MEMORANDUM
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JOSS: ACCOUNTING AND PERFORMANCE MEASUREMENT

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PREFACE

JOSS† is a multi-user, single-server computing system that provides for the solution of numerical problems. The system consists of a central computer containing the JOSS program and a number of typewriter consoles connected to the computer through telephone lines. The central computer turns its attention rapidly from console to console, in such a way that individual users would appear to have exclusive use of the system.

When the JOSS system was first developed in the early sixties, it was implemented on the JOHNNIAC computer. The system was impressive enough, in spite of JOHNNIAC's doddering years, to substantiate the acquisition of a new computer, the Digital Equipment Corporation PDP-6, and the creation of a second JOSS. Introduction of the new JOSS in formal operation took place in February 1966. The final hardware and corresponding software were added to the system during that year, providing a high-speed drum for swapping of large user programs and a disc file for long-term storage of user programs.

The supervisory unit that maintains overall control of the JOSS system's operation is the monitor, which acts as a scheduling, resource-allocating, and synchronizing device, deciding when, and ensuring that, all data and hardware necessary for a particular action are simultaneously available. The monitor's supervisory functions have been

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†JOSS is the trademark and service mark of The RAND Corporation for its computer program and services using that program.

documented in a companion piece, RM-5216-PR, JOSS: User Scheduling and Resource Allocation.

A major function of the monitor is the gathering of data for revenue accounting and for producing performance measures of the system and its users. The present memorandum includes detailed descriptions of the data gathering processes for accounting and performance measurement, together with samples of the several reports produced from these data. A future memorandum will deal in depth with JOSS system and user performance as measured by the reporting processes described here.

This study should be of interest to those engaged in the design and implementation of time-shared or real-time computing systems. The work is a part of The RAND Corporation's continuing program of research in computer sciences under U.S. Air Force Project RAND.

SUMMARY

The monitor is that part of the JOSS system program that acts as the supervisory unit of the JOSS machine. This memorandum describes those portions of the monitor that produce accounting records for charging functions and that gather performance statistics descriptive of typical user operation, overall system usage, and machine performance.

Charges for JOSS usage are based on the product of machine time and core space required plus the product of space and time required for long-term storage of programs and data on the disc file. Charge units for both types of usage are accumulated during JOSS operation and recorded on magnetic tape for later processing in the general RAND accounting system.

Four reports are produced from the tape records, the Daily Usage Summary, the Charge Unit Analysis Report, the Department Usage Report, and the Project Usage Report. These reports record charges and other characteristics of individual JOSS sessions, and, at the end of the month, the total usage both by department number and by project number.

A substantial amount of the code and storage in the JOSS system is devoted to recording the occurrence of events that will help determine the system's performance and its operating environment. Performance is measured not only to confirm that the context in which the system was designed is still a valid one, but also to provide a basis for possible system expansion. Certain data are displayed each minute on the JOSS master console, providing

an instantaneous measure of performance. Other, more global, data are recorded in memory and displayed every four hours. Periodically, the four-hour summary is reduced by a JOSS program to give profiles of both the system's overall operation and of the characteristics of individual usage of the system.

ACKNOWLEDGMENT

All of the computer reports described in Sec. II of this memorandum are the results of computer programs written by T. K. Sawtelle. His careful work is very much appreciated.

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I. INTRODUCTION

The monitor, that part of the JOSS† system program that acts as the supervisory unit of the JOSS machine, provides several logically distinct system functions. Some sections of the monitor are the logical equivalents of machine input/output units controlling transfer of information to the drum, tape, and master console; another section provides the needed synchronization of programs, devices, and data, and controls the allocation of system resources to the users to ensure high-speed response to their requests; a final section provides the true monitoring functions for the system, producing accounting records for charging purposes and gathering performance statistics descriptive of typical user operation, overall system usage, and machine performance.

Those portions of the monitor dealing with input/output and supervision are described in a companion piece, JOSS: User Scheduling and Resource Allocation, RM-5216-PR. The present memorandum is concerned with the system monitoring functions, and covers two major areas: (1) accounting for usage charging, and (2) the statistics of operation that are gathered to give measures of system performance and efficiency and to provide profiles of typical user operation.

Although this memorandum includes examples of all the statistical reports generated by the system, it is intended as a description of the details of the data-gathering process. A subsequent memorandum, JOSS: 20,000 Hours at the

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Console--A Statistical Summary, will present complete statistics of JOSS operation during the first year of operation on the Digital Equipment Corporation PDP-6 computer.

II. USAGE ACCOUNTING

Charges are made for use of the JOSS system on the basis of only three system resources: (1) the amount of compute time used, (2) the amount of core required for program and data, and (3) the amount of file space used on the disc.

CHARGES FOR COMPUTE TIME AND CORE SIZE

Compute time is measured only when the user's program is being actively serviced by the JOSS interpreter. This includes storing steps, preparing to type the results of a short computation, and setting the value of variables, as well as longer "compute-bound" tasks including the overlapped production of typed results. It does not include time spent waiting for service, typing time by the user, time the user spends thinking while the console green light is on, or time waiting for the typewriter output to catch up. There is no charge for console time.

Roughly speaking, the user is charged for the time his console red light is on. This time, however, may be drastically modified in at least two ways. First, if output typing is included, the computation time for each line may be much less than the time required to actually type the line; therefore, the charged time will be less than the red light time. For long output lines requiring only a trivial amount of computation, the ratio of red light time to charged time may be as high as 1000 to 1. Second, since the machine is time-shared among users, a compute-bound program will only receive and be charged for its proportionate

share of the time, which is divided between all the compute-bound programs.

Compute time is measured by a hardware time signal that occurs every 1/60th of a second. We refer to this unit of time as a tic. Thus, the shortest time interval that can be recorded is 16.7 ms.

As explained in the companion memorandum (RM-5216-PR), users are assigned core space in 1024-word units or "blocks." Each program begins with one block and is assigned additional blocks as required to accommodate the program and data up to the system-imposed limit of four blocks. No action on the user's part is necessary to accomplish the addition of needed core blocks.

The number of core blocks assigned to a user is related to his "size." The user may determine the amount of storage currently used by giving a "Type size" command to JOSS. The first block allows sizes up to 367 cells, and subsequent blocks add 512 cells each up to a maximum of 1903 cells. The table below gives the number of cells available at each increment of the number of blocks.

Blocks	Cell Size Range
1	0-367
2	368-879
3	880-1391
4	1392-1903

At the end of each computation period of each user (a maximum of 200 ms or 12 tics), JOSS charge units are computed for the period that has just ended and accumulated

with those from previous periods in a cell in the user's block. JOSS charge units for each period are the product of the number of tics during the period and the user's current number of core blocks. Therefore, the charge units for each total computation are as given in the following equation:

$$C = \sum_i t_i b_i ,$$

where t_i is the number of tics in each computation period, and b_i is the number of core blocks assigned during that period. The charge for a minute of computing may therefore vary by as much as a factor of four, depending on the amount of core space the user requires.

At the end of each user's session (at the time the user turns off his console), a record is written on magnetic tape. Information contained on the tape record includes the total number of charge units accumulated during the session; the user's project number, department, and initials; and other information regarding the session. The tape, containing a charge record for each user session, provides input for the RAND computer usage charge allocation program on another computer. The exact contents of the charge record is given below in the section on tape accounting records (p. 8).

CHARGES FOR DISC SPACE AND TIME

Charges for items of program and data stored in JOSS files are based on the arithmetic product of the number of

storage records required and the number of full days of storage. There is no charge for items filed and deleted on the same day.

The record-day product is multiplied by ten to convert charges for files into the same units that are accumulated for compute time. The factor of ten is calculated to produce a revenue, under average conditions, which approximates the cost of the hardware that is associated with the file system.

Charge records are produced on the accounting tape each time an item is discarded from the files. In addition, charge records for items currently on file are automatically produced at midnight of the last day of the month by that portion of the JOSS program called the midnight skulker.† Thus, charges from the beginning of the month to discard time are recorded in the discard record, and charges for items remaining in the files over the end of the month are recorded by the skulk records. Exact formats of these records are given in the section on tape accounting records (p. 8).

The name of the owner of each file, as well as his initials and department number, are not carried in the disc file but are provided to the RAND accounting system on punched cards. The format of these cards is given on the facing page.

The project number to which the charge is made is that in use when the item was filed.

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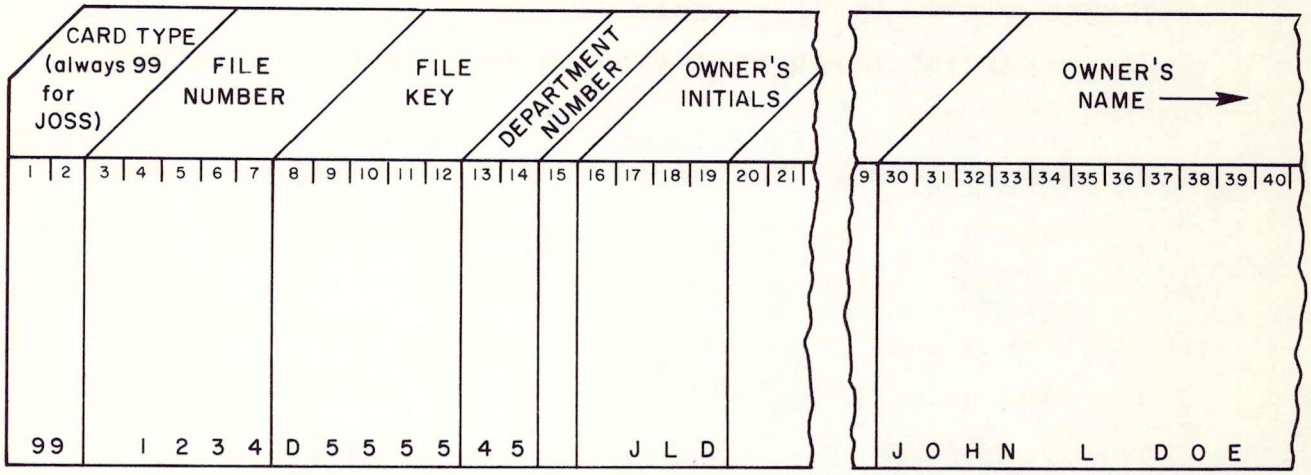
†The name "midnight skulker" is derived from the well-known Johnny Hart comic strip "B.C.," in which the title character "skulks" about in the middle of the night in a cape and mask.



PROJECT NUMBERS AND DEPARTMENTS

At log-on time JOSS requests the project number and under certain circumstances the RAND department of the user. These two items of information are used to order the monthly reports of JOSS usage. Project numbers 1000 and above mean, as usual, that assignment of the charges is to a particular RAND client. Project numbers less than 1000 are reserved either for general overhead, such as learning JOSS, JOSS demonstrations, and system test in the cases of numbers 1, 2, 3, and 4, or for the accounting convenience of special consoles, especially those in remote locations. In the latter case, the department number is assigned automatically on the basis of the console number, and the use of certain project-number ranges is restricted to certain consoles.

Thus, usage of a special remote console is separately accounted for each month and is further broken down by individual project numbers unique to that console. The present assignment of department numbers and project numbers to special consoles is listed in Table 1.

Table 1

SPECIAL DEPARTMENT AND PROJECT NUMBERS

Console Number	Department Number	Legal Project Numbers
33	70	200-299
37	71	300-399
43	72	400-449
47	73	500-549
42	74	600-649
2	75	700-724
3	76	800-824

Legal RAND department numbers together with the JOSS-recognized abbreviations are given in Table 2 on the facing page.

TAPE ACCOUNTING RECORDS

As outlined above, tape records are produced during JOSS operation to record charges for compute time and disc-file usage. These records are processed by the RAND general-purpose computer to produce daily and monthly reports of JOSS usage broken down by department number and project number. Figure 1 shows the general flow of accounting information through the various computers.

Tape records vary in size depending on type, but all records have a common format for the first word (36 bits),

Table 2

RAND DEPARTMENT NUMBERS AND ABBREVIATIONS

Department Number	Legal Abbreviation	Department
10	ECO	Economics
11	COS	Cost Analysis
12	LOG	Logistics
20	MFS	Materiel, Facilities & Services
21	LIB	Library
22	WO, WAS	Washington Office
23	ADM	Administration
26	M/R, M+R	Mail and Records
27	SEC	Security
28	PER	Personnel
30	RES	Research Council
32	AER	Aero-Astronautics
33	ELE	Electronics
34	SYO, SYS	System Operations
35	AST, G/A, G+A, GEO	Geophysics and Astronomy
40	PHY	Physics
60	RD, REP	Reports
80	MAT	Mathematics
81	COM, CSD	Computer Sciences
90	SOC, SSD, SS	Social Sciences

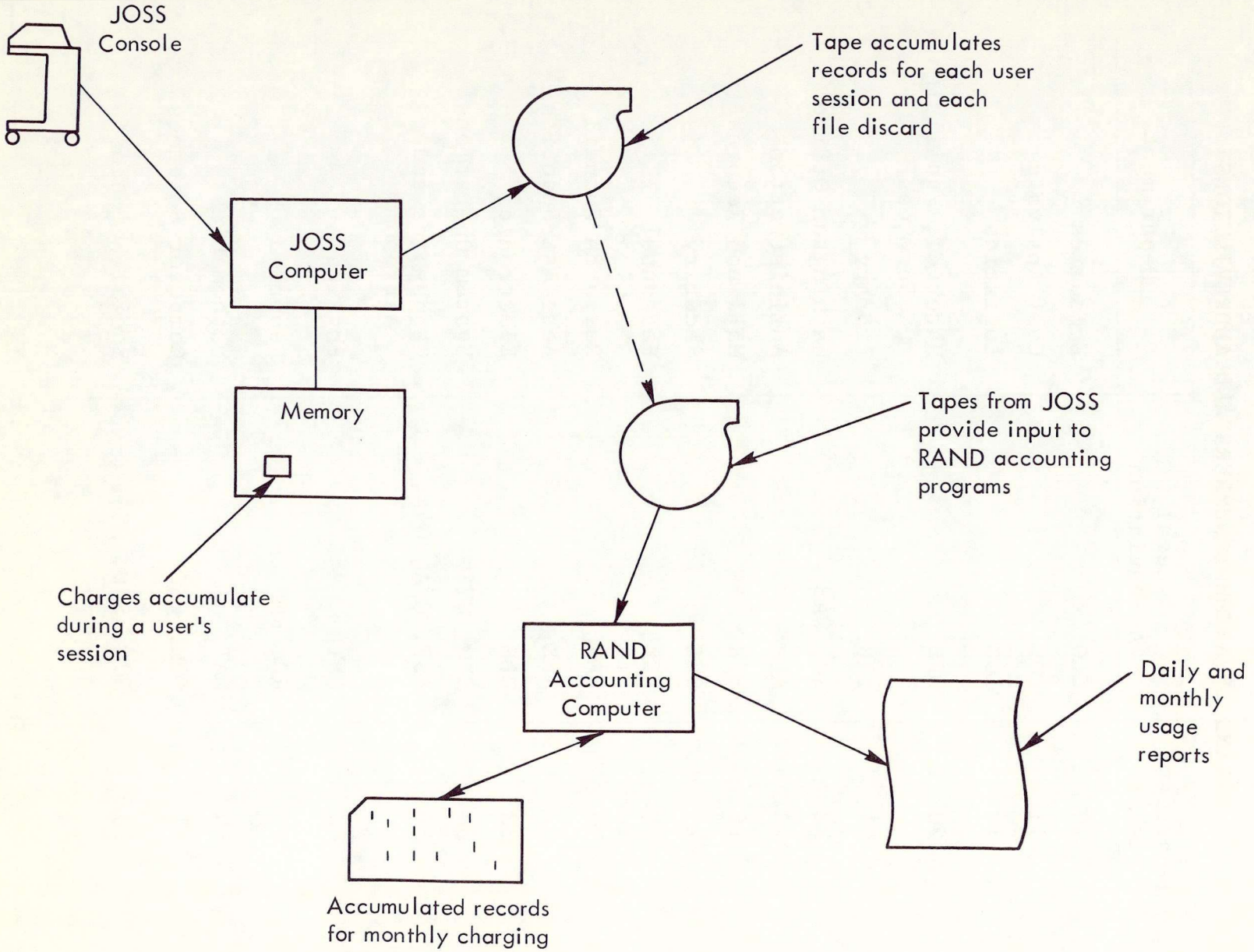


Fig. 1--Flow of JOSS Accounting Information

which is the record header. The format gives, in its left half, the number of words in the record, and in its right half a type number for the record. Detailed contents of the accounting records (Types 1, 6, 8, and 9) are listed below. The format for the 36-bit word is a binary integer unless otherwise noted. Record Types 2-5 and 7 are not currently needed, but as in the past may be used again for such purposes as recording system usage statistics.

Type 1

Type 1 records are written at turn-off time to record computer time charges for each user's session. The record is not produced if the user does not complete the log-on procedure. See Fig. 2 on p. 12.

Type 6

Type 6 is the system initialization record. It is written each time the JOSS system is restarted from the beginning, including automatic total system recovery. See Fig. 3 on p. 13.

Type 8

Type 8 records, the midnight skulk records, are written at midnight on the last day of each month and record the contents of the files at that time. Charges for the preceding month for all programs currently stored are computed from these records. One record is produced for each file that contains stored items. The 129 words in the record include a four-word header followed by 25 five-word blocks--one for each possible stored item. See Fig. 4 on p. 14.

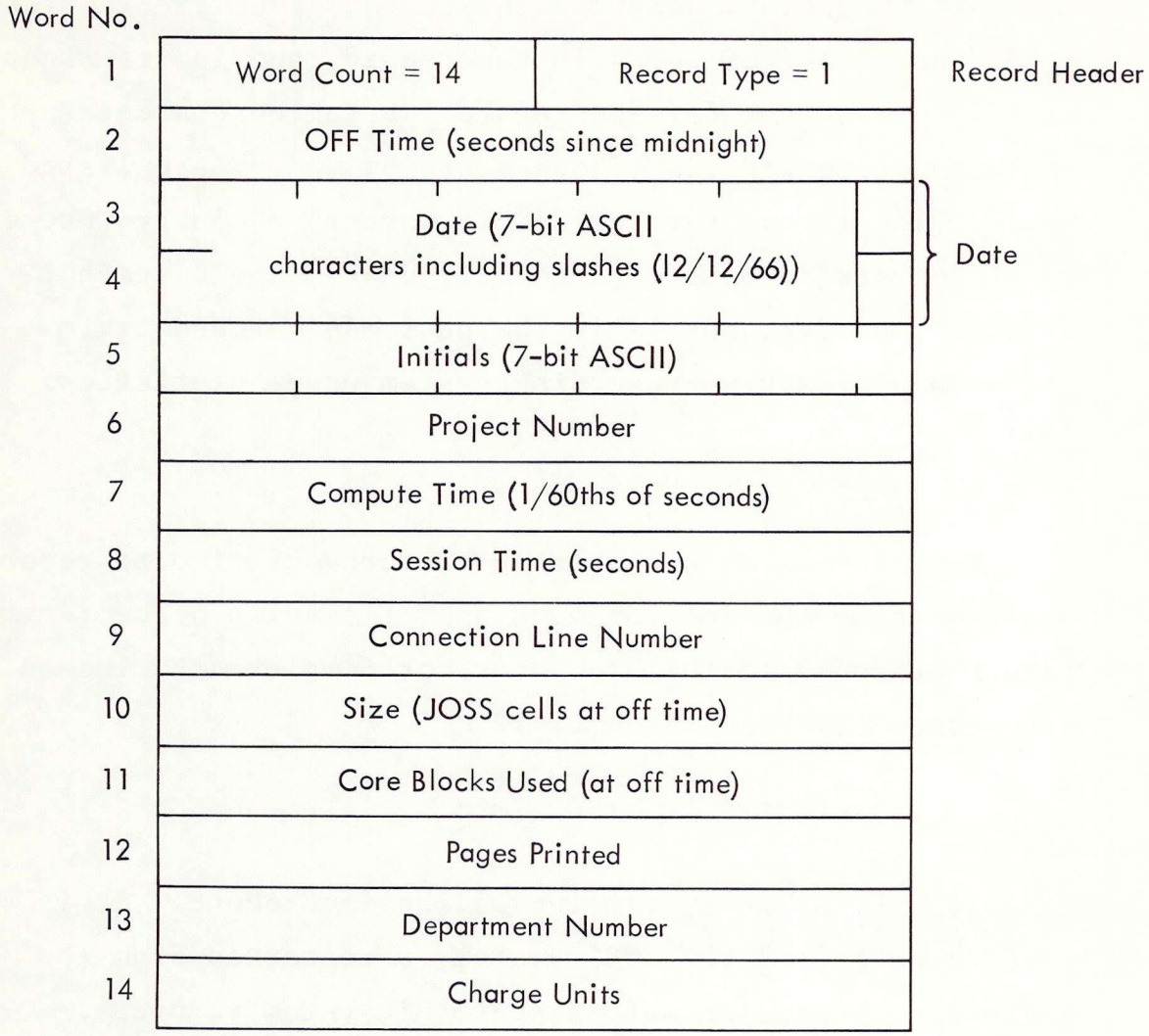


Fig. 2--Type 1 Record: Session Accounting

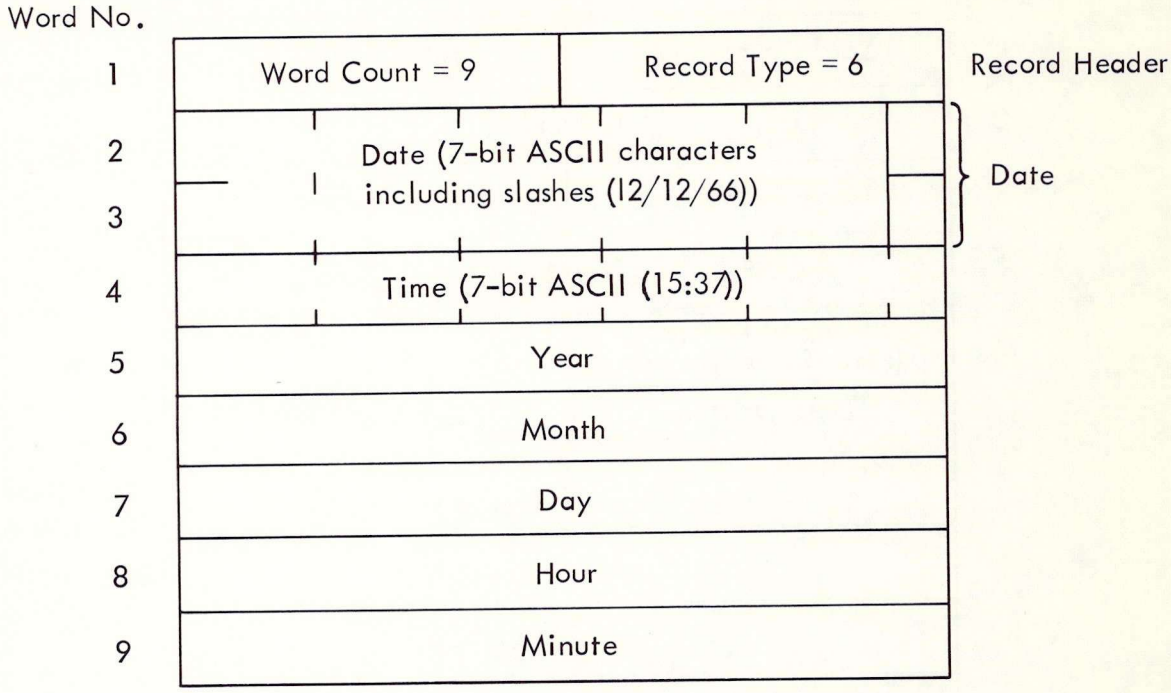


Fig. 3--Type 6 Record: System Initialization

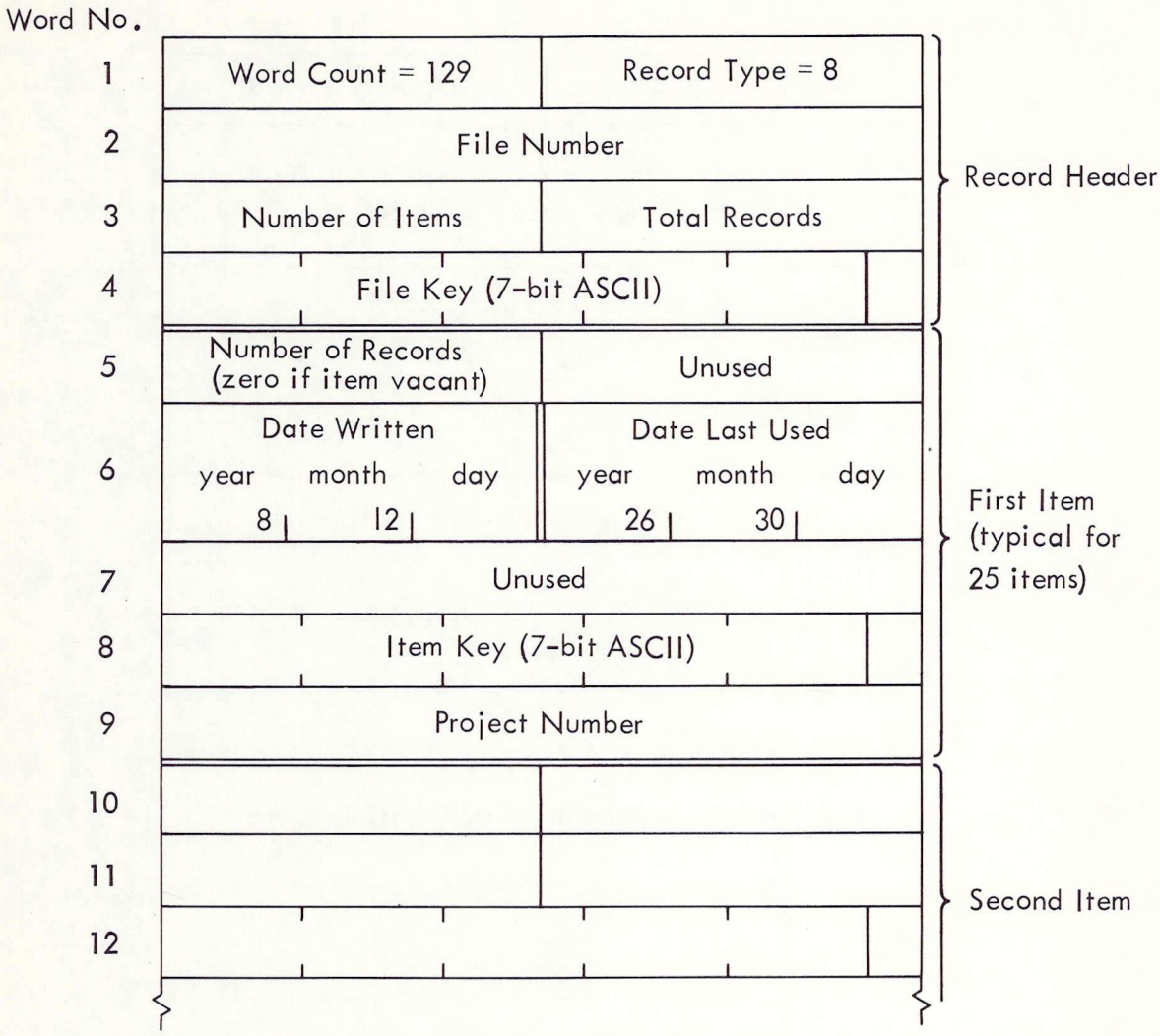


Fig. 4--Type 8 Record: Monthly Disc Accounting

Type 9

The Type 9 record is produced each time an item is discarded from the files. Charges covering the period since the first of the month are computed from this record. If the discard occurs on the same day that the item was filed, no record is written. Therefore, there is no charge made for using the files for less than one day. Figure 5, on the facing page, gives the form of the disc discard record.

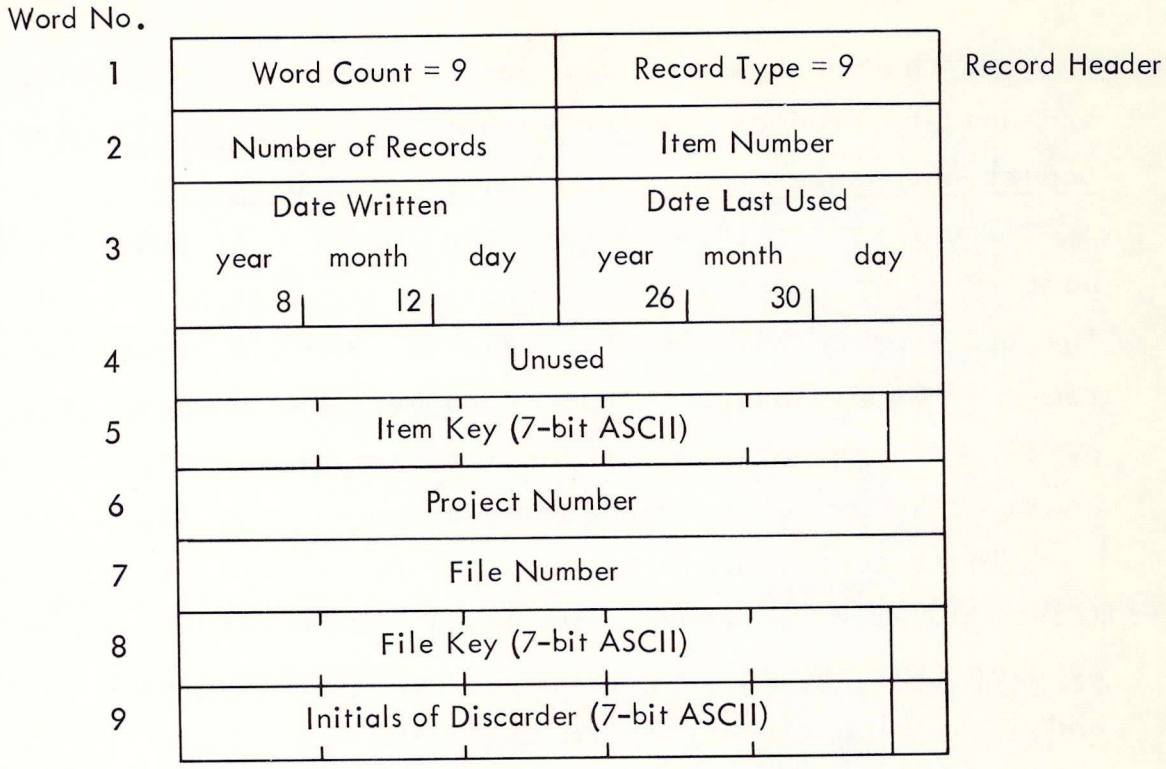


Fig. 5--Type 9 Record: Disc Discard Record

USAGE REPORTS

From the information recorded in the tape records described above, four different reports of JOSS usage are produced: one daily by user session and three monthly. The first report, the Daily Usage Summary, is a by-product of the initial processing of JOSS log tapes by the RAND accounting programs. This processing produces a record on punched cards for each of the Type 1 and Type 9 records, and one for each valid item listed in a Type 8 record. For each card, a line is written in the Daily Usage Summary. The report is divided into two parts: the session log proper (Fig. 6a, p. 17), that contains one report line for each user session; and the disc usage log (Fig. 6b, p. 18), where all records pertaining to disc-file usage are gathered.

At the month's end, the punched cards are assembled and used to produce the Charge Unit Analysis Report, the Department Usage Report, and the Project Usage Report.

The first monthly report, the Charge Unit Analysis Report (Fig. 7), contains an exception log listing charges to invalid project numbers (Fig. 7a, p. 19), and general summaries of monthly usage: charges to overhead numbers (Fig. 7b, p. 20), charges by project work order number† (Fig. 7c, p. 20), and a breakdown of charges by department (Fig. 7d, p. 21).

The second monthly report, the Department Usage Report (Fig. 8a, p. 22), breaks down usage within the department by user (initials), by project number (RPN) for each user, and by session time, compute time, and cost.

Total session time, compute time, and chargeable costs are computed for the entire month (Fig. 8b, p. 23). The final page of the Department Usage Report (Fig. 8c, p. 24), includes totals and proportions of usage by department for the categories of number of users, number of console sessions, session elapsed time, and compute time.

The third monthly report, the Project Usage Report, is similar to the previous report, but breaks information down with the project number as the major heading. Within each project, usage and charges are broken down by department and within department by user. (See Fig. 9, p. 25.)

These reports enable the departments and project leaders to review JOSS machine usage in their areas of work. Thus, costs covering the JOSS system are distributed among the projects making use of the service.

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†Work order numbers are RAND's internal references for accumulating charges. There is not always a one-to-one correspondence with project numbers.

DISC USAGE LOG(CODE 8 = MONTH-END CHARGE, 9 = DISCARD CHARGE) - 3/67

CODE	USER	DEPT	RPN	WORK ORDER	DATE WRITTEN	DATE DISCARDED(9) OR LAST USED(8)	ITEM NO.	FILE NO.	ELAPSED DAYS	NO. OF RECORDS	CHARGE UNITS
9	AFA	71	306	1000	3/22/67	3/23/67	19	124	1	2	20
9	ACSA	72	400	1000	3/ 1/67	3/24/67	14	323	23	2	460
9	ACSA	72	400	1000	3/ 1/67	3/24/67	15	323	23	2	460
9	ACSA	72	400	1000	3/ 1/67	3/24/67	16	323	23	4	920
9	TAC	75	707	1000	3/23/67	3/24/67	6	312	1	1	10
9	RAND	81	300	1000	3/23/67	3/24/67	4	100	1	9	90
9	AL	81	4	0	3/22/67	3/24/67	21	8	2	3	60
9	REL	40	1036	1000	2/ 8/67	3/24/67	10	285	24	1	240
9	OG	80	1057	1000	3/23/67	3/24/67	14	5	1	1	10
9	CLAY	34	9643	0	3/23/67	3/24/67	25	270	1	1	10
9	CLAY	34	9643	0	3/23/67	3/24/67	1	270	1	1	10
9	MHD	35	1250	1000	3/21/67	3/24/67	4	78	3	5	150
9	MHD	35	1250	1000	3/21/67	3/24/67	9	78	3	14	420
9	MHD	35	1250	1000	3/20/67	3/24/67	1	78	4	1	40
9	LB	33	1211	0	3/23/67	3/24/67	24	29	1	3	30
9	CYF	32	1007	1000	3/23/67	3/24/67	16	308	1	5	50
9	TAC	75	707	1000	3/23/67	3/24/67	19	312	1	4	40
9	REL	40	9740	9700	3/13/67	3/24/67	4	84	11	4	440
9	CT	11	9643	0	3/23/67	3/24/67	3	300	1	8	80
9	RHM	32	1352	1000	3/23/67	3/24/67	2	32	1	4	40
9	DCM	10	1	0	3/23/67	3/24/67	1	245	1	2	20
9	WRG	40	5709	5709	3/23/67	3/24/67	3	220	1	11	110
9	CT	11	1046	1000	3/10/67	3/24/67	5	300	14	7	980
9	CT	11	9643	0	2/10/67	3/24/67	8	300	24	4	960
9	RNS	80	1351	1000	12/ 9/66	3/24/67	6	28	24	1	240
9	GSF	12	1252	1000	1/16/67	3/24/67	3	37	24	1	240
9	CYF	32	1007	1000	3/22/67	3/24/67	13	308	2	5	100
9	DCK	34	9643	0	3/22/67	3/24/67	7	76	2	7	140
9	DCK	34	9643	0	3/23/67	3/24/67	9	76	1	11	110
9	CLAY	34	9643	0	3/23/67	3/24/67	2	270	1	1	10
9	EWP	80	3	0	3/18/67	3/24/67	18	12	6	24	1440
9	DM	40	1290	1000	3/ 3/67	3/24/67	3	244	21	6	1260
9	PK	12	1267	1000	3/22/67	3/24/67	1	38	2	5	100
9	DCK	34	9643	0	2/21/67	3/24/67	2	76	24	12	2880
									274	172	12170

Fig. 6b--Daily Usage Summary: Disc Usage Log

SESSION LOG REPORT - 3/67

DATE	MAN	DEPT	RPN	W.O.	*OFF TIME** HRS	MIN	SEC	SESSION TIME HRS	MIN	SEC	COMPUTE TIME MIN	SECONDS	STATION NUMBER	PROGRAM SIZE	CORE BLKS	PAGES PRINTED	CHARGE UNITS	BAD FILE
3/24/67	WRG	40	1036	1000	11	45	22	0	29	45	0	6 5	25	59	1	12	703	
3/24/67	REL	40	1036	1000	11	47	57	2	54	57	2	19 2	27	478	2	39	20041	
3/24/67	WDM	71	300	1000	11	48	14	0	13	9	0	2 58	37	89	1	4	178	
3/24/67	WRG	40	5709	5709	11	48	18	2	53	43	14	53 22	41	118	3	16	158900	
3/24/67	JCC	80	1351	1000	11	51	53	0	11	50	0	0 9	31	367	1	1	9	
3/24/67	TDS	70	266	1000	11	59	58	1	9	52	0	1 41	33	216	1	8	101	
3/24/67	JMC	0	1	0	12	1	15	0	12	50	0	0 24	37	367	1	3	24	
3/24/67	LS	70	266	1000	12	3	2	0	3	2	0	0 1	33	367	1	3	1	
3/24/67	CYF	32	1007	1000	12	8	46	0	18	11	0	0 27	46	367	1	3	27	
3/24/67	OG	80	1057	1000	12	9	59	0	2	26	0	0 30	31	316	1	2	30	
3/24/67	R	81	1057	1000	12	11	54	1	9	29	1	23 50	15	286	2	13	9907	
3/24/67	RLC	81	1407	1000	12	15	57	0	2	7	0	0 5	00	367	1	1	5	
3/24/67	TEST	0	4	0	12	17	5	0	0	18	0	0 2	00	367	1	1	2	
3/24/67	BK	60	8213	8213	12	24	35	0	1	55	0	0 6	13	349	1	1	6	
3/24/67	OG	0	3	0	12	26	24	3	32	50	97	31 15	01	289	1	28	351232	
3/24/67	RGR	75	707	1000	12	27	38	0	46	51	0	19 1	02	490	3	11	2273	
3/24/67	OG	81	1057	1000	12	27	55	0	0	31	0	0 2	01	367	1	1	2	
3/24/67	UG	12	1057	1000	12	30	5	0	1	38	0	0 3	01	367	1	1	3	
3/24/67	DIT	71	300	1000	12	33	44	0	32	27	0	16 22	37	528	3	9	2657	
3/24/67	DCM	10	1344	1000	12	34	23	0	42	59	1	2 45	12	239	1	10	3939	
3/24/67	GSF	12	1252	1000	12	35	33	1	51	52	16	32 44	45	249	1	8	59564	
3/24/67	SN	33	1211*	0	12	47	51	2	48	52	0	48 7	10	135	1	16	2887	
3/24/67	CYF	32	1007	1000	12	58	23	0	35	57	0	34 53	46	463	2	9	4120	
3/24/67	RLC	81	1407	1000	12	59	42	0	23	55	0	22 59	45	366	1	11	1936	
3/24/67	OG	80	1057	1000	13	0	11	0	16	51	0	4 28	31	367	1	9	586	
3/24/67	NZS	81	1381	1000	13	10	58	0	5	31	0	16 16	15	278	4	1	3304	
3/24/67	RLC	0	4	0	13	10	59	0	7	49	0	1 28	01	367	1	1	244	
3/24/67	RHM	32	1352	1000	13	12	32	0	10	9	0	41 37	46	513	2	3	4926	
3/24/67	CYF	32	1007	1000	13	16	25	0	2	56	0	0 7	46	367	1	2	7	
3/24/67	VMH	75	716	1000	13	22	47	0	8	14	0	1 3	02	181	1	3	63	
3/24/67	GFM	0	1	0	13	22	57	3	49	17	0	11 58	43	367	1	16	974	
3/24/67	OG	80	1057	1000	13	24	15	0	5	33	0	0 56	31	259	1	3	56	
3/24/67	LS	70	266	1000	13	25	29	0	0	37	0	0 2	33	367	1	3	2	
3/24/67	RTO	32	1435	1000	13	28	18	0	11	51	0	2 6	46	315	1	2	126	
3/24/67	LS	70	266	1000	13	31	4	0	5	26	0	0 3	33	367	1	12	3	
3/24/67	CBH	0	1	0	13	35	4	1	0	52	0	8 19	37	231	1	13	499	
3/24/67	RLC	81	1407	1000	13	44	40	0	0	18	0	0 1	01	367	1	1	1	
3/24/67	FEC	32	1230	1000	13	48	53	0	14	51	0	4 47	46	514	4	7	686	
3/24/67	VMH	75	716	1000	13	52	54	0	29	51	0	20 27	02	505	4	6	2630	
3/24/67	DCM	40	1290	1000	13	56	1	0	4	2	0	0 9	41	367	1	3	9	
3/24/67	SJ	80	9643*	0	13	56	13	0	15	26	0	7 35	31	367	1	3	998	
3/24/67	AEV	75	711	1000	13	57	18	0	1	38	0	0 5	02	367	1	1	5	
3/24/67	DK	34	9643*	0	13	57	55	0	15	36	0	25 53	25	367	1	2	4416	
3/24/67	LS	70	266	1000	14	2	45	0	31	13	0	0 9	33	367	1	64	9	
3/24/67	RLC	81	1407	1000	14	8	45	0	24	3	0	1 2	01	367	1	3	62	
3/24/67	JEF	72	400	1000	14	13	58	0	51	-0	0	21 21	43	367	1	16	1281	
3/24/67	CYF	32	1007	1000	14	14	31	3	22	17	71	1 13	40	243	3	9	766773	
3/24/67	AEV	75	711	1000	14	25	57	0	24	53	0	7 45	02	367	1	8	658	
3/24/67	RDS	34	1283	1000	14	29	28	1	18	6	0	42 -0	16	232	1	15	2520	
3/24/67	RLC	81	1407	1000	14	29	37	0	7	45	0	3 18	32	88	1	4	198	

Fig. 6a--Daily Usage Summary: Session Log

JOSS II USAGE - 1/1967

INVALID RAND PROJECT NUMBERS

RPN	INITIALS	DATE	CHARGE UNITS
1000	125	1/20/67	116
1000	REL	8/ 4/66	600
1000	REL	8/ 6/66	600
1000	REL	8/11/66	1200
1000	ECD	7/27/66	600
1000	MB	1/27/67	381
1000	MB	1/27/67	3168
1000	JJG	1/27/67	8941
1000	JJG	1/26/67	1198
1000	BB	8/27/66	1800
1000	MEA	1/20/67	2
1000	MEA	1/20/67	129520
1000	WNB	1/26/67	32889
1000	WNB	2/ 1/67	2400
1000	NL	7/22/66	1500
1000	JYL	1/ 6/67	154
1000	JYL	1/ 9/66	175
1000	JYL	1/ 9/66	199
1000	JYL	1/23/67	1
1000	JYL	1/23/67	34
1000	JYL	1/ 9/66	300
1000	MM	12/ 5/66	300
1000	MM	12/ 5/66	300
1000	SDM	1/14/67	2
1000	GSF	1/13/67	205
1000	JCC	1/ 3/67	408
1000	SJB	1/29/67	21
1000	SJB	1/30/67	40
1000	SJB	1/30/67	14
1000	SJB	1/30/67	13
1000	SJB	1/30/67	123
1000	SJB	1/30/67	4
1000	SG	1/20/67	189
1000	SG	1/20/67	55295
1035	LAF	1/17/67	391
1047	TONI	1/22/67	108
1071	MS	1/23/67	307
1071	MS	1/23/67	666
1094	ME	1/11/67	16079
1125	MB	1/20/67	5
1125	MB	1/20/67	22297
1125	MB	1/24/67	13474
1125	MB	1/24/67	15
1125	MB	1/24/67	36
1125	MB	1/24/67	17555
5709	WRG	9/11/66	2660
			316285

Fig. 7a--Charge Unit Analysis Report: Invalid RAND Project Numbers

JOSS II USAGE - 1/1967

OVERHEAD CHARGES

CODE	CHARGE UNITS	SESSIONS
1 -	1307113	470
2 -	84369	68
3 -	313913	127
4 -	13447	237
TOTALS	1718842	902

PROJECT RAND USAGE

78472874 CHARGE UNITS

Fig. 7b--Charge Unit Analysis Report: Overhead Charges

JOSS II USAGE - 1/1967

SUMMARY BY WORK ORDER

WORK ORDER	CHARGE UNITS	PCT OF TOTAL
1000	78466661	82.196
1700	6213	0.007
5709	1091834	1.144
5725	654	0.001
6700	1809096	1.895
7000	15744	0.016
7103	784	0.001
8213	251282	0.263
9210	272693	0.286
9255	600	0.001
9460	3843	0.004
9480	7250 8	0.076
9545	28028	0.029
9550	24812	0.026
9600	13401941	14.039
9690	4787	0.005
9991	11653	0.012
	95463133	100.000

Fig. 7c--Charge Unit Analysis Report: Work Order Summary

JOSS II USAGE - 1/1967

SUMMARY BY DEPARTMENT

DEPARTMENT	CHARGE UNITS	PCT OF TOTAL
10	1223799	1.282
11	471252	0.494
12	728407	0.763
23	3	0.000
32	18599640	19.484
33	7620925	7.983
34	6419827	6.725
35	961860	1.008
40	18171852	19.035
60	251762	0.264
70	1443166	1.512
71	623476	0.653
72	1231855	1.290
73	11100	0.012
74	637944	0.668
80	36538805	38.275
81	527424	0.552
90	36	0.000
	95463133	100.000

Fig. 7d--Charge Unit Analysis Report: Department Summary

JOSS II USAGE FOR FEB 1967

MATHEMATICS

USER	RPN	********* COMPUTER USAGE ********* SESSION TIME HRS	MIN	SEC	COMPUTE TIME MIN	SEC	TIC	COST	** DISC STORAGE USAGE *** NO. OF ITEMS	ITEM DAYS OF STORAGE	COST	TOTAL COST
SJ												
	9700	40	35	42	498	8	51	.92	0	0	.00	.92
		40	35	42	498	8	51	.92	0	0	.00	.92
SMJ												
	9700	69	34	-0	615	36	17	.75	0	0	.00	.75
		69	34	-0	615	36	17	.75	0	0	.00	.75
TAB												
	1	0	0	0	0	0	0		2	60		
	1057	0	0	0	0	0	0		6	122		
	1415	0	48	27	2	17	53		0	0		
		0	48	27	2	17	53	.00	8	182	.00	.00
TB												
	1415	0	0	0	0	0	0		1	23		
		0	0	0	0	0	0	.00	1	23	.00	.00
USE												
	9700	0	36	4	8	55	53	.21	0	0	.00	.21
		0	36	4	8	55	53	.21	0	0	.00	.21
OG												
	2	0	0	0	0	0	0		2	4		
	3	0	0	0	0	0	0		9	87		
	4	0	0	0	0	0	0		1	8		
	1057	0	0	0	0	0	0		14	63		
	1396	0	0	0	0	0	0		1	1		
	1407	0	0	0	0	0	0		1	8		
		0	0	0	0	0	0	.00	28	171	.00	.00
		191	39	22	1160	7	54	.29	176	2799	.55	.84

Fig. 8a--Department Usage Report: Individual

JOSS II USAGE FOR FEB 1967

DEPARTMENT SUMMARIES

DEPARTMENT	USERS NO.	USERS PCT.	SESSIONS NO.	SESSIONS PCT.	SESSION TIME HRS	SESSION TIME MIN	SESSION TIME SEC	SESSION TIME PCT.	COMPUTE TIME MIN	COMPUTE TIME SEC	COMPUTE TIME TIC	COMPUTE TIME PCT.	
ECONOMICS	15	3.	104	4.	80	6	8	4.	123	9	-0	2.	10
COST ANALYSIS	18	4.	132	5.	76	32	47	4.	19	29	14	0.	11
LOGISTICS	36	8.	181	7.	87	39	17	4.	161	25	39	3.	12
SM ADMINISTRATION	2	0.	14	1.	7	21	1	0.	1	33	48	0.	23
AERO - ASTRONAUTICS	27	6.	325	12.	384	46	44	19.	1199	13	7	19.	32
ELECTRONICS	22	5.	172	6.	173	45	15	9.	999	20	29	16.	33
SYSTEM OPERATIONS	39	9.	289	11.	267	39	32	13.	1385	19	31	22.	34
GEOPHYSICS + ASTRON	18	4.	82	3.	49	33	13	2.	25	5	33	0.	35
PHYSICS	21	5.	112	4.	92	23	16	5.	294	7	57	5.	40
PUBLICATIONS	6	1.	99	4.	57	49	1	3.	13	44	50	0.	60
AF - SACRAMENTO	64	14.	228	9.	98	27	50	5.	243	35	7	4.	70
AIR FORCE ACADEMY	94	21.	407	15.	152	15	59	8.	27	16	6	0.	71
AFXSA - PENTAGON	17	4.	77	3.	100	34	31	5.	435	37	54	7.	72
ARPA - PENTAGON	1	0.	0	0.	0	0	0	0.	0	0	0	0.	73
O.A.S.D.	9	2.	51	2.	40	37	1	2.	94	35	47	1.	74
MATHEMATICS	19	4.	176	7.	191	39	22	10.	1160	7	54	18.	80
COMPUTER SCIENCES	34	8.	219	8.	134	28	34	7.	141	26	17	2.	81
	442		2668		1995	39	31		6325	8	13		99

Fig. 8c--Department Usage Report: Department Comparisons

JOSS II USAGE FOR FEB 1967

USER	RPN	********* COMPUTER USAGE ********* SESSION TIME HRS	MIN	SEC	COMPUTE TIME MIN	SEC	TIC	COST	** DISC STORAGE USAGE *** NO. OF ITEMS	ITEM DAYS OF STORAGE	COST	TOTAL COST
		2421	57	55	6749	18	1	[redacted].60	2515	42558	[redacted].15	[redacted].75

Fig. 8b--Department Usage Report: Totals

JOSS II USAGE FOR FEB 1967

RPN 9700

DEPT	USER	********* COMPUTER USAGE ********* SESSION TIME HRS	MIN	SEC	COMPUTE TIME MIN	SEC	TIC	COST	** DISC STORAGE USAGE *** NO. OF ITEMS	ITEM DAYS OF STORAGE	COST	TOTAL COST
10												
	NT	0	0	0	0	0	0	.00	1	30	.44	.44
		0	0	0	0	0	0	.00	1	30	.44	.44
11												
	AJT	1	23	18	0	8	40	.16	0	0	.00	.16
	CT	41	14	38	4	49	54	.37	22	333	.38	.75
	HLG	3	46	19	0	53	52	.97	0	0	.00	.97
	LAD	0	0	0	0	0	0	.00	1	1	.01	.01
	SAH	0	23	6	0	7	31	.12	0	0	.00	.12
		46	47	21	5	59	57	.62	23	334	.39	.01
32												
	CVC	9	15	58	101	7	29	.82	2	39	.91	.72
	ECH	0	0	0	0	0	0	.00	1	30	.24	.24
		9	15	58	101	7	29	.82	3	69	.15	.97
33												
	ARS	0	0	0	0	0	0	.00	5	150	.58	.58
	BP	0	0	0	0	0	0	.00	5	150	.12	.12
	JJG	0	0	0	0	0	0	.00	8	224	.28	.28
	MB	2	5	16	0	28	36	.28	0	0	.00	.28
	TFB	53	21	44	595	53	5	.62	15	328	.13	.75
		55	27	-0	596	21	41	.90	33	852	.12	.01
34												
	CLAY	1	42	30	0	15	32	.26	9	188	.08	.34
	DCK	21	36	48	128	18	57	.02	35	557	.05	.07
	DK	0	45	-0	3	30	9	.95	0	0	.00	.95
	SYOP	0	0	0	0	0	0	.00	12	339	.83	.83
		24	4	18	132	4	38	.24	56	1084	.96	.20
35												
	DEC	4	40	45	3	2	34	.11	0	0	.00	.11
	JML	9	12	23	2	13	58	.46	6	113	.47	.93
	JVM	0	6	59	0	0	14	.00	0	0	.00	.00
	KML	0	14	42	0	1	12	.01	0	0	.00	.01
		14	14	49	5	17	58	.58	6	113	.47	.05
40												
	PHYS	0	0	0	0	0	0	.00	1	30	.39	.39
	REL	1	30	55	29	45	3	.86	0	0	.00	.86
		1	30	55	29	45	3	.86	1	30	.39	.24
80												
	EWP	3	50	5	0	42	34	.44	43	141	.35	.79
	LLSS	0	0	0	0	0	0	.00	4	11	.20	.20
	SJ	40	35	42	498	8	51	.92	0	0	.00	.92
	SMJ	69	34	-0	615	36	17	.75	0	0	.00	.75
	USE	0	36	4	8	55	53	.21	0	0	.00	.21
		114	35	51	1123	23	35	.32	47	152	.55	.87
81												
	H	0	28	38	0	4	40	.05	0	0	.00	.05
	HEP	12	6	51	1	57	-0	.47	12	149	.31	.77
	JCS	0	0	0	0	0	0	.00	7	210	.39	.39
		12	35	29	2	1	40	.51	19	359	.69	.21
		278	31	41	1996	2	1	.84	189	3023	.16	.00

Fig. 9--Project Usage Report

III. PERFORMANCE MEASUREMENT

A substantial amount of the code and storage in the JOSS system is devoted to recording the occurrence of events that will help determine the system's performance and its operating environment. Performance is measured not only to confirm that the context in which the system was designed is still a valid one, but also to provide a basis for possible system expansion.

Statistics may be evaluated in several ways. Among the possibilities are (1) determining the environment in which the JOSS system works and the trends over time of this environment, and (2) determining the characteristics of the typical user of the system.

In this section, we shall describe the kinds of statistics that are currently gathered by the system, the way in which these are displayed, and the general mechanisms for data gathering. Certain event counts are displayed each minute on the TTY machine console, others are recorded on magnetic tape for future analysis, and still others are accumulated in core memory for display at the TTY console every four hours.

ON-LINE LOG

Figure 10 is a sample page from the log produced at the master console, a Model 35 Teletype. A line of the log is produced each minute[†] to display counts descriptive

[†]The log line is not produced for minutes during which no characters were transmitted to or received from user consoles.

```
10: 3/24/67
TM UR-GQ-C-B COM-STA-A I--TL-CR-CI-CO T-K-T-#-R-#-D T%-RP-U-IC  SW-S-L-D
00 15  6 2 5 589 642 .25 113 57 43 33 . . . .43 1 . 58  . .  8  52 . 1 .
01 15  9 2 4 595 593 . . 106 36 22 31 . .33 1 . . . 99  . .  9  19 . . .
02 15  7 1 5 590 654 .26 152 30 31 42 . . . . . . . 98  . .  9  38 1 . .
03 16 10 1 1 595 636 . 1 129 42 29 34 . . . . . . . 98  . . 10  16 . 3 .
04 16  9 1 3 591 696 .15 118 67 36 30 . . . . . . . 98  . . 10  36 . 1 .
05 16 10 1 2 591 700 .21 107 58 29 23 . . . . . . . 98  . . 10  32 . . .
06 16 13 1 2 594 717 . 5  68 65 36 15 . . . .42 1 . 98  . . 10  26 . . .
07 16 11 1 4 593 702 . 4  78 51 44 21 . . . . . . . 98  . .  9  39 . . .
08 16 10 1 5 594 670 .13  96 18 28 30 . . . .37 1 . 98  . .  9  20 . . .
09 17 13 2 2 592 670 . 5  59 38 29 19 . . . .3725 . 98  . . 11  29 . . .
10 16  9 1 5 592 686 . 9 104 44 50 24 . . . . . . . 98  . .  9  39 2 3 1
11 16 12 1 2 593 698 . 8  92 43 41 24 . . . . . . . 98  . . 10  31 1 . 2
12 16 13 1 2 594 688 . .  55 41 38 18 . .42 2 . . . 98  . . 11  17 . 1 .
13 18 16 1 . 598 734 . .  69 34 31 22 . . . . . . . 98  . . 11  10 . . .
14 18 15 1 1 596 702 . 2  38 43 55  9 . . . . . . . 98  . . 11  12 . 1 .
00-OG   01-OG   02-RGR  10-SN   11-ECD  12-DCM  16-RDS  27-REL
30-TEST 31-RS   34-CT   37-DIT  40-RHM  41-WRG  42-SS   43-GFM
45-AJG  46-CMW
15 18 15 1 . 597 731 . .  46 31 44 11 . . . . . . . 99  . . 11   4 1 . 1
16 18 15 1 1 594 655 . 8  61 37 51 18 . . . . . . . 99  . . 11  14 1 2 .
17 18  9 2 4 590 740 .30  78 51 68 27 . . . . . . . 98  . . 11  56 . 2 1
18 18 11 1 2 591 713 .38 108 32 41 31 . . . . . . . 98  . . 10  35 1 1 .
19 17 12 1 3 593 711 .19  98 35 56 30 . . . . . . . 98  . . 10  34 . 1 .
20 16 10 1 4 595 705 .14 112 18 31 31 . . . . . . . 98  . .  9  23 . . .
21 16  9 1 3 506 606 . 6  92 22 27 25 . . . . . . . 98  6 .  8  13 . . .
22 16 11 . 5  28  25 .14 109 36 49 30 . . . . . . . 94 40 .  8  24 . . .
23 17 11 1 4 460 595 . 5  99 31 36 24 . . . .33 2 . 93  9 .  9  30 . 1 1
24 17 10 2 4 594 778 .21  53 20 23 20 . . . .43 2 . 93  . .  7  24 . . .
25 17 11 1 5 594 750 .10  74 23 32 24 . . . . . . . 93  . .  8  23 1 . .
26 17  9 . 7 408 508 . . 124 33 30 32 . . . . . . . 92 13 . 10  10 . 1 .
27 18 13 . 4  39  43 .12 177 27 24 41 . .25 1 . . . 89 39 . 10  33 . . .
28 18 12 1 2 550 686 .16  92 53 44 27 . . . . . . . 89  3 . 10  22 1 1 2
29 19 14 1 3 586 662 .22 129 52 37 39 . .47144712 . 89  . .  9  62 1 3 .
01-OG   10-SN   11-ECD  12-DCM  16-RDS  25-CBE  27-REL  30-TEST
31-RS   33-JRW  34-CT   40-RHM  41-WRG  42-SS   43-GFM  45-AJG
46-CMW  47-RWE
30 18  8 . 7 579 648 .25 127 48 48 40 . . . . . . . 9065! .  8  80 . . .
31 18 14 1 2 530 621 .35 102 42 36 33 . . . . . . . 90  3 .  9  49 . 1 1
32 19 13 2 3 583 665 .29 108 61 55 32 . . . .33 1 . 90  . .  9  81 . 2 .
33 18 12 3 2 588 775 . 8  82 45 30 27 . . . . . . . 90  . .  9  49 1 . 1
34 17 10 1 5 593 739 . 6 128 28 23 32 . . . .43 1 . 90  . .  9  31 1 . .
35 17 12 1 4 592 684 . 9 164 31 15 48 . . . . . . . 91  . .  8  31 . 3 .
36 17 15 1 1 593 767 .16  93 35 32 28 . . . .47 2 . 91  . .  7  35 . 1 .
37 17 13 1 . 594 736 .19  83 60 44 20 . .42 1 . . . 91  . .  9  28 1 1 .
38 17  9 1 3 592 754 .11  81 62 35 23 . . . . . . . 91  . . 10  33 . 2 .
39 17 10 1 3 517 659 .29 111 62 33 31 . . . . . . . 91  5 . 10  38 . . .
40 18 13 1 3 593 707 .16 124 47 40 37 . . . .30 1 . 91  . .  8  31 1 . 1
41 19 12 1 4 592 730 . 3 108 29 34 37 . . . . . . . 91  . . 11  22 . 1 .
42 18  8 2 6 594 693 .26  92 30 36 31 . .43 143 1 . 92  . .  9  43 1 2 1
43 17 12 2 2 590 741 .14 104 22 19 38 . . . . . . . 92  . .  7  35 . 1 .
44 18 11 1 3 590 760 .20  75 44 49 26 . . . .43 1 . 92  . .  8  56 . . .
01-OG   02-GWS  10-SN   11-ECD  12-DCM  16-RDS  25-CBE  27-REL
30-TEST 31-CRH  33-JRW  34-CT   41-WRG  42-SS   43-GFM  44-LAD
45-GSF  46-CMW  47-RWE
45 19 12 1 3 585 747 .29 131 49 34 35 . . . . . . . 92  . .  6  81 1 1 .
46 19 10 1 4 588 744 .18 115 47 38 36 . . . . . . . 92  . .  8  60 . 1 .
47 18 10 1 5 589 719 .17 121 29 34 37 . . . . . . . 92  . .  6  57 . . .
48 18 12 1 3 579 724 .83 130 35 27 39 . . . .42 1 . 92  . .  7  99 1 1 1
49 17 12 2 2 586 768 .39  99 42 25 30 . . . . . . . 92  . .  7  53 . . 1
50 17  9 3 3 588 789 .32  82 37 27 25 . . . . . . . 92  . .  9  66 . 1 .
51 18 14 1 3 587 838 .36 118 55 20 31 . . . .43 5 . 93  . .  7  77 . . .
52 18 14 . 4 435 560 .40 102 52 35 32 . . . . . . . 92 10 .  7  58 . . .
53 19 11 . 3  87  59 . 2 133 28 26 38 . . . .43 1 . 91 36 .  7  43 . . .
```

Fig. 10--Minute-by-minute On-line Log

of operation during the minute that has just been completed. A heading line (shown in Fig. 11) is produced each hour, and the initials and console numbers of currently active users are posted each quarter hour.

Table 3 summarizes the events counted in each column of the log. The scale factor, which is also given for each column, is such that its use will produce a number that will in most instances fit conveniently into the allotted columns. But as this is not always possible, special procedures apply when division of the count by the scale factor produces a zero quotient, and when the quotient is still too large for the allotted field. In the former case, the number is displayed in its unscaled form followed by an asterisk. In the latter case, the count is divided by additional factors of the ten until a fit is obtained. The number of such divisions required is indicated by replacing the low-order digit with a special character: !, if one factor of ten was needed (! may thus be read as × 100), and the characters

" # $ % & ' ( ) *

if

2 3 4 5 6 7 8 9 10

powers of 10 were required to achieve a fit in the allotted field.

In cases where the scale factor is larger than the field size, it is possible that both adjustments may be needed. For example, the RP column that is allotted a three-character field and that has a scale factor of 2000 would have displays as shown at the top of p. 32.

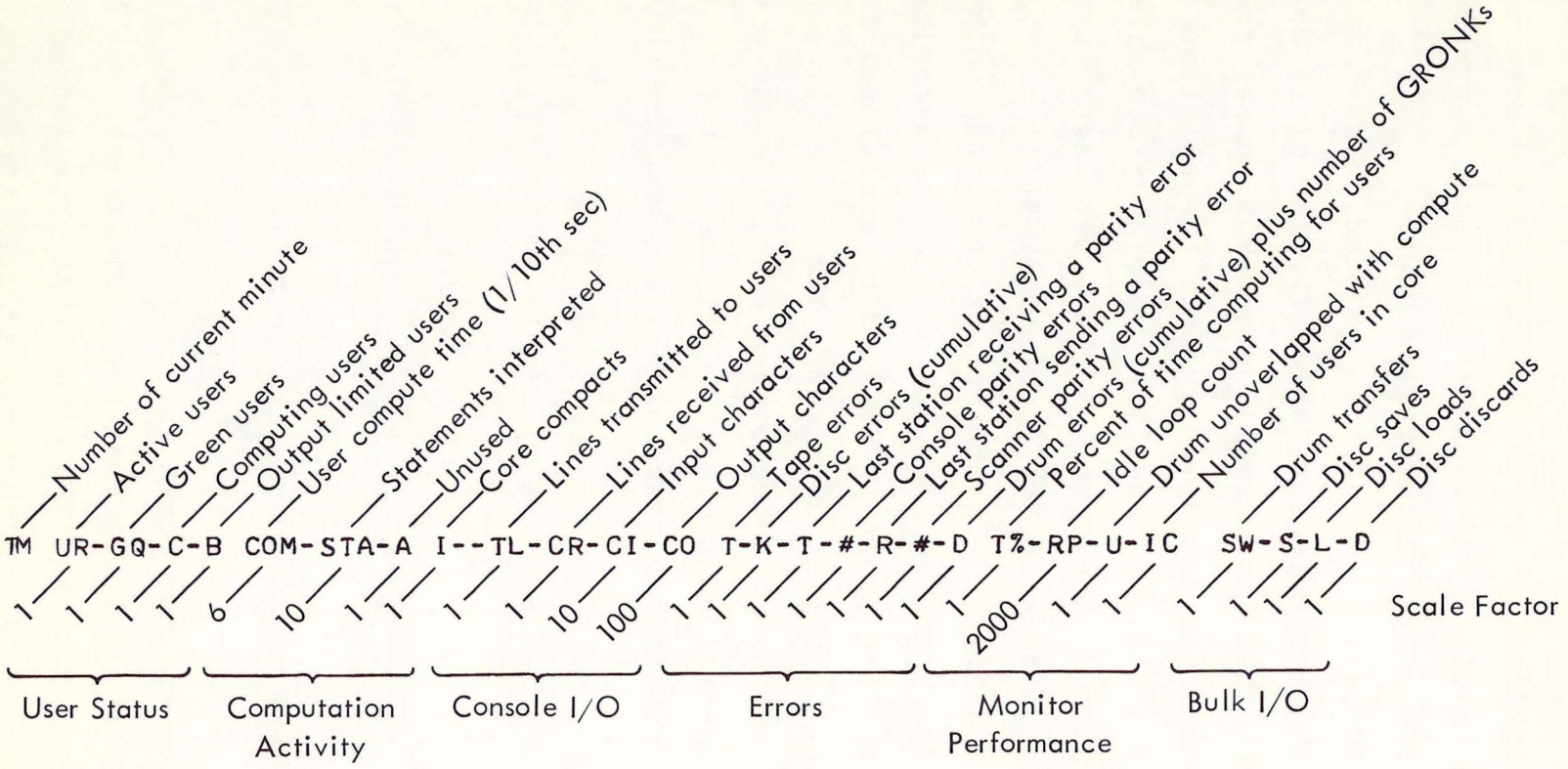


Fig. 11--Minute-by-minute Log Heading Line

Table 3

JOSS MINUTE-BY-MINUTE ON-LINE LOG

	Log Heading	Scale Factor	Contents
User Status	TM	----	Current minute
	UR	1	Active users
	GQ	1	Green users
	C	1	Computing users
	B	1	Output limited users
Computation Activity	COM	6	User compute time (1 count = 100 ms)
	STA	10	Statements interpreted
	A	1	Unused
	I	1	Core compacts
Console I/Ø	TL	1	Lines transmitted to users
	CR	1	Lines received from users
	CI	10	Input characters
	CO	100	Output characters
Errors	T	1	Tape errors
	K	1	Disc errors (cumulative)
	T	1	Last station receiving a parity error
	#	1	Console parity errors
	R	1	Last station sending a parity error
	#	1	Scanner parity errors
	D	1	Drum errors plus number of GRONKs
Monitor Performance	T%	1	Percent of time computing for users
	RP	2000	Idle loop count
	U	1	Drum unoverlapped with compute
	IC	1	Number of users in core
Bulk I/Ø	SW	1	Drum transfers
	S	1	Disc saves
	L	1	Disc loads
	D	1	Disc discards

```
-D T%-RP-U-IC  SW
 • 71  1 •  9  68 •
 • 72  2 •  8  98
 • 72 10" • 10 156
 • 73 50! •  7 104 •
 • 73  3* •  9 346 •
```

Display	Count
1	2000-3999
2	4000-5999
10"	1000
50!	500
3*	3

Note that in the second and third cases the values of the special marks have been reduced by one factor of ten due to the shift introduced in the first part of the algorithm to make room for the asterisk.

The algorithm thus leads to some ambiguities: Does 50! mean 500 or 10,000,000 in the RP column? In a column with a scale factor of 1, does 3* mean that the actual count was 3 or 3×10^{10}? The possibility that the high-count interpretation is valid is usually eliminated by the limited speed of the machine and rationality arguments.

Further information about the counts displayed in each column is given below.

TM (Time)

The two-column time field contains the number of the current minute. Data given on each log line covers the preceding sixty seconds; thus, the first log line of each hour is labeled 00 and contains data for the last minute of the preceding hour.

```
14: 12/12/66
TM UR-GQ-C-B COM-STA-A I--TL-CR-CI-CO T-K-T-
00 14  9 1 4 152  33 . 2  98 21 27 34 . . .
01 14  8 2 4 595 292 . 2  53 15 22 20 . . .
02 13 10 1 1 596 299 . 1  51 13 12 18 . . .
03 13  8 2 1 5971322 . 2  78 16 15 30 . . .
```

UR (Users)

The three-column users' field has a scale factor of 1 and records the number of users of the system at the current time.

GQ (Green Queue), C (Computer Queue), and B (Buffer Queue)

The green, computer, and buffer queues, each of which has a scale factor of 1, are instantaneous counts of the lengths of three system queues. They represent the number of users inputting, computing, and output limited at the current moment. Since there are many other queue states within the system, GQ, C, and B will not always add up to the total number of users as given under UR. The example below shows this to be the case for minute 03:

```
14: 12/12/66
TM UR-GQ-C-B COM-STA-A I--TL-CR-CI-CO T-K-T-
00 14  9 1 4 152  33 . 2  98 21 27 34 . . .
01 14  8 2 4 595 292 . 2  53 15 22 20 . . .
02 13 10 1 1 596 299 . 1  51 13 12 18 . . .
03 13  8 2 1 5971322 . 2  78 16 15 30 . . .
```

COM (Charged Compute Time)

The charged compute time field counts the total compute time accumulated by all users. The scale factor of 6 results in the display recording the number of tenths of

seconds computing for users during the preceding minute. For instance, in the example below, the last line shows 59.7 seconds of the minute were devoted to user computations. User compute time includes all time spent interpreting user statements and time spent preparing results of the indicated computations. It does not include console "green" time or time not computing while waiting for the typewriter to print results. The count does not always reach the maximum of 600 during full-use minutes. The difference is system overhead time.

```
14: 12/12/66
TM UR-GQ-C-B COM-STA-A I--TL-CR-CI-CO T-K-T-
00 14  9 1 4 152  33 . 2  98 21 27 34 . . .
01 14  8 2 4 595 292 . 2  53 15 22 20 . . .
02 13 10 1 1 596 299 . 1  51 13 12 18 . . .
03 13  8 2 1 5971322 . 2  78 16 15 30 . . .
```

STA (Statements Interpreted)

Under STA is recorded the number of users' statements, including both direct and indirect commands, interpreted during the preceding minute. The complexity of a JOSS statement can vary widely and so can the time required to execute it (for example, compare the statements Set x=0. and Set x=sum(i=1(1)1000:i+2·i*3.5).). The count recorded in this column can fluctuate even under continuous full load depending on the kinds of programs that the current users are executing. Under full load, the statement count varies between 1000 and 25,000 statements per minute, corresponding to interpretation rates of 60 to 2.4 ms per statement. The average rate is approximately 10 ms per statement, corresponding to a per-minute count of 6000.

In the example below, the number of statements executed ranges from 330 in the first minute given to 13220 in the final minute:

```
14: 12/12/66
TM UR-GQ-C-B COM-STA-A I--TL-CR-CI-CO T-K-T-
00 14  9 1 4 152  33 • 2  98 21 27 34 • • •
01 14  8 2 4 595 292 • 2  53 15 22 20 • • •
02 13 10 1 1 596 299 • 1  51 13 12 18 • • •
03 13  8 2 1 5971322 • 2  78 16 15 30 • • •
```

I (Core Compacts)

The core compacts column lists the number of blocks of core moved in user memory to provide space for a user being transferred from the drum. Core shuffling is a prime contributor to system overhead under heavy load. During periods of extremely heavy use, as much as 20 percent of time may be required by this process. Typically, however, total overhead is under 4 percent.

TL, CR, CI, and CO (Console I/O)

These four console I/O columns record the console activity during the preceding minute. They are, respectively, the number of lines transmitted to users (TL), lines received from users (CR), characters received from users (CI), and characters transmitted to users (CO). All four counts are recorded by the monitor at the time the buffers are returned by the distributor. The character counts, therefore, are not accumulated until the line containing them is complete. The character count reflects the final length of input lines, ignoring backspaces and retyping for line correction.

In the example below, the first minute recorded (minute 00) indicates that 98 lines of output were sent to users and 21 lines were received. The input lines contained 270 characters in total (scale factor of 10 for the CI column), while the output lines contained 3400 characters (scale factor of 100):

```
14: 12/12/66
TM UR-GQ-C-B COM-STA-A I--TL-CR-CI-CO T-K-T-
00 14  9 1 4 152  33 • 2  98 21 27 34 • • •
01 14  8 2 4 595 292 • 2  53 15 22 20 • • •
02 13 10 1 1 596 299 • 1  51 13 12 18 • • •
03 13  8 2 1 5971322 • 2  78 16 15 30 • • •
```

T, K, T, #, R, #, and D (Error Counts)

The error counts record errors detected by various input/output devices. T, K, and D record the number of errors detected and recovered on magnetic tape, the disc file, and the drum. The disc and drum column counts are not reset on the minute and thus record the cumulative error counts since system startup. The drum column also records the number of GRONKs,† or user data that has been discarded because it was found to be unusable.

The column pairs T, # and R, # record characters received with bad parity. T and R mean "transmitted" and "received" by the computer. Thus, under T we record errors in characters transmitted from machine to console. The console detects the error and reports the find back

†The word GRONK is derived from the Johnny Hart comic strip "BC," in which a brontosaur shatters earth and sky by uttering the word GRONK. When the machine or program error causes the entire system to fail, we call it a system GRONK.

to the machine for reporting under T. The number of such errors is recorded under #, and the console number of the last console producing the error is printed under T or R. This recording has proved valuable in detecting bad consoles, transmission lines, concentrator equipment, and scanner parts. In the example below, it is reported, during the first minute, that one character was received in error by the console connected to line 35 (that is, transmitted from the computer), and that during the second minute 4 errors were detected at consoles, at least the last one by the console on line 30. During the next to last minute, the machine received over 100 (1!=100) characters with parity errors at least the last of which came from line 43.

```
-CI-CO T-K-T-#-R-#-D T%-RP-U-IC  SW-S-L-D
 2130* . .35 1 . . . 83 41 .  4   2 . . .
 23  8 . .30 4 . . . 81 37 .  4   2 . . .
 26 15 . . . .12 1 . 8017" .  6  24 1 2 1
 26 17 . . . .431! . 81  . .  6  36 . 1 .
 26 24 . . . . . . . 82  . .  8 325 . . .
```

T% (Percent of Time Computing for Users)

The T% column is scaled so that it displays the percent of time within the current hour spent computing for users. Under conditions of full load, the system overhead may be determined directly from this column.

In the example below, we see from the first record line that 83 percent of the preceding hour was spent computing for users. The counter is reset at the beginning of the new hour, and the second and following lines record that 81, 80, 81, and 82 percent of the first 1, 2, 3, and 4 minutes were devoted to users.

```
-CI-CO T-K-T-#-R-#-D T%-RP-U-IC  SW-S-L-D
 2130* . .35 1 . . . 83 41 .  4   2 . . .
 23  8 . .30 4 . . . 81 37 .  4   2 . . .
 26 15 . . . .12 1 . 80 17" .  6  24 1 2 1
 26 17 . . . .431! . 81  . .  6  36 . 1 .
 26 24 . . . . . . . 82  . .  8 325 . . .
```

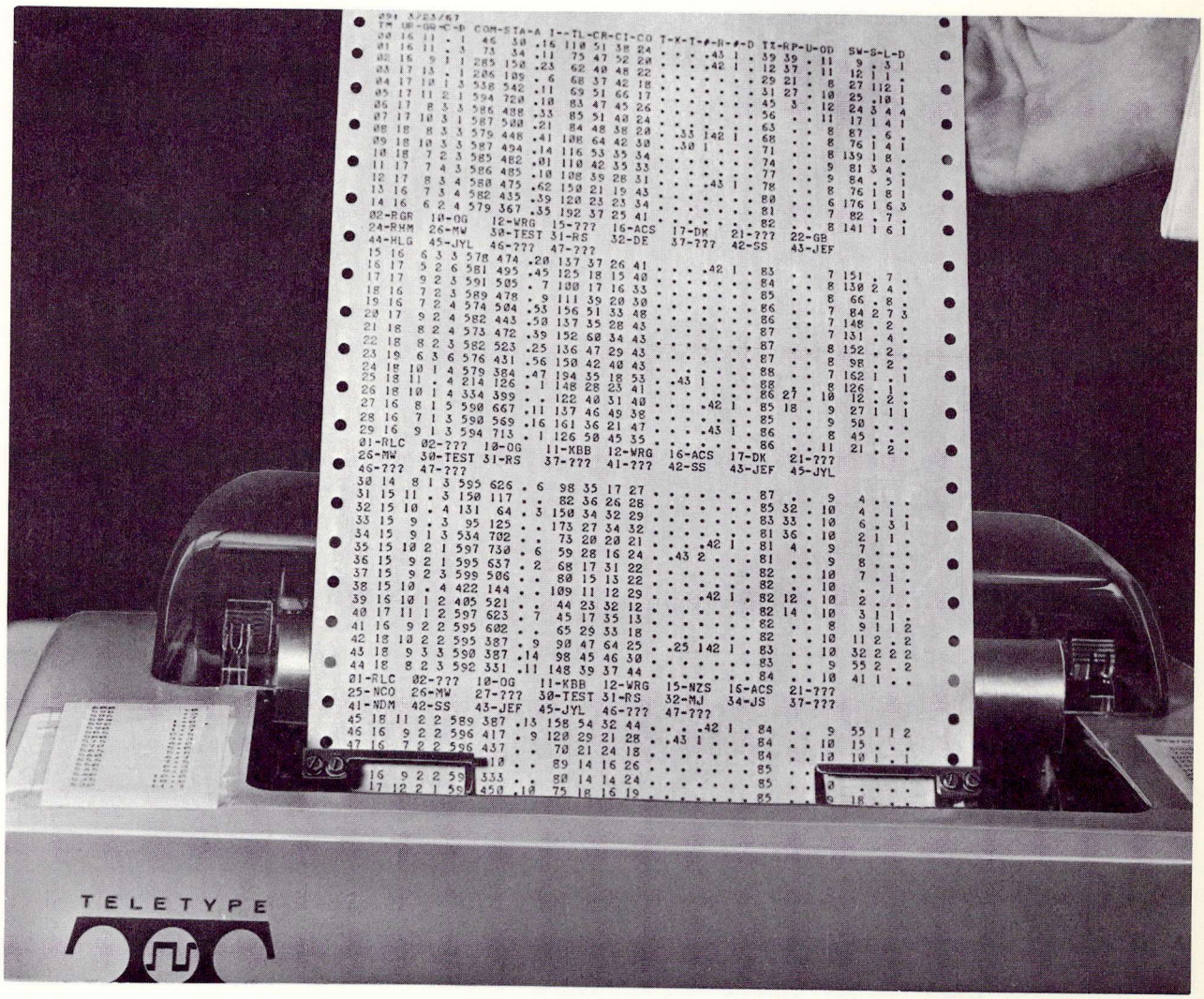
RP (Idle Loop Count)

A branch of the JOSS Main Processing Loop (MPL) that is entered if no work for users is requested contains an instruction to increment this counter. When this counter shows zero, the entire minute was spent working on user programs; when it is nonzero, it is a measure of the reserve power remaining in the system. In normal operation with no computing and no users on the drum, the log column displays a count of 73, corresponding to 146,000 cycles through the MPL. If users are on the drum, the count drops to about 44, reflecting the additional action required by the monitor in searching for possible drum-core swaps.

```
-CI-CO T-K-T-#-R-#-D T%-RP-U-IC  SW-S-L-D
 2130* . .35 1 . . . 83 41 .  4   2 . . .
 23  8 . .30 4 . . . 81 37 .  4   2 . . .
 26 15 . . . .12 1 . 80 17" .  6  24 1 2 1
 26 17 . . . .431! . 81  . .  6  36 . 1 .
 26 24 . . . . . . . 82  . .  8 325 . . .
```

U (Unoverlapped Drum Time)

When the idle branch of MPL is entered, and the drum is busy, and there are users in the compute queue, it means that core did not contain a user requesting compute and that we must wait for the drum transfer to complete to obtain the data for a user on whom we can compute. A low value of this count is a measure of the success of the


TELETYPE

system's swapping algorithms, which are designed to keep core filled with the users most likely to need compute power.

IC, SW, S, L, and D (Bulk I/O Counts)

IC records the number of users currently in core (the rest of the active users are on the drum). SW records the number of drum transfers (one count for each user block written or read from the drum). S, L, and D, which record disc-file activity, are, respectively, counts of saves, loads, and discards of items on the disc file. All of the counts in this group have a scale factor of one.

IC is a particularly important measure of system efficiency. If the number of in-core users is high, the probability is low that the system will be caught without work to do on users in core.

-CI-CO	T-K-T-#-R-#-D	T%-RP-U-IC	SW-S-L-D
2130*	. .35 1 . . .	83 41 . 4	2 . . .
23 8	. .30 4 . . .	81 37 . 4	2 . . .
26 15	. . . .12 1 .	8017" . 6	24 1 2 1
26 17	. . . .431! .	81 . . 6	36 . 1 .
26 24	. . . . . .	82 . . 8	325 . . .

FOUR-HOUR CUMULATIVE STATISTICS

The JOSS monitor accumulates certain counts and distributions of counts throughout each continuous period of JOSS operation. Fourteen tables of ten cells each are allocated to this purpose and are displayed on the on-line log once every four hours and when the system is shut down. The contents of the displayed counters have been summarized in Table 4.

Table 4

FOUR-HOUR STATISTICAL SUMMARY

Line 1. General information (T6) (Fig. 13)

Item 1. Total minutes since JOSS startup
Item 2. Total compute tics (1/60th sec) for users
Item 3. Total statements interpreted
Item 4. Total drum actions
Item 5. Total "Recalls" from disc
Item 6. Total "Files" on disc
Item 7. Total user minutes with 4 blocks
Item 8. Total user minutes with 3 blocks
Item 9. Total user minutes with 2 blocks
Item 10. Total user minutes with 1 block

(Fig. 16)

Line 2. General information (T7) (Fig. 13)

Item 1. Total disc "Discards"
Item 2. Compute tics unoverlapped with drum (excluding CR from user on drum when not computing)
Item 3. Total lines received from users
Item 4. Total lines sent to users
Item 5. Total session time for users (seconds)
Item 6. Total core compacts
Item 7. Total number of computer users swapped to drum
Item 8. Number of full compute minutes (RP=0)
Item 9. Number of overhead tics during full compute minutes
Item 10. Number of arithmetic (+, -, ·, /, *, sin, cos, log, exp, sqrt, arg) and comparison operations

Line 3. Task turnaround time (carrier return to switch to green) (Fig. 15)
Log scale, 1 sec

Line 4. Average interpretation rate per minute (Fig. 14)
Log scale, 6 ms

Line 5. Session time (Fig. 14)
Log scale, 1 min

Line 6. Compute time per session (Fig. 14)
Log scale, 10 sec

Table 4--continued

Line 7. Interaction time (Fig. 15)
Log scale, 6 sec

Line 8. Compute time per interaction (Fig. 15)
Log scale, 1/60th sec

Line 9. Used size at off time (Fig. 16)
Log scale, 10 cells

Line 10. Characters per input line (Fig. 17)
Linear scale, 5 characters

Line 11. Characters per output line (Fig. 17)
Linear scale, 5 characters

Line 12. Input characters per second (Fig. 18)
Log scale, .03 char/sec/user

Line 13. Output characters per second (Fig. 18)
Log scale, .03 char/sec/user

Line 14. Total characters per second (Fig. 18)
Log scale, .03 char/sec/user

NOTES:

For the log and linear scales, the ranges of the ten columns are given below. The ranges include the high end but not the low end.

Log Scale	Linear Scale
>500	≤5
500-200	5-10
200-100	10-15
100-50	15-20
50-20	20-25
20-10	25-30
10-5	30-35
5-2	35-40
2-1	40-45
≤1	>45

Lines 1 and 2 of Table 4 record summary event counts, while the remaining lines are distributions of measured events. Two scales are used in the distributions, as shown in the notes to the table: a linear scale, and a scale that is divided into approximately equal logarithmic intervals.

The event or measurement distributions are built up at the time of event or measurement occurrence by determining the range of the measurement along a predetermined scale and incrementing a count that corresponds to that range. Thus, after a period of time we have a series of counters, each recording the number of events that occurred in each range. For instance, the interpretation rate distribution records the number of minutes during which the rate fell into each range, such as 10 minutes where the average rate was between 0-6 ms per statement, 8 minutes when it was between 6-12 ms per statement, etc. This instant reduction technique allows a large number of events to be recorded with a small investment in required storage.

Figure 12 is a sample of the display of the four-hour statistics. For example, line five (line, or table numbers, are on the right of the display preceded by the character #) shows that 2 user sessions required one minute or less, while at the other end of the scale 4 user sessions fell in the range 200-100 minutes.

A JOSS program is used to display the information from these 14 tables and thus provides a summary of system use during the period covered by the data. Sample output of this program is shown in Figs. 13-18.

Although most of the counts displayed are self-explanatory, the following additional remarks are in order:

```
01-OG   02-RGR  10-SN   15-R    21-CLB  25-WRG  27-REL  30-TEST
31-JCC  33-TDS  37-WDM  40-CYF  41-WRG  43-GFM  45-GSF  47-RWE
45 16 10 2 3 599 627 . .  43 10 14 13 . . . . . . . 96  . . 10   2 . . .
46 15 10 2 3 596 613 . .  44  7 18 16 . . . . . . . 96  . .  9   4 . . .
47 15  9 2 3 599 616 . 2  64 16 16 14 . . . . . . . 96  . .  9   2 . . .
48 14  8 2 3 596 633 . .  57 20 22 21 . . . . . . . 96  . .  8   8 1 . .
49 13  8 2 3 599 623 . .  57 11  6 22 . . . . . . . 96  . .  9   2 . . .
50 13  9 2 2 597 617 . .  32 15 18 13 . . . . . . . 96  . .  9   . . . .
51 14 11 2 1 599 627 . .  17 13 19  8 . . . . . . . 96  . . 10   . . . .
52 14 10 2 2 596 621 . .  24 27 50  7 . . . . . . . 96  . . 10   4 . 1 .
53 14  9 2 2 596 634 . 8  77 24 30 16 . . . . . . . 96  . . 10   6 . 1 .
54 14  8 2 2 597 631 . .  70 16 24 16 . . . . . . . 96  . . 11   7 . . .
55 14  8 3 2 597 721 .10  57 16 14 18 . . . . . . . 96  . .  9  14 . 1 .
56 14  7 3 4 596 753 . .  88 13 17 24 . . . . . . . 96  . .  9   2 . . .
57 14  7 3 4 598 786 . .  89  8 14 22 . . . . . . . 96  . .  9   8 . . .
58 14  8 3 2 597 770 . 4  87 22 14 22 . . . . . . . 97  . . 10   7 1 . .
59 14  8 3 3 598 763 . .  55 19 16 15 . . . . . . . 97  . . 11   1 . 1 .
01-OG   02-RGR  10-SN   12-DCM  15-R    21-CLB  30-TEST 37-JMC
40-CYF  43-GFM  45-GSF  46-CYF  47-RWE
   1875367261065 81   9333   127    46   108   423   618  1645   # 01
     37      0  5486 16299108480  4467   623   127  9262349161   # 02
     13     34    43    88   180   270   591  1503  1240  1589   # 03
      0      0     1     1     1     2     4     8   167     2   # 04
      0      0     4     6    16    12     9     5     2     2   # 05
      0      0     0     1     1     2     3     7     5    37   # 06
      2      4    17    38   113   270   538  1114  1168  2222   # 07
     55     37   132   139   151   104   112   417  2344  1995   # 08
      0      0     7     4    16     4     9     3     0    13   # 09
   2753    961   689   304   325   152    61    48    36   157   # 10
   2603    887  1446  2771   985  1080  1169   819   746  3793   # 11
      0     89   662  3860  3219  2194   782   305    41    68   # 12
      3    196  5095  4411  1164   108    37    23    14   169   # 13
      4   1706  6992  2200   282    17     8     9     1     1   # 14

12: 3/24/67
TM UR-GQ-C-B COM-STA-A I--TL-CR-CI-CO T-K-T-#-R-#-D T%-RP-U-IC  SW-S-L-D
00 13  8 3 2 599 816 . .  40 14 19 12 . . . . . . . 97  . . 10   . . . .
01 14  7 3 2 596 794 . 3  30 18 14  7 . . . . . . . 99  . . 11   2 . . .
02 14  8 3 2 598 756 . .  30 15 14  7 . . . . . . . 99  . . 11   4 . . .
03 14  9 3 2 595 823 . 2  43 37 23 11 . . . . . . . 99  . . 11   2 . . .
04 13  9 3 1 599 798 . .  15 10 21  3 . . . . . . . 99  . . 10   . . . .
05 13  9 3 1 599 784 . .  10 22 21  2 . . . . . . . 99  . . 10   . . . .
06 13  7 3 3 596 766 . .  44 20 26 11 . . . . . . . 99  . . 10   . . 2 .
07 13  6 4 2 598 815 . .  37 19 32 11 . . . . . . . 99  . . 10   . . . .
08 14  8 2 2 600 765 . .  45 19 12 10 . . . . . . . 99  . . 11   . . . .
09 13  7 2 3 597 840 . .  46 35 29 14 . . . . . . . 99  . . 10   . . 1 .
10 12  6 3 1 597 846 . .  63 25 21 19 . . . . . . . 99  . .  9   . . . .
11 12  6 3 3 597 811 . .  38 23 13  9 . . . . . . . 99  . .  9   . . . .
12 11  7 3 1 600 808 . .  33 16 15  9 . . . . . . . 99  . .  8   . 1 . .
13 11  6 3 1 597 794 . .   6 16 19  1 . . . . . . . 99  . .  8   . . . .
14 12  6 4 1 597 880 . .  21 11 11  6 . . . . . . . 99  . .  9   4 . 2 .
```

Fig. 12--Four-hour Cumulative Summary

- The first item of line 1 records the total clock minutes during which the statistics were gathered.
- A drum action is either a transfer of user data from the drum to core or vice versa. Some swaps may require many drum actions since more than one in-core user may be transferred to the drum to provide space for a single large user.
- Items 7-10 in line 1 display the distribution of user size in real time. The distribution is not weighted by compute time and thus is not a good measure of strain on the system, since large users who are not highly active do not load the system significantly.
- Item 2 of line 2 is the sum of all counts in the U column of the log. As explained above, this counter records the main processing loop passes, during which all requested work was for users on the drum and at least one user was in the compute queue. Thus, light compute load situations with a large number of users, in which the probability is high that the only work to do is for a user on the drum, are excluded. A simple example of this last situation is one in which there are 25 users (thus, at least 9 users are on drum), all of whom are in green state--say, typing program steps, or out for coffee. If one of them now hits carrier return, the only work to be done will be the processing of the line that has just been released. The probability that a swap must be performed to bring the user's data in from the drum is relatively high.

- Item 7 of line 2 is the total number of users in the compute queue (those who have computations currently in progress) that the system found it had to swap to the drum. This would often happen, for example, if there were five compute-bound programs each requiring 4K of memory.
- Items 8 and 9, line 2, form a measure of system overhead during full-use minutes. A full-use minute is one during which no passes through the idle loop were recorded. During these minutes, the overhead is calculated by subtracting the compute time recorded for users from the maximum possible in the minute. Since the normal system overhead is about one-half percent, the count in item 9 is a close measure of the major overhead process--the compaction of core in preparation for swaps.
- Line 4 displays the distribution of the interpretation rate (time to process one JOSS statement). Because of the method of computing the mean from these data and the shape of the curve, this mean differs considerably from the more accurate one calculated from items 2 and 3 of line 1.
- Session time (line 5) is the clock time between power on and power off at a console. Interaction time (line 7) is the time between pushes of the carrier-return key at individual consoles.
- Task turnaround time is the time between carrier return and the completion of transmission of the last output line required (the time switch-to-green occurs).

- Line 9 is the distribution of used size by users at off time. We believe that no consistent bias exists as might if users executed the JOSS command Delete all. just prior to power off.

Figures 13 through 18 are sample output from the JOSS program that is used to display the data of Fig. 12. Figure 13 is a general summary mainly gathered from the first two lines of the four-hour summary. The remaining figures are displays of the data lines in histogram form. The histograms are formed by typing a figure containing a number of zeros equivalent to the percent of counts in the given range. Since the formatting allows for only 33 spaces, percentage counts over that value are treated specially by printing the percent at the left of the maximum (33) size number.

In examining the histograms, one should take particular note of the scales used. Most are logarithmic, and the linear scale for line lengths has a wide range at the high end.

```
Statistics for  22.0 hours ending 1530 hours  3/ 8/67.

User sessions:  227 totalling 157.0 hours, averaging  7.1 simultaneous users.
                Average session time:   41 minutes.
                Average number of tasks (input lines):   73
                Compute time per task:   1.42 seconds.
                Compute time per session:   1.72 minutes.

Compute hours:   6.50 or 29.6 percent of available time.
                  280 compute-bound minutes.
                    3.7  percent system overhead.

JOSS  statements:  2148200 processed in   390.1 minutes; 10.9 ms./statement.
                   9463 statements executed per session.
                     10702000 arithmetic ops;  5.0 per statement;   2.2 ms/op.

Disc actions:   500 Recalls;   236 Files:   255 Discards.

Console I/O:    49639 lines transmitted to users;    16466 received.
                Output/Input ratio:    3.01

Lines per user-session-minute:  1.7 input,  5.3 output,  7.0 total.

Drum:  42644 actions;   5507 computing users swapped;  10.45 sec unoverlapped.

Core was compacted  23639 times.
```

Fig. 13--Results of JOSS Reduction Program for Cumulative Data--I

Statistics for 22.0 hours ending 1530 hours 3/ 8/67.

Average interpretation rate	millisec.		pct.	cumul.
10000000000000000000000000000000	.0-	6.0	32.60	32.60
100000000000000000000000	6.0-	12.0	25.25	57.85
1000000000000000000000000000	12.0-	30.0	28.66	86.50
1000000	30.0-	60.0	6.52	93.03
1000	60.0-	120.0	3.34	96.36
100	120.0-	300.0	2.81	99.17
1	300.0-	600.0	.68	99.85
1	600.0-	1200.0	.15	100.00
1	1200.0-	3000.0	.00	100.00
1	3000.0-	6000.0	.00	100.00

mean = 25.53 total = 1319

Session time	minutes		pct.	cumul.
10000	.0-	1.0	4.41	4.41
100000	1.0-	2.0	5.29	9.69
10000000000000	2.0-	5.0	13.66	23.35
1000000000000	5.0-	10.0	12.33	35.68
100000000000000	10.0-	20.0	14.10	49.78
1000000000000000000000000	20.0-	50.0	24.23	74.01
10000000000000000	50.0-	100.0	16.74	90.75
1000000	100.0-	200.0	6.17	96.92
1000	200.0-	500.0	3.08	100.00
1	500.0-	1000.0	.00	100.00

mean = 44.70 total = 227

Compute time per session	seconds		pct.	cumul.
66079295200000000000000000000000000	.0-	10.0	66.08	66.08
1000000000	10.0-	20.0	9.69	75.77
10000000	20.0-	50.0	7.49	83.26
1000	50.0-	100.0	3.96	87.22
1000	100.0-	200.0	3.08	90.31
10000	200.0-	500.0	4.41	94.71
100	500.0-	1000.0	2.20	96.92
100	1000.0-	2000.0	2.20	99.12
1	2000.0-	5000.0	.88	100.00
1	5000.0-	10000.0	.00	100.00

mean = 110.79 total = 227

Fig. 14--Results of JOSS Reduction Program for Cumulative Data--II

Statistics for 22.0 hours ending 1530 hours 3/ 8/67.

Task turn-around time	sec.		pct.	cumul.
350002998000000000000000000000000000|	.0-	1.0	35.00	35.00
1000000000000000000|	1.0-	2.0	18.21	53.21
10000000000000000000000000|	2.0-	5.0	25.74	78.95
10000000000|	5.0-	10.0	10.71	89.66
1000|	10.0-	20.0	3.89	93.55
100|	20.0-	50.0	2.82	96.37
10|	50.0-	100.0	1.77	98.14
10|	100.0-	200.0	1.00	99.14
1|	200.0-	500.0	.55	99.69
1|	500.0-	1000.0	.31	100.00

mean = 10.80 total = 16677

Interaction time	seconds		pct.	cumul.
1000000000000000000000000000000|	.0-	6.0	31.12	31.12
100000000000000000000|	6.0-	12.0	22.95	54.08
1000000000000000000000000|	12.0-	30.0	26.25	80.33
10000000000|	30.0-	60.0	10.45	90.77
100000|	60.0-	120.0	5.61	96.39
100|	120.0-	300.0	2.48	98.86
1|	300.0-	600.0	.70	99.56
1|	600.0-	1200.0	.23	99.79
1|	1200.0-	3000.0	.13	99.93
1|	3000.0-	6000.0	.07	100.00

mean = 34.77 total = 16466

Compute time per interaction	millisec.		pct.	cumul.
3569172840000000000000000000000000000|	.0-	16.7	35.69	35.69
3941455120000000000000000000000000000|	16.7-	33.4	39.41	75.11
1000000000|	33.4-	83.5	9.93	85.04
100|	83.5-	167.0	2.26	87.30
100|	167.0-	334.0	2.33	89.62
100000|	334.0-	835.0	5.13	94.75
100|	835.0-	1670.0	2.49	97.24
1|	1670.0-	3340.0	.89	98.14
1|	3340.0-	8350.0	.63	98.77
10|	8350.0-	16700.0	1.23	100.00

mean = 302.19 total = 16466

Fig. 15--Results of JOSS Reduction Program for Cumulative Data--III

Statistics for 22.0 hours ending 1530 hours 3/ 8/67.

Used size at off time	cells		pct.	cumul.
10000000000000000000000000000|	.0-	10.0	28.19	28.19
1000|	10.0-	20.0	3.08	31.28
10000000|	20.0-	50.0	7.93	39.21
1000000000|	50.0-	100.0	9.69	48.90
1000000000000000000|	100.0-	200.0	18.06	66.96
100000000000000|	200.0-	500.0	15.42	82.38
100000000000|	500.0-	1000.0	11.01	93.39
1000000|	1000.0-	2000.0	6.61	100.00
1|	2000.0-	5000.0	.00	100.00
1|	5000.0-	10000.0	.00	100.00

mean = 274.69 total = 227

Core block minutes	blocks		pct.	cumul.
100000|	4.0-	4.0	5.84	5.84
10000000000000|	3.0-	3.0	13.41	19.25
100000000000000000000000|	2.0-	2.0	24.67	43.92
560759494000000000000000000000000000|	1.0-	1.0	56.08	100.00

mean = 1.69 total = 9480

Fig. 16--Results of JOSS Reduction Program for Cumulative Data--IV

Statistics for 22.0 hours ending 1530 hours 3/ 8/67.

Characters per input line	char.		pct.	cumul.
1000	45.0-	78.0	3.92	3.92
1	40.0-	45.0	.92	4.83
10	35.0-	40.0	1.31	6.14
10	30.0-	35.0	1.76	7.90
10000	25.0-	30.0	4.34	12.24
10000000	20.0-	25.0	7.48	19.71
10000000000	15.0-	20.0	10.56	30.27
1000000000000000	10.0-	15.0	15.40	45.66
10000000000000000000	5.0-	10.0	19.14	64.81
3519373250000000000000000000000000000	.0-	5.0	35.19	100.00

mean = 12.82 total = 16466

Characters per output line	char.		pct.	cumul.
1000000000000000000000000000	45.0-	78.0	27.73	27.73
1000	40.0-	45.0	3.31	31.05
100000	35.0-	40.0	5.98	37.03
1000000000000	30.0-	35.0	12.93	49.96
1000000	25.0-	30.0	6.54	56.50
10000000	20.0-	25.0	7.97	64.47
10000000000000	15.0-	20.0	13.16	77.64
1000000	10.0-	15.0	6.31	83.95
10000	5.0-	10.0	4.97	88.92
100000000000	.0-	5.0	11.08	100.00

mean = 32.25 total = 49639

Fig. 17--Results of JOSS Reduction Program for Cumulative Data--V

Statistics for 22.0 hours ending 1530 hours 3/ 8/67.

Input characters/sec/user	char.		pct.	cumul.
37168667100000000000000000000000000|	.0-	.0	37.17	37.17
1|	.0-	.1	.13	37.30
1|	.1-	.2	.85	38.15
1000|	.2-	.3	3.55	41.70
10000000000000000|	.3-	.6	16.69	58.39
1000000000000000000000000000|	.6-	1.5	28.69	87.08
100000000|	1.5-	3.0	8.67	95.75
1000|	3.0-	6.0	3.77	99.53
1|	6.0-	15.0	.47	100.00
1|	15.0-	30.0	.00	100.00

mean = .81 total = 79150

Output characters/sec/user	char.		pct.	cumul.
45214150300000000000000000000000000|	.0-	.0	45.21	45.21
1|	.0-	.1	.01	45.23
1|	.1-	.2	.04	45.27
1|	.2-	.3	.25	45.51
10|	.3-	.6	1.03	46.55
10000|	.6-	1.5	4.09	50.64
10000000000000000|	1.5-	3.0	15.50	66.13
1000000000000000000000000000|	3.0-	6.0	26.21	92.34
1000000|	6.0-	15.0	6.36	98.70
10|	15.0-	30.0	1.30	100.00

mean = 2.54 total = 79150

Total characters/sec/user	char.		pct.	cumul.
100000000000000000000000000000000|	.0-	.0	32.81	32.81
1|	.0-	.1	.00	32.81
1|	.1-	.2	.00	32.81
1|	.2-	.3	.09	32.90
10|	.3-	.6	1.83	34.73
100000|	.6-	1.5	5.32	40.05
10000000000000|	1.5-	3.0	13.46	53.51
35125710700000000000000000000000000|	3.0-	6.0	35.13	88.63
1000000000|	6.0-	15.0	9.88	98.51
10|	15.0-	30.0	1.49	100.00

mean = 3.32 total = 79150

Fig. 18--Results of JOSS Reduction Program for Cumulative Data--VI

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