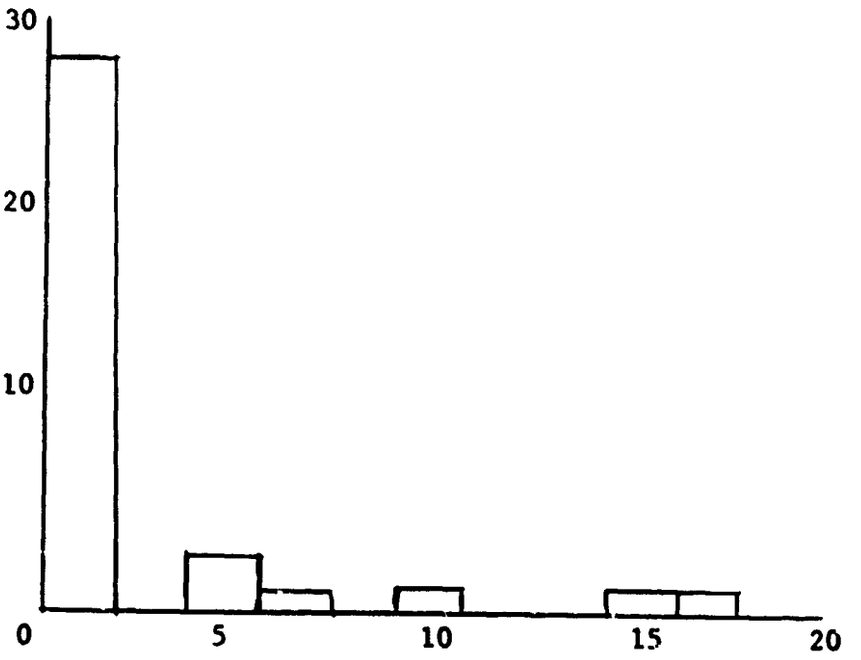


OTHERS GROUP G FREQUENCY COUNT

Number of Jobs	
0-2	30
3-5	2
6-8	1
9-11	2
12-14	1

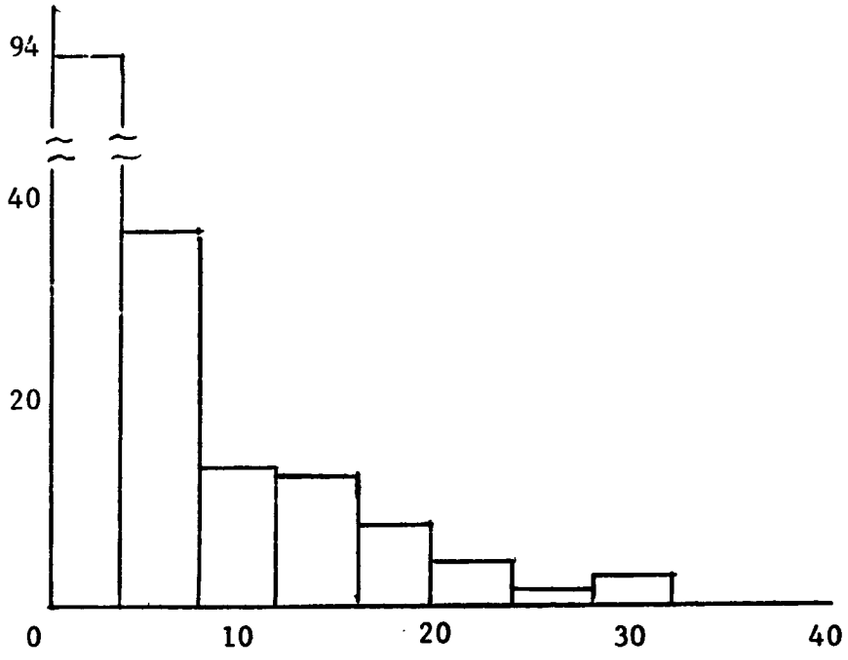


Average Running Times	
0 -1.7	29
1.8-3.5	
3.6-5.3	
5.4-7.1	1
7.2-8.9	
9.0-10.7	1
10.8-12.5	
12.6-14.3	
14.4-16.1	1
16.2-17.9	1

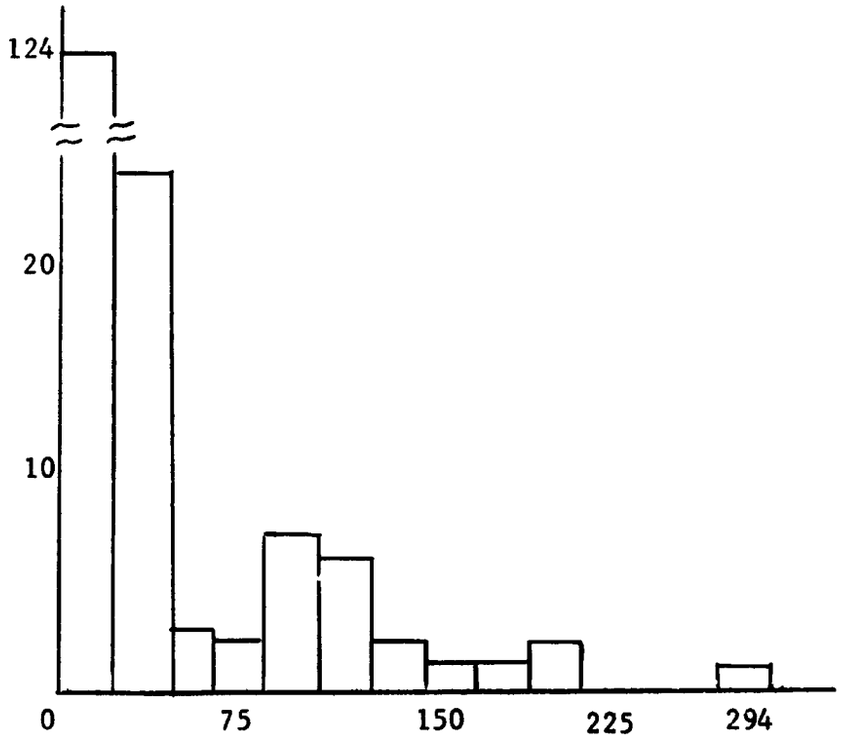


TOTAL GROUP H FREQUENCY COUNT

Number of Jobs	
0-3	94
4-7	38
8-11	13
12-15	12
16-19	9
20-23	5
24-27	1
28-31	3
32-35	
36-39	

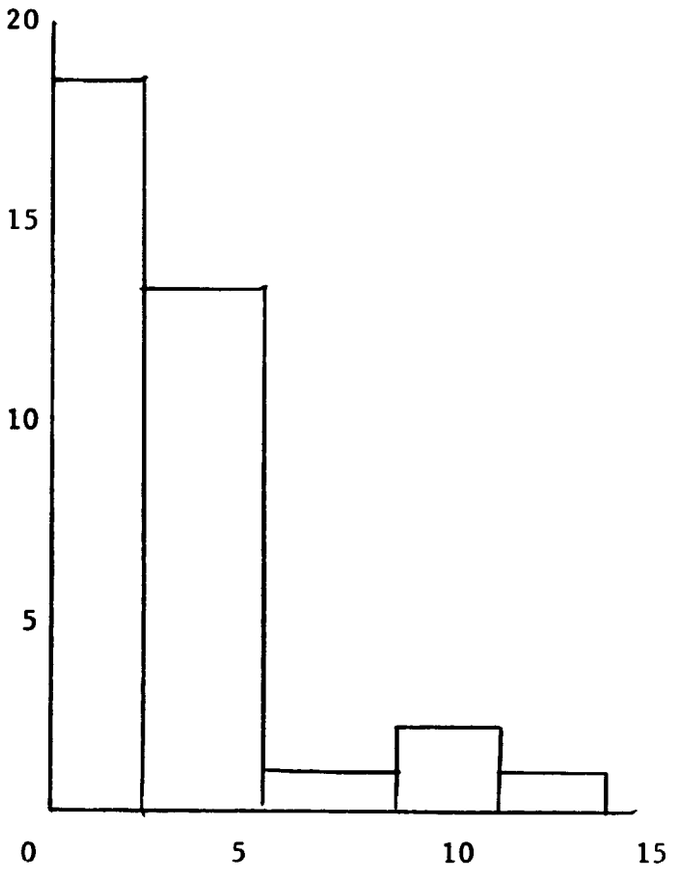


Average Running Times	
0-19	124
20-39	26
40-59	3
60-79	2
80-99	7
100-119	6
120-139	2
140-159	1
160-179	1
180-199	2
294	1

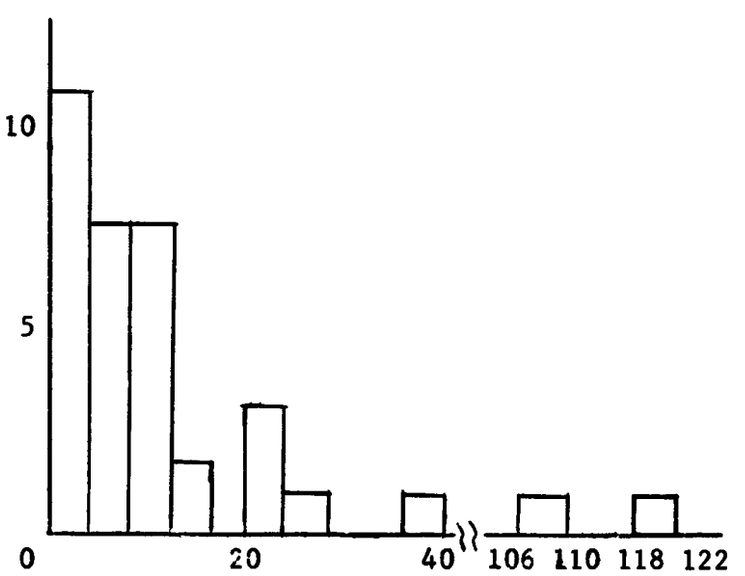


RANDOM GROUP H FREQUENCY COUNT

Number of Jobs	
0-2	19
3-5	13
6-8	1
9-11	2
12-14	1

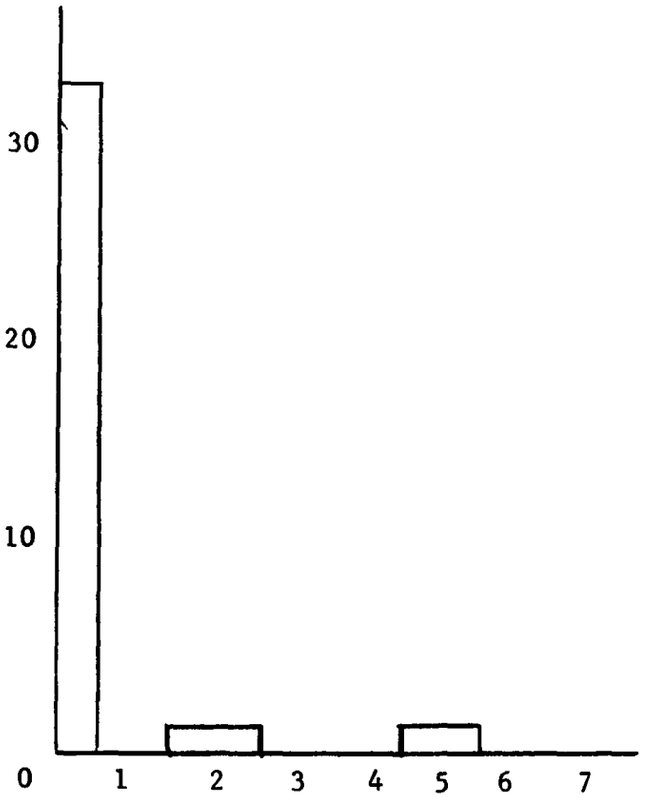


Average Running Times	
0-3.9	11
4-7.9	8
8-11.9	8
12-15.9	2
16-19.9	
20-23.9	3
24-27.9	1
28-31.9	
32-35.9	
36-40	1
108.0	1
119.0	1

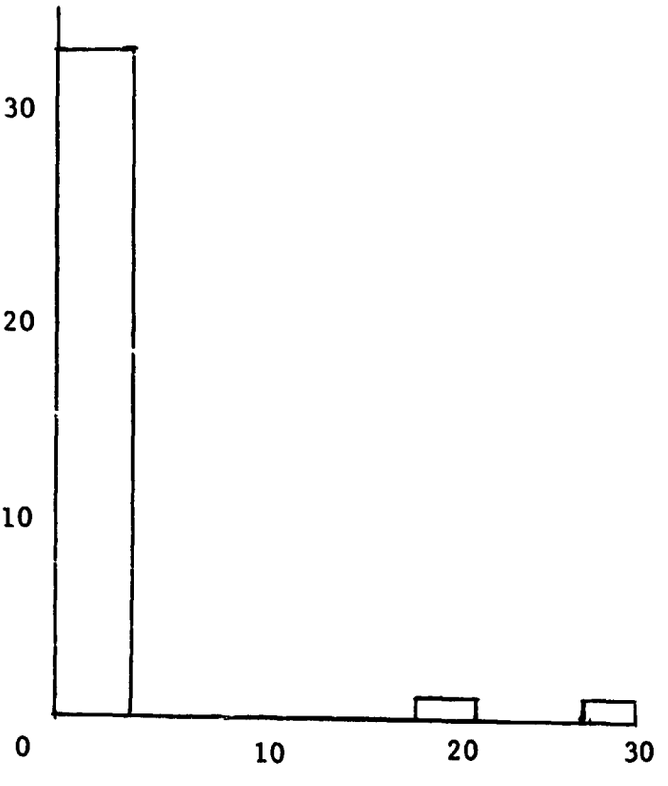


DAILY GROUP H FREQUENCY COUNT

Number of Jobs	
0	34
1	
2	1
3	
4	
5	1

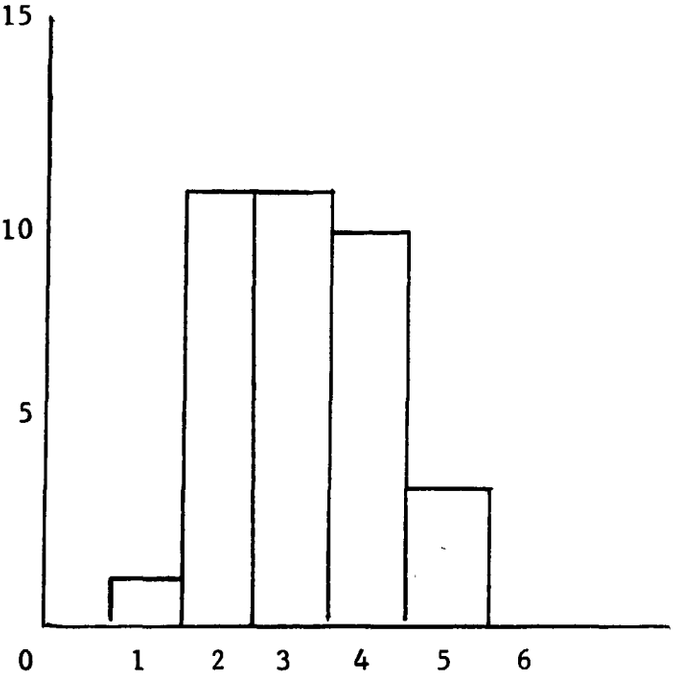


Average Running Times	
0-2.9	34
3-5.9	
6-8.9	
9-11.9	
12-14.9	
15-17.9	
18-20.9	1
21-23.9	
24-26.9	
27-29.9	1

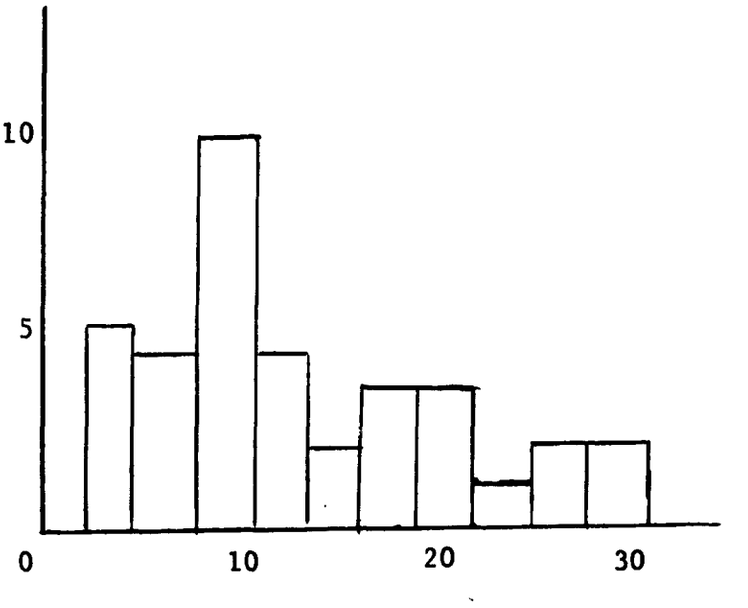


WEEKLY GROUP H FREQUENCY COUNT

Number of Jobs	
0	
1	1
2	11
3	11
4	10
5	3
6	

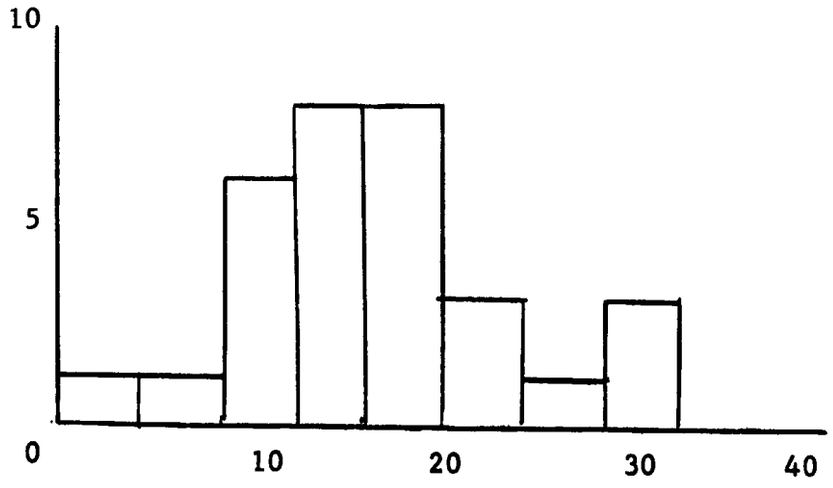


Average Running Times	
2.0-4.8	5
4.9-7.7	4
7.8-10.6	10
10.7-13.5	4
13.6-16.4	2
16.5-19.3	3
19.4-22.2	3
22.3-25.1	1
25.2-28.0	2
28.1-30.9	2

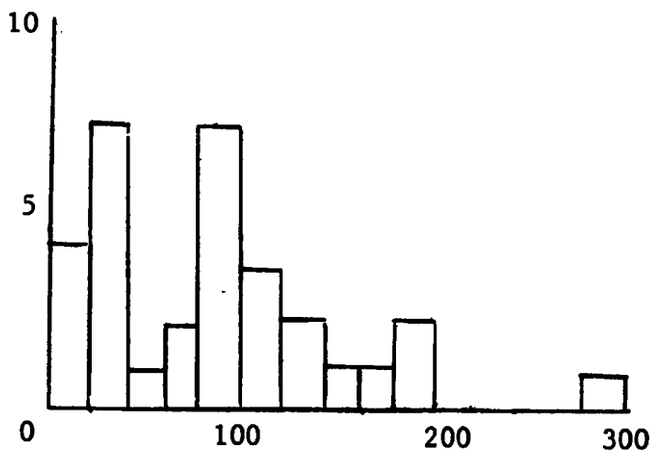


MONTHLY GROUP H FREQUENCY COUNT

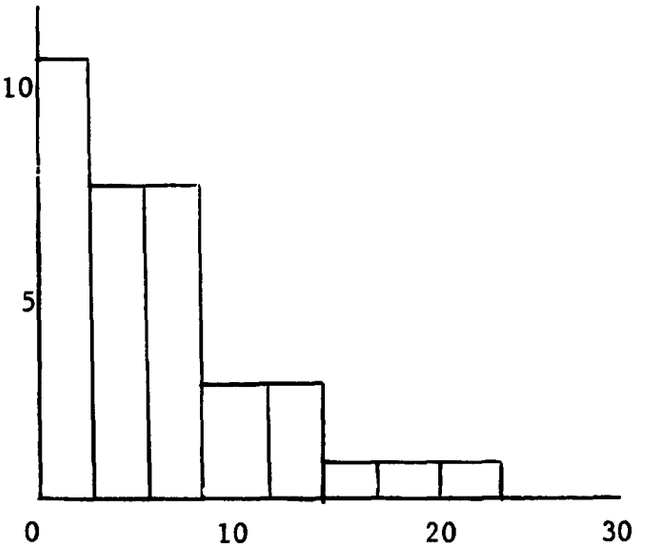
Number of Jobs	
0-3	1
4-7	1
8-11	6
12-15	8
16-19	8
20-23	3
24-27	1
28-31	3
32-35	
36-39	



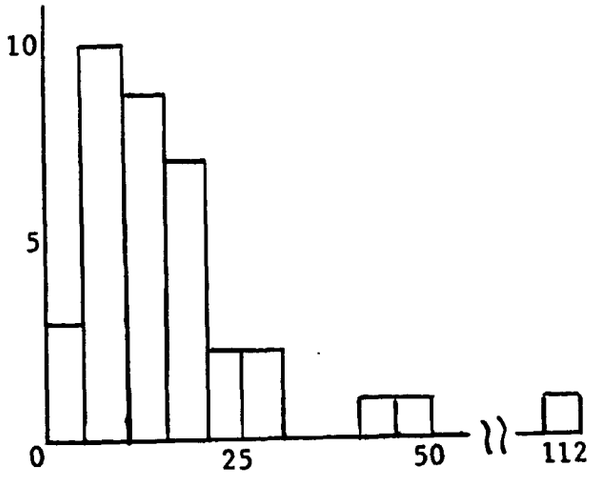
Average Running Times	
0-19.9	4
20-39.9	7
40-59.9	1
60-79.9	2
80-99.9	7
100-119.9	3
120-139.9	2
140-159.9	1
160-179.9	1
180-199.9	2
294.0	1



Number of Jobs	
0-2	11
3-5	8
6-8	8
9-11	3
12-14	3
15-17	1
18-20	1
21-23	1

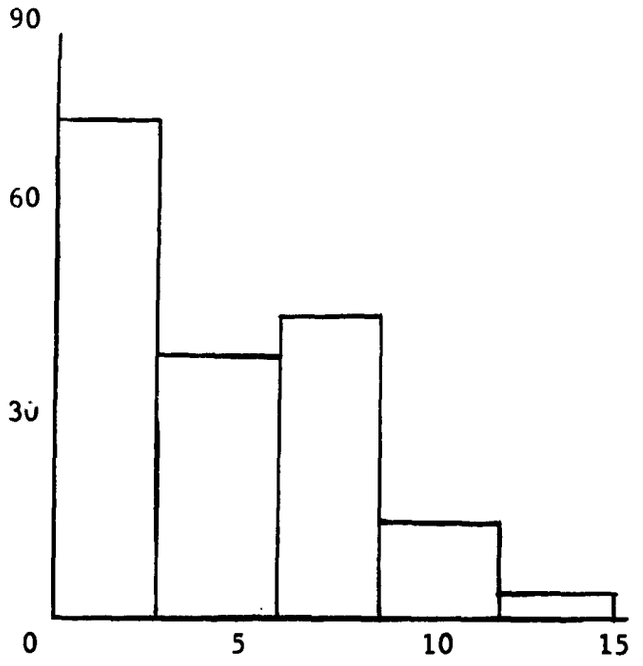


Average Running Times	
0-4.9	3
5-9.9	10
10-14.9	9
15-19.9	7
20-24.9	2
25-29.9	2
30-34.9	
35-39.9	
40-44.9	1
45-49.9	1
112.0	1

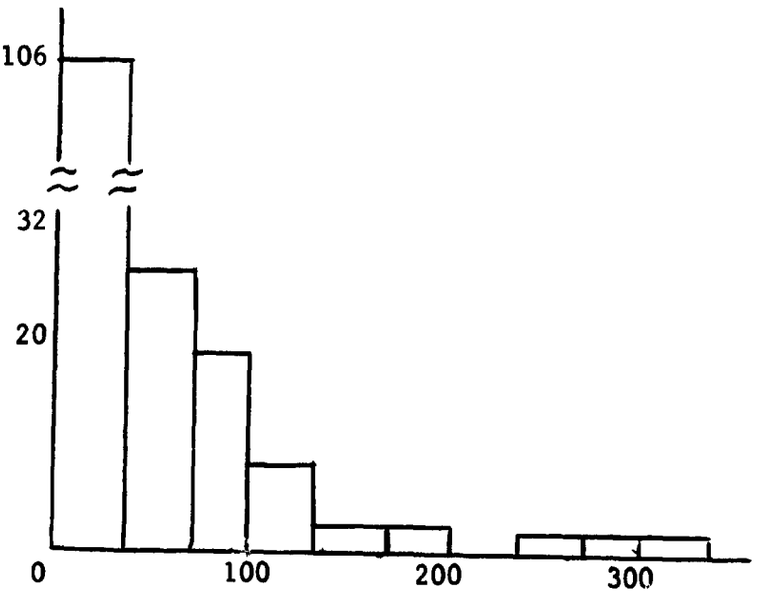


TOTAL GROUP I FREQUENCY COUNT

Number of Jobs	
0-2	74
3-5	41
6-8	46
9-11	12
12-14	2



Average Running Times	
0-33	106
34-67	30
68-101	22
102-135	10
136-169	2
170-203	2
204-237	
238-271	1
272-305	1
306-339	1

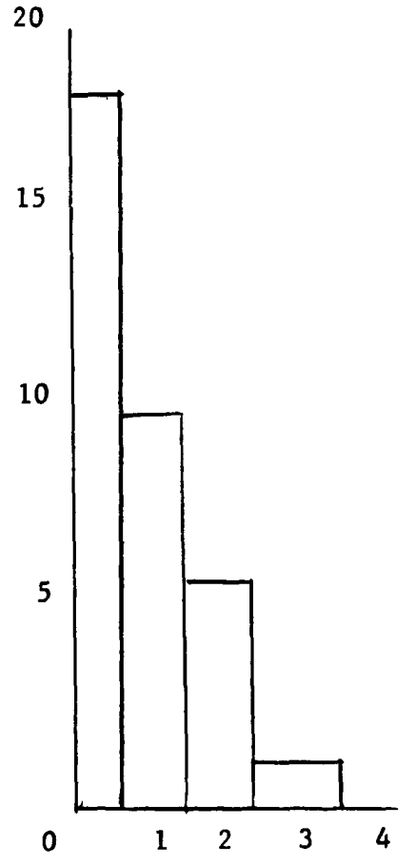


RANDOM

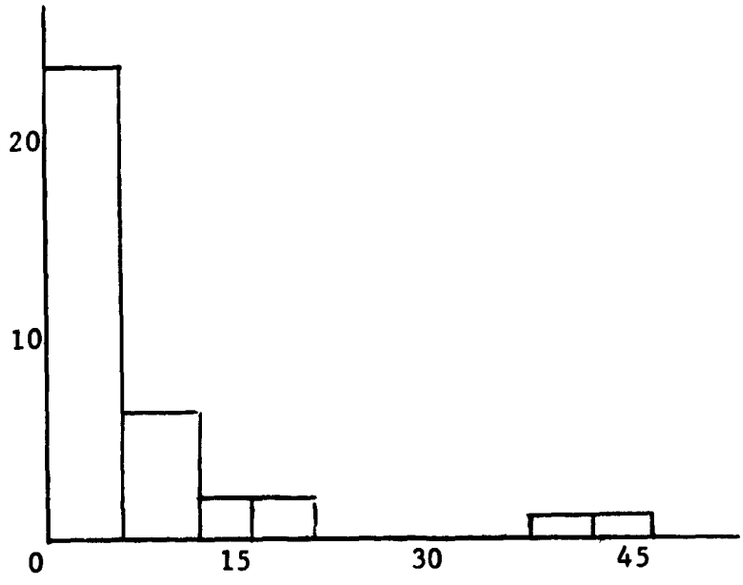
GROUP I

FREQUENCY COUNT

Number of Jobs	
0	19
1	10
2	6
3	1

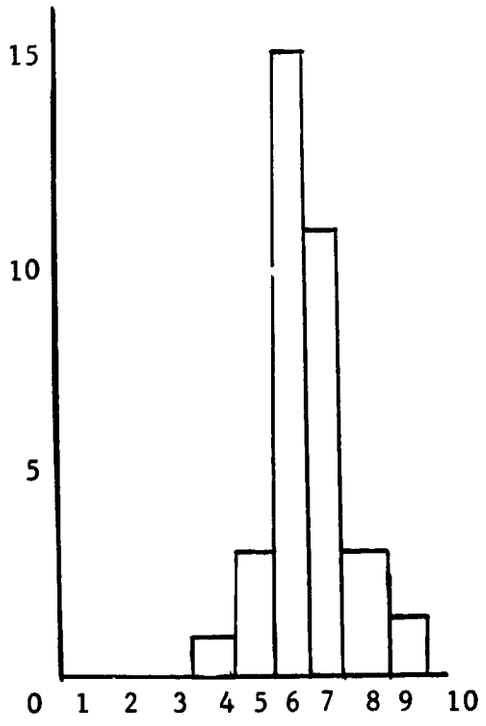


Average Running Times	
0 -5.1	25
5.2-10.3	5
10.4-15.5	2
15.6-20.7	2
20.8-25.9	
26.0-31.1	
31.2-36.3	
36.4-41.5	
41.6-46.7	1
46.8-51.9	1

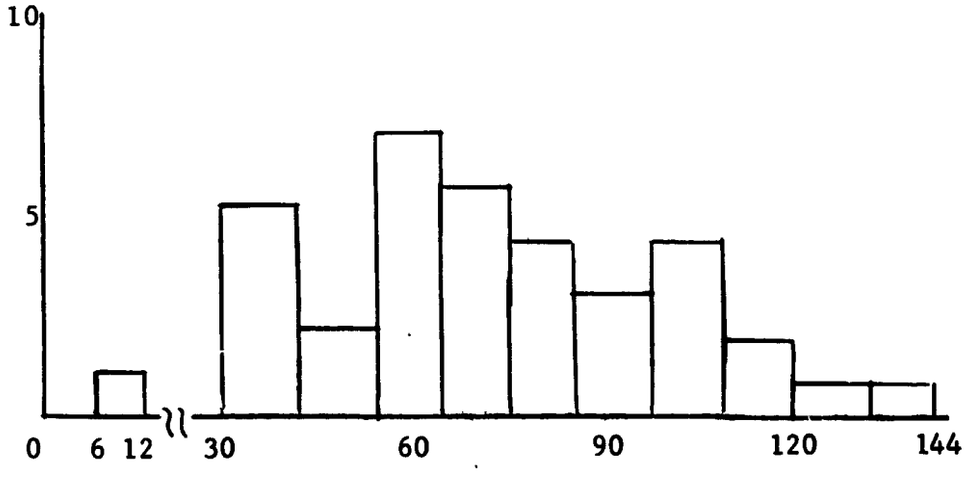


DAILY GROUP I FREQUENCY COUNT

Number of Jobs	
4	1
5	3
6	16
7	11
8	3
9	2

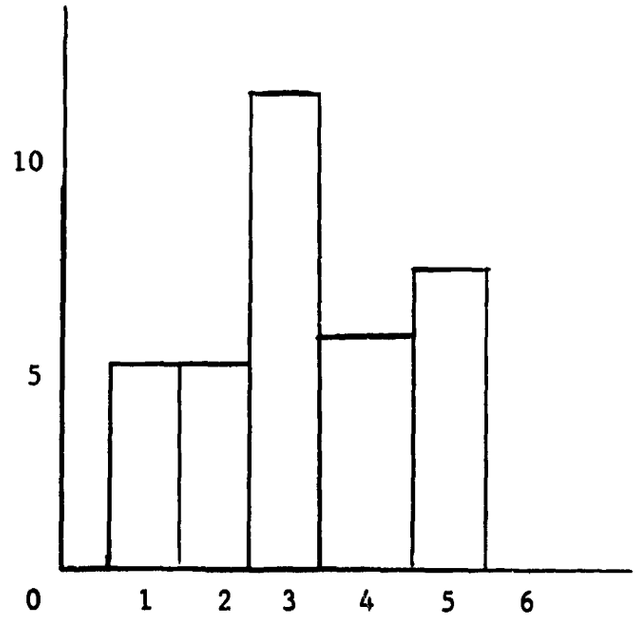


Average Running Times	
9.0	1
32-42.9	5
43-53.9	2
54-64.9	7
65-75.9	6
76-86.9	4
87-97.9	3
98-108.9	4
109-119.9	2
120-130.9	1
131-141.9	1

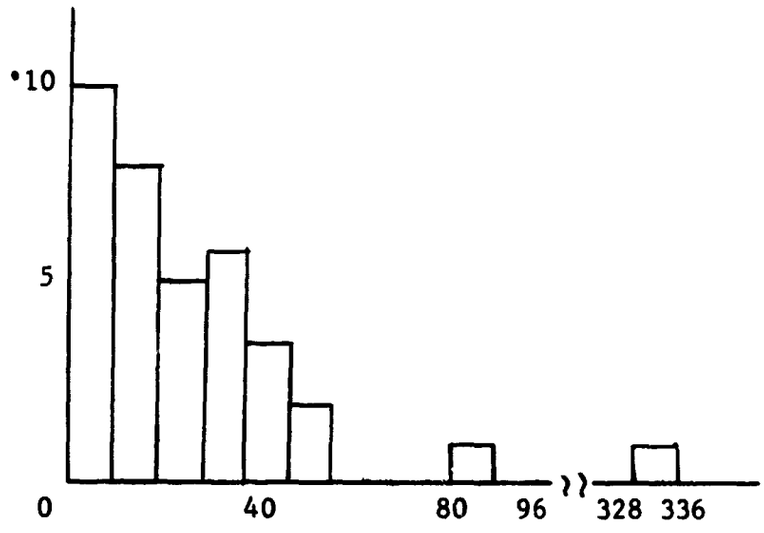


WEEKLY GROUP I FREQUENCY COUNT

Number of Jobs	
1	5
2	5
3	12
4	6
5	8

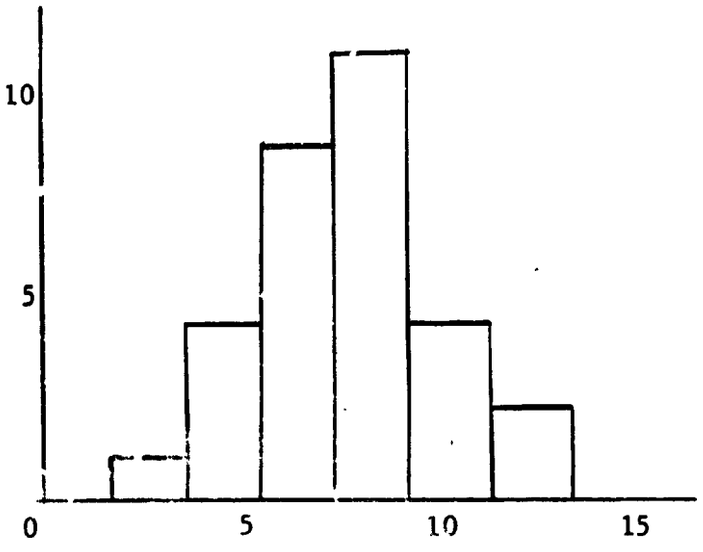


Average Running Times	
0-8.9	10
9-17,9	8
18-26.9	5
27-35.9	6
36-44.9	3
45-53.9	2
54-62,9	
63-71.9	
72-80.9	
81-89.9	1
333	1

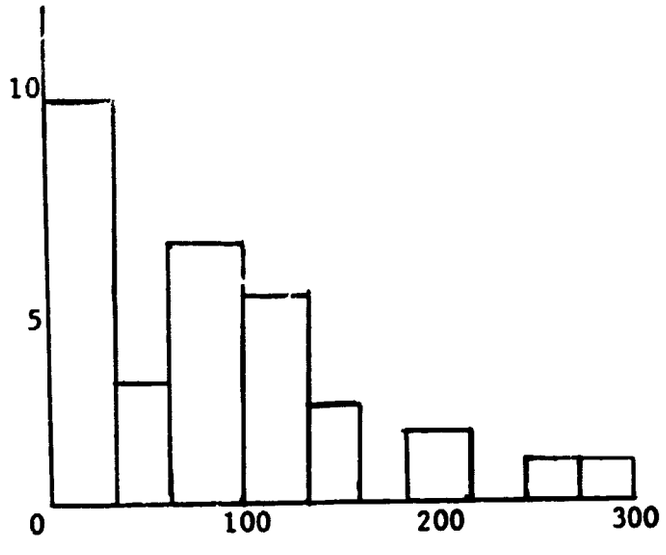


MONTHLY GROUP I FREQUENCY COUNT

Number of Jobs	
0-1	
2-3	1
4-5	4
6-7	9
8-9	11
10-11	4
12-13	2
14-15	

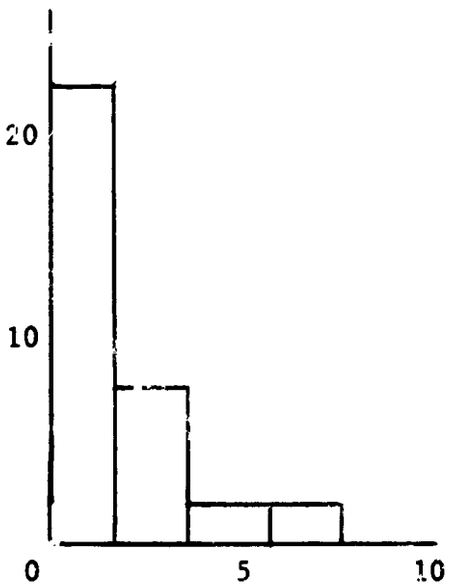


Average Running Times	
0-29.9	10
30-59.9	3
60-89.9	6
90-119.9	5
120-149.9	3
150-179.9	
180-209.9	2
210-239.9	
240-269.9	1
270-299.9	1

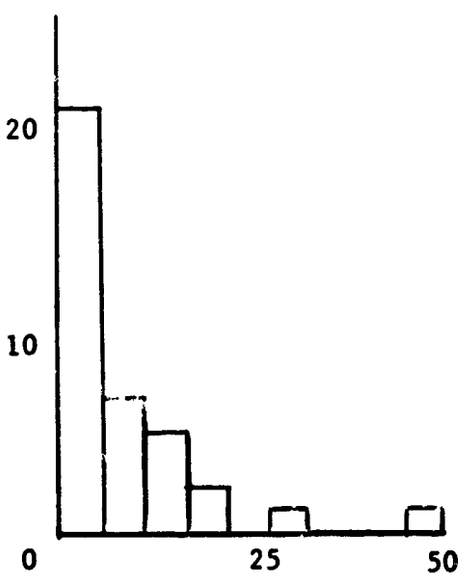


OTHERS GROUP I FREQUENCY COUNT

Number of Jobs	
0-1	24
2-3	8
4-5	2
6-7	2
8-9	

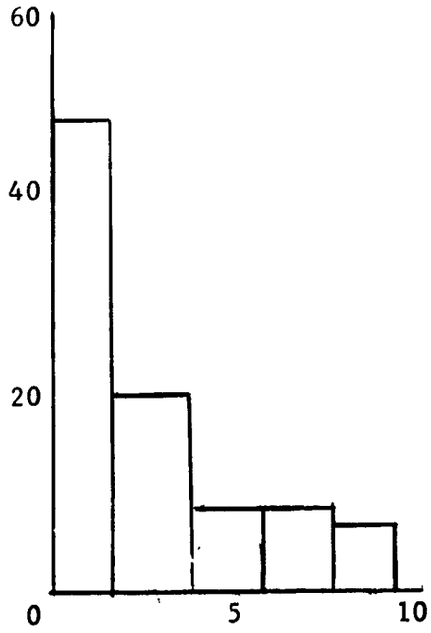


Average Running Times	
0-4.9	21
5-9.9	6
10-14.9	5
15-19.9	2
20-24.9	
25-29.9	1
30-34.9	
35-39.9	
40-44.9	
45-49.9	1

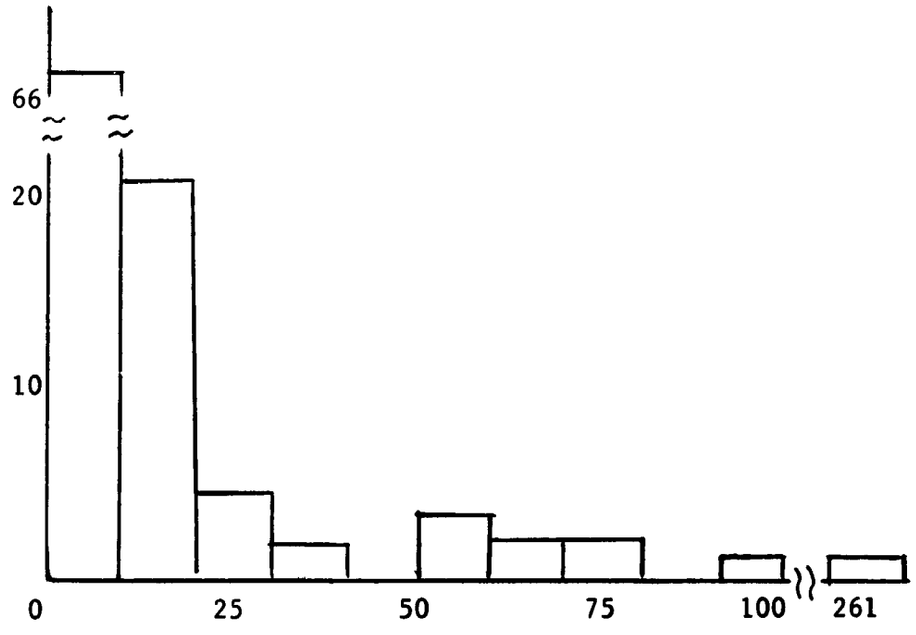


TOTAL GROUP K FREQUENCY COUNT

Number of Jobs	
0-1	50
2-3	20
4-5	9
6-7	9
8-9	7

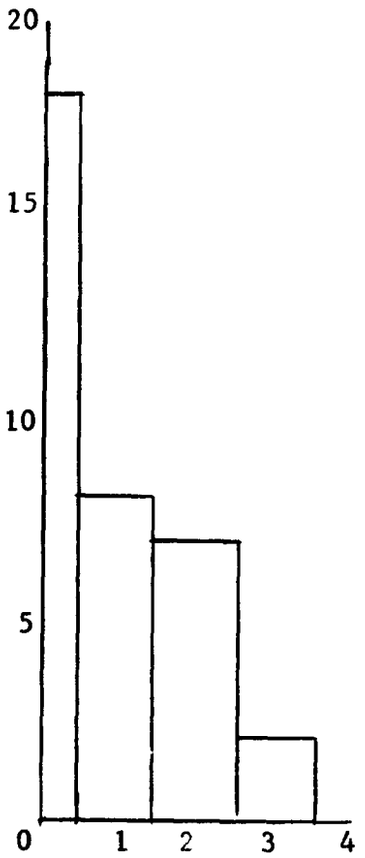


Average Running Times	
0-9	67
10-19	21
20-29	4
30-39	2
40-49	
50-59	3
60-69	2
70-79	2
80-89	
90-99	1
261	1

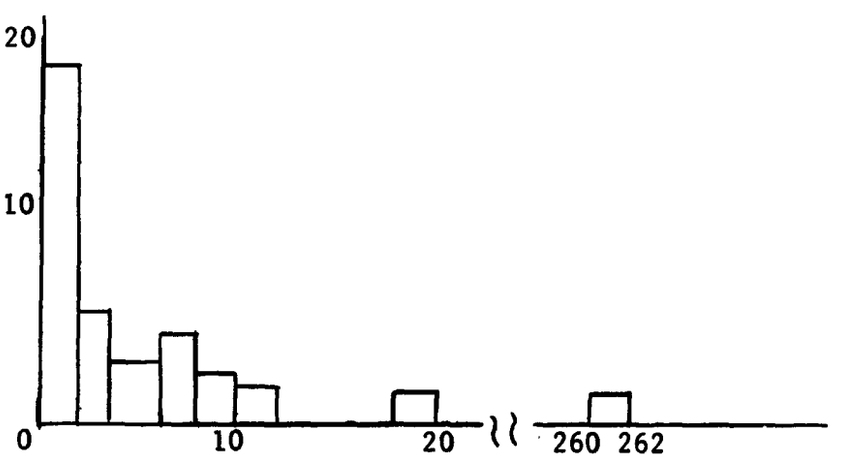


RANDOM GROUP K FREQUENCY COUNT

Number of Jobs	
0	19
1	8
2	7
3	2

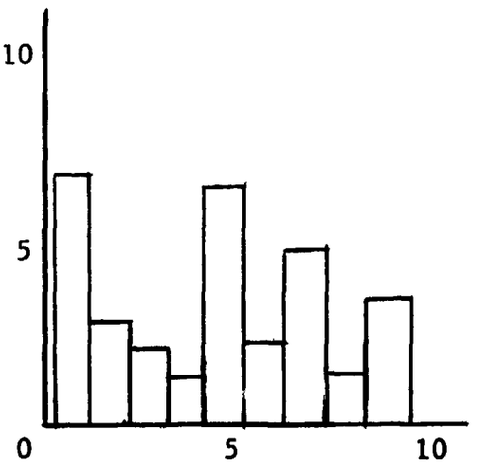


Average Running Times	
0-1.9	19
2-3.9	5
4-5.9	3
6-7.9	4
8-9.9	2
10-11.9	1
12-13.9	
14-15.9	
16-17.9	
18-19.9	1
261.0	1

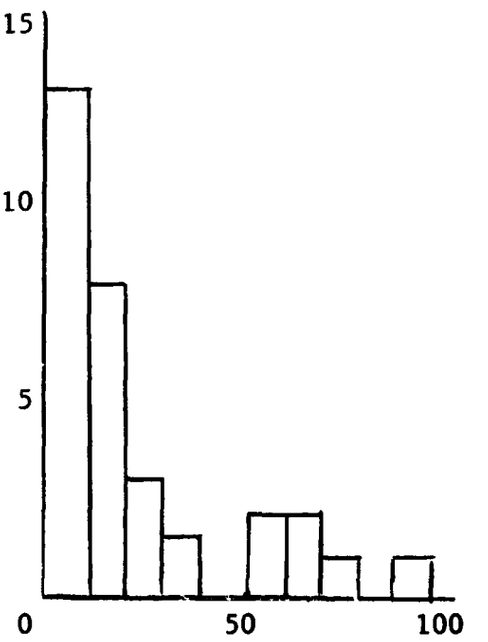


MONTHLY GROUP K FREQUENCY COUNT

Number of Jobs	
0	
1	7
2	3
3	2
4	1
5	8
6	2
7	4
8	1
9	3

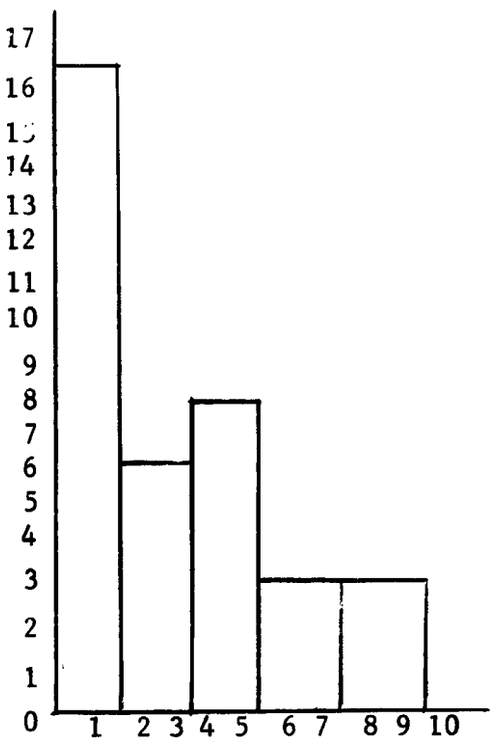


Average Running Times	
0-9.9	13
10-19.9	8
20-29.9	3
30-39.9	1
40-49.9	
50-59.9	2
60-69.9	2
70-79.9	1
80-89.9	
90-99.9	1

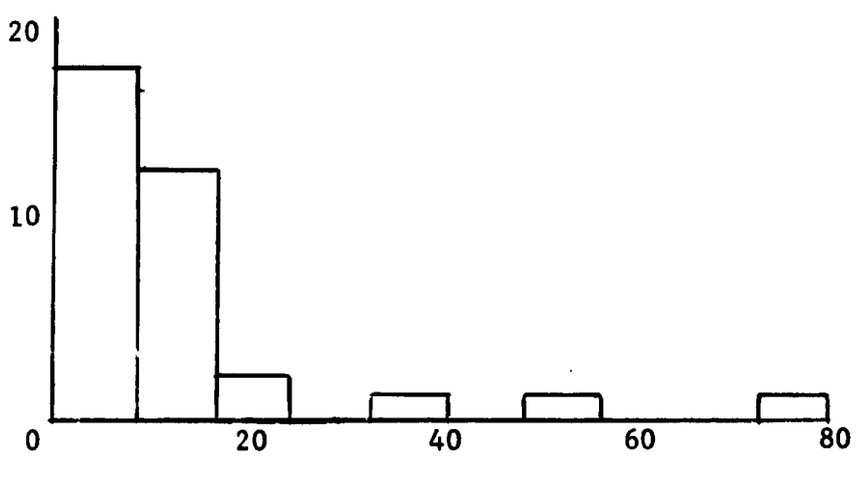


OTHERS GROUP K FREQUENCY COUNT

Number of Jobs	
0-1	16
2-3	6
4-5	8
6-7	3
8-9	3



Average Running Times	
0-7.9	19
8-15.9	12
16-23.9	2
24-31.9	
32-39.9	1
40-47.9	
48-55.9	1
56-63.9	
64-71.9	
72-79.9	1



APPENDIX B

LISTING OF THE MATHEMATICAL SIMULATION MODEL COMPUTER PROGRAM

```
$JOB    IE351T  COCHRAN FOR BELL
$TIME           25
$PAGE           100
$IBJOB NASA
$IBFTC
      DIMENSION CARRY(39),RUNHR(39),HOLD(39,4),TCOST(39)
      DIMENSION TABLE(39,10),S9185(39,2),BLDG(2),N(20)
      DIMENSION SCOST(20,4),TYPE(4),RCOST(39),BOLD(39,4)
      REAL MAXHR
      DATA BLDG/4H4491,4H4485/
      DATA TYPE/24HPRESENT LOADDOUBLE LOAD /
      DO2I=1,39
      READ(5,1) (TABLE(I,J),J=1,10)
1     FORMAT(10(F6.0))
      S9185(I,1)=0.
      S9185(I,2)=TABLE(I,3)/45.
      DO2K=1,10
      IF(K.NE.3) S9185(I,1)=S9185(I,1)+TABLE(I,K)/45.
2     CONTINUE
      DO12LL=1,2
      MA=LL*2
      NA=MA-1
      DO12L=1,2
      I=0
20    I=I+1
      N(I)=1
      J=0
21    J=J+1
      SCOST(I,J)=0.
      MAXHR=40*I*J
      WRITE(6,11) BLDG(L),(TYPE(III),III=NA,MA),I,J
11    FORMAT(1H1,10X,24HSIMULATION FOR BUILDING ,A4,5H FOR ,2A6/1H0,15X,
     111HMACHINE  = ,I1/1H+,15X,12HOPERATORS = ,I1/1H-,29X,5HHOURS,11X,
     25HCARRY,12X,3HRUN,11X,5HTOTAL/1H+,15X,4HWEEK,11X,3HRUN,13X,4HOVER,
     311X,4HCOST,12X,4HCOST/)
      DO4K=1,39
      SUM        =FLOAT(LL)*S9185(K,L)
      CARRY(K)=0.
      RUNHR(K)=SUM
      IF(SUM        .LE.MAXHR) GO TO 3
      RUNHR(K)=MAXHR
      CARRY(K)=SUM        -MAXHR
3     RCOST(K)=RUNHR(K)*10.
      TCOST(K)=RCOST(K)+40.*CARRY(K)+100.*FLOAT(J*((I+1)/2))
      WRITE(6,30) K,RUNHR(K),CARRY(K),RCOST(K),TCOST(K)
30    FORMAT(1H+,16X,I2,4(7X,F9.2))
4     SCOST(I,J)=SCOST(I,J)+TCOST(K)
      WRITE(6,32) SCOST(I,J)
32    FORMAT(1H0,15X,17HWEEKLY COST TOTAL,39X,F11.2)
      JJ=J-1
      IF(J.EQ.1) GO TO 21
      IF(SCOST(I,J).LT.SCOST(I,JJ)) N(I)=J
      IF(J.NE.4) GO TO 21
      IF(I.EQ.1) GO TO 20
      LM=N(I)
      II=I-1
      M=N(II)
      IF(SCOST(I,LM).LT.SCOST(II,M)) GO TO 20
      WRITE(6,13) BLDG(L),(TYPE(III),III=NA,MA)
13    FORMAT(1H1,10X,9HBUILDING ,A4,13H SUMMARY FOR ,  2A6/1H-,15X,
```

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     19HNUMBER OF,6X,9HNUMBER OF,11X,6HWEEKLY/1H+,16X,8HMACHINES,8X,
     26HSHIFTS,10X,10HCOST TOTAL/)
      DO15MI=1,I
      KK=N(MI)
15    WRITE(6,14) MI,KK,SCOST(MI,KK)
14    FORMAT(1H+,18X,I2,13X,I1,13X,F11.2)
12    WRITE(6,33) II,M
33    FORMAT(1H-,5X,23HTHE OPTIMUM SOLUTION IS ,I2,14H MACHINES AND ,
     1I1,8H SHIFTS.)
      STOP
      END
```