AECU-3632

UNIVERSITY OF ILLINOIS

GRADUATE COLLEGE

DIGITAL COMPUTER LABORATORY

TECHNICAL PROGRESS REPORT

Teaching and graduate research are
not, in general, reported herein.

- PART I: STUDY PROGRAM ON HIGH-SPEED COMPUTER
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GENERAL LABORATORY INFORMATION

October, 1957

C32 001

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PART I

STUDY PROGRAM ON HIGH-SPEED COMPUTER

This work is supported in part through Contract No. At(11-1)-415 of the Atomic Energy Commission. The contract is supported jointly by the Atomic Energy Commission and the Office of Naval Research. In addition, this work is supported through Contracts N6ori-07130 and Nonr-1834(15), both from the Office of Naval Research.

The University of Toronto is participating in this work through staff members of its Computation Centre.

1. Arithmetic Unit

Carry Propagation Study

The problem of determining the expected maximum carry propagation when adding random numbers using various logical designs was investigated. This problem is of interest for:

- (A) Illiac-type adders modified for a carry completion signal, when the adder is of length $n \geq 40$ stages. Burkes, Goldstine, and von Neumann give recursive probability equations for the maximum expected carry. These equations easily generalize for joint propagation of carries or zero-carries. These equations have been evaluated on Illiac for $40 \leq n \leq 64$ (Problem Specification 1060). A Monte Carlo experiment for $n = 40$ is reported in the literature giving 5.6 stages as the expected value. The Illiac result for $n = 40$ was 5.69.
- (B) The type of adder reported in Report No. 80 in which two random numbers x and y are added and two new numbers are obtained, s and c . Carry assimilation then consists of adding $s + c$ and allowing generated carries to propagate. In this problem

$$s_i = (x_i \oplus y_i) \oplus (x_{i+1} y_{i+1})$$

$$c_i = (x_{i+1} \oplus y_{i+1}) \cdot (x_{i+2} y_{i+2})$$

A new phenomena occurs which makes a mathematical-probability analysis much more difficult than for (A). When adding s and

c combinations 0,1 or 1,0 propagate while combinations 0,0 or 1,1 initiate a carry or zero-carry. These states are not independent probability-wise from the two preceding states. For example

	i	i+1	
s	0	1	cannot occur.
c	1	0	

Consequently an analysis must be made of each stage conditional on the two preceding stages.

- (C) Carry-borrow type adder discussed in Report No. 81. Given s and c as the sum and carry digits when assimilation is to be performed, the equations have been analyzed sufficiently to yield the following:

$$\text{Zero-borrow} \quad e_{i-1} = \bar{s}_i (c_i s_{i+1} y_i \vee c_i \bar{s}_{i+1} \vee \bar{c}_i s_{i+1} \vee \bar{c}_i \bar{s}_{i+1} e_i)$$

$$\text{Borrow} \quad x_{i-1} = \bar{s}_i (c_i s_{i+1} f_i \vee \bar{c}_i \bar{s}_{i+1} x_i)$$

$$\text{Zero-carry} \quad f_{i-1} = s_i (c_i \bar{s}_{i+1} x_i \vee c_i s_{i+1} \vee \bar{c}_i \bar{s}_{i+1} \vee \bar{c}_i s_{i+1} f_i)$$

$$\text{Carry} \quad y_{i-1} = s_i (\bar{c}_i s_{i+1} y_i \vee c_i \bar{s}_{i+1} e_i)$$

The four Boolean functions so defined are pairwise disjoint and

$$e_{i-1} \vee f_{i-1} \vee x_{i-1} \vee y_{i-1} = 1 \quad (e_{n+1} = 1, f_{n+1} = 0).$$

From these we obtain immediately

$$\text{Propagating states} \quad \overline{s_i \oplus c_i \oplus s_{i+1}}$$

$$\text{Initiating states} \quad s_i \oplus c_i \oplus s_{i+1}$$

One other interesting relation that may be deduced is:

$$x_{i-1} \vee y_{i-1} = \bar{c}_i (x_i \vee y_i) (\overline{s_i \oplus s_{i+1}}) \vee c_i (\overline{x_i \vee y_i}) (s_i \oplus s_{i+1})$$

Floating Point Arithmetic

A double precision, interpretive, floating binary subroutine has been written to experiment with various possible types of wired-in floating point orders for the new computer. This subroutine has an order code which is an extension of the order code of Library Routine A-1, and includes such orders as "standardize the floating accumulator". There are 4096 addressable double precision numbers - numbers with low addresses are held in the Williams memory, and the routine transfers words automatically to or from the drum when necessary. This routine may be easily modified to vary the effective word-length or the standardization procedure to compare various possible computers. It is proposed first to study matrix algebra.

2. Control Studies

Trial Programming

A detailed study of the problems arising in writing the inner loops of two problems has been made. These are the root-finding procedures in Givens' method for the eigenvalues of a symmetric matrix after the matrix has been reduced to tri-diagonal form, and a hyperbolic hydrodynamical problem with 2 space variables and time. In both cases, inner loops existed for which the memory access-time was almost entirely overlapped with arithmetic, and the problem was to find this loop. A useful aid in this search was a chart indicating the partial ordering in time which the various operations have to satisfy. This is a generalization of the idea of a flow chart, since a flow chart generally specifies a unique order for doing operations.

Order Code

A new class of orders have been found, called conditional arithmetic orders. If some arithmetic condition, such as $A \geq 0$, is satisfied, an operation such as "add 1 to the contents of a B-register" is performed. This can save two memory references compared to the two control transfers that would otherwise have to be executed. (Jump out to record the result of the test, and then jump back into sequence.)

3. Core Storage Unit

One-word Unit

The effect of half selection of the switch core on the stored contents of the 50-bit test unit has been investigated experimentally. One of two current drivers was excited continuously by a clock pulse to simulate half-selection of the switch core; the other driver was turned on manually to perform one complete cycle, using a one-shot circuit synchronized with the clock. The following results were obtained:

1. The readout signals did not deteriorate after being disturbed for long periods by the half-selected switch core.
2. The disturbed readout signal was small in comparison to the normal readout signal.
3. Appreciable pickup on the readout wire from the rewrite B-drivers was noted. The amount of pickup to be expected in the full-scale storage unit could not be estimated from the one-word test.

Logical Design

Investigation into the logic necessary for a full-scale memory is being made, and in light of the results, a suitable logic for the test memory is being worked out. At the speeds under consideration for this memory, pulse delay times in the switch core matrix and in the bit core planes themselves, become an appreciable fraction of the access-time. Therefore a careful study must be made of current coincidences within the memory to make sure proper time is allowed for reading and readout. This study has been started and will continue.

Peripheral Circuits

A transistorized pulser was designed and tested; it delivers pulses from 80 μ s to 1 μ s apart and is driven by a regenerative amplifier developing sharp edges (for proper triggering from a sine-wave).

More suitable high current drivers were designed. A pair of 6DQ5 power pentodes are used for the output stage of the 0.4 ampere and 0.75 ampere drivers. The UL84, a 12-watt, 100 ma pentode, is used for voltage gain. The

complete driver uses 1 GF-45011 transistor, 2 UL84's, and 2 6DQ5's and generates a 0.4 ampere, 50 μ s pulse from a two-volt input signal after a delay of approximately 50 μ s.

4. Transistor Circuits

Redesign and Tests of the Basic Logical Circuits described in Report 80

Under the first heading come extensive modifications of the flipflops described in Report 80. The principal change was to take the emitter-followers out of the collector-to-base feedback loop and to use them exclusively to drive the outputs from the last moving points. Further changes took account of the increase in the allowed reverse bias on the emitter from 1v to 3v. A minor readjustment of the average emitter-base forward drop figures had also some influence on the new design.

It seems now possible to obtain operation times of 40 μ s and 15 μ s respectively for the symmetric Eccles-Jordan and the Schmidt-Trigger type respectively. As soon as definitive figures are available the circuit values of the new designs will be published.

The EXCLUSIVE OR circuit of Report 80 was redesigned in view of obtaining more realistic tolerance conditions. To this end the input inverters were designed to give full swing of the (bumped) collector with inputs between ± 0.5 v and ± 1.5 v. The figure below gives the final design which produces under the worst conditions an operation time of 45 μ s. It should be pointed out that this is slower than the one obtainable by the usual half-adder.

The "Flow-Gating" System

A new principle of information transfer (called "flow gating") was investigated. The fundamental idea can be stated as follows. Consider a flipflop having only one supply voltage (see below for an example) and choose one input and one output such that they are in phase but have a different average potential. Suppose for instance that the average potential of the input is greater than that of the output. We then connect the flipflops with diodes, each diode being always reverse biased as long as the supply voltages E_1 and E_2 (see figure) are the same. No information flows in this case. Now we observe that the state of such a flipflop does not change when we alter the supply voltage since the circuit equations cannot contain E (all currents are proportional to E , the coefficients of proportionality depending on the state!). We now lower the average potential of IN_2 by lowering E_2 : at a given moment information will flow through diode D_{12} if flipflop 1 is in the "up"-state, while otherwise flipflop 2 will remain unaffected. If we now continue to clear flipflop 2 to the "down"-state whenever E_2 is lowered (see again below for an

PRICIPLE OF FLOW GATING

example), we have a perfect clearing and gating system using as a coupling element one single diode. Once flipflop 2 has received its information, we can swing E_2 back to the normal value and the state is "trapped".

The make-up of one possible type of flow-gating flipflop is shown in the figure below, the layout being adapted to pnp transistors. Circuit values are only approximate and refer to a prototype the static behavior of which has been tested.

FLOW GATING FLIPFLOP

In the case of the circuit just described, it is easy to see how the clearing and gating comes about. $-E$ is made more and more negative until $-u_0$ holds the base of T_1 at a fixed potential. Suppose that IN is held at a potential below $-u_0$: then T_1 is cut off, driving OUT toward the more negative state. If however IN is at a potential above $-u_0$, the emitter of T_1 will continue to conduct and will also continue to do so as $-E$ goes back to its normal value: OUT will be in its more positive state all the time.

5. Transistor and Diode Procurement and Testing

232 GF-45011 transistors were received during the month of October. A production tester which measures the dc α as well as emitter-base forward and reverse drops (plus some other parameters) was built and is now used to test the incoming units.

About 150 each of Q5-250 and Q10-600 units have been received from Qutronics Semiconductors and have been tested. In general they meet our specifications but tend to have a larger spread of forward drops than did National Union types. Qutronics has agreed to tighten limits and indicates this is quite possible.

The recovery times of these diodes seem to be quite satisfactory. Q5-250 when switched from 10 ma to 5 volts recovers to 250 μ a in about 80 μ ms. Q10-600 when switched similarly recovers to 600 μ a in about 60 μ ms.

Certain more general work has been done with the diodes available with respect to recovery time. It is now possible on the basis of one speed measurement to partially predict quantitatively the recovery at other current and voltage conditions.

PART II

SWITCHING CIRCUIT THEORY

(This work is supported in part by the Office of Naval Research under Contract N6ori-07130.)

1. Complex switching circuits are generally designed by combining "blocks" consisting of simpler circuits, which are designed individually without regard to their interaction with the whole. Rules for combining such blocks which are semi-modular in such a way as to preserve semi-modularity have been set down in Digital Computer Laboratory Reports 66 and 80, and constitute the basis of a useful synthesis technique.

An alternative to this method of combining blocks is to effect a corresponding combination of the partially ordered sets of C-signals which were originally used to describe the blocks in question. This alternative has two advantages over the block combination method.

- (a) The effect upon sequencing of operations is clearer since chronological ordering is expressed directly in the resulting partially ordered set.
- (b) A much more general set of rules has been obtained for combining partially ordered sets of C-signals than was obtained for combining circuits. Thus a greater variety of combinations is possible using the alternative method.

All of the rules for combining partially ordered sets of C-signals may be derived without great difficulty from a general theorem describing the conversion of a partially ordered set of C-signals Σ into a contracted set Σ' .

Let Σ be a partially ordered set of C-signals which is realizable as a binary circuit. Then Σ' is similarly realizable if it is formed in the following manner and it is partially ordered.

- (1) Place (γ, k) in Σ' if (γ, k) is in Σ , and $k \neq i, k \neq j$.
- (2) Place (α, i) in Σ' if (α, i) and (α, j) are both in Σ .
- (3) Make $(\gamma, k) < (\delta, l)$ in Σ' if $(\gamma, k) < (\delta, l)$ in Σ .
- (4) Make $(\gamma, k) < (\alpha, i)$ or $(\gamma, k) > (\alpha, i)$ in Σ' if $(\gamma, k) < (\alpha, j)$ or $(\gamma, k) > (\alpha, j)$ in Σ .
- (5) Include no further ordering relations Σ' except those needed to satisfy the condition of transitivity.

2. Conditions for realizability of a partially ordered set of C-signals in terms of a switching circuit have been set down in an earlier report. It was also shown that these conditions were sufficient for the realization of a binary circuit provided that one is allowed to place additional C-signals in the partially ordered set which correspond to additional circuit elements. This result was proved by exhibiting a particular method for placing such additional elements. A different method for placing such additional elements has now been found which allows one to write down a particularly simple realization of the circuit. This realization requires the use of only four types of logical circuit elements and hence is particularly attractive from the standpoint of electronic circuit design. The required element types are AND, OR, NOT, and C-elements. A C-element is a single output flipflop whose output tends to change only when it disagrees with both inputs. Although such elements have not been designed using high-speed transistors, it seems likely that designs similar to the present single output flipflops are possible.

3. Greater generality has been achieved in the theory concerned with the distributive lattice $\mathcal{A}$ of C-states used to represent a circuit. This was done by extending the definition of excitation so as to apply to any such lattice derived from a partially ordered set of C-signals, without regard to whether or not it may be realized in terms of a binary or other specific type of circuit.

The required conditions on $\mathcal{A}$ are:

- (i) The elements $\underline{a}$ of $\mathcal{A}$ must be n-tuples of non-negative integers: $\underline{a} = (\underline{a}_1, \underline{a}_2, \dots, \underline{a}_n)$.
- (ii) They must form a lattice under componentwise ordering in which the least upper bounds and greatest lower bounds are componentwise maxima and minima respectively.
- (iii) This lattice contains the zero element whose components are all zero.
- (iv) An element $\underline{b}$ covers an element $\underline{a}$ in $\mathcal{A}$ if and only if for some i we have $\underline{b}_i = \underline{a}_i + 1$ and $\underline{b}_j = \underline{a}_j$ when $j \neq i$.

The extended definition of excitation now reads: Node i is excited in C-state a if and only if there exists a C-state b which covers a and for which $\underline{b}_i = \underline{a}_i + 1$.

The general theorems concerning excitation which were developed in Digital Computer Laboratory Report 78, as well as several subsequent results, may be extended accordingly.

PART III

MATHEMATICAL METHODS

1. Relativistic Field Equations (Supported in part by the National Science Foundation under Grant G2794.)

Work continues on the static spherically symmetric Einstein field equations for a space-time in which a perfect gas at constant entropy exists. A complete set of ordinary differential equations have been derived which take into account the relativistic effects in the determination of the internal energy of the gas as a function of the temperature. These equations will be integrated numerically for various values of central pressure p_c and the constant entropy s . The mass and radius of a spherical distribution of matter will then be determined. Particular attention will be paid to the values of p_c and s for which non-singular solutions of the field equations do not exist and for which the mass as functions of p_c for constant s have maxima.

2. Hydrodynamic Flows with Shocks (Supported in part by the National Science Foundation under Grant G2794.)

The various difference equations obtained from the integral form of the conservation equations in Eulerian coordinates are being studied for their stability.

PART IV
GENERAL RESEARCH

Wave Function of the Hydrogen Molecule

The problem of obtaining the wave function of the hydrogen molecule (originally started at MURA by Nordsieck, Taub, Fosdick and Snyder) is being programmed for the IBM 704. This problem falls into three parts. First the two double equations for the hydrogen molecule ion are solved to obtain a set of basis functions. The first forty states will be used. These are formed into 114 normalized two-electron product basis wave functions. This portion of the programming is complete. In connection with it, it was necessary to program a routine which would obtain the intersection of the two eigenvalue curves given several points on each curve. Second, a matrix of the interelectron interaction energy is formed with these 114 wave functions as bases. Each matrix element is a 6-dimensional configuration integral which by analysis can be reduced to a 4-dimensional integral. This portion of the problem has been formulated and analyzed but not yet programmed. Two subroutines necessary for this routine are under preparation at MURA. Third, this matrix will be diagonalized to find the eigenvalues and eigenvectors which will in turn determine the hydrogen molecule wave function in terms of the two-electron basis functions. The appropriate matrix programs have been prepared at MURA.

PART V

ILLIAC USE AND OPERATION - GENERAL LABORATORY INFORMATION

Machine Use

During October specifications were presented for 14 new problems. This list does not indicate how the Illiac was used because large amounts of machine time may have been consumed by problems with numbers less than 1060. Numbers followed by T are for theses.

1060 Computer. Carry Propagation Studies. The problem is to study the probable characteristics of carry propagation for various types of logical design of adders. For some types of designs, the only reasonable way (at present) of estimating expected maximum carry propagation is by Monte Carlo methods which will be tried on Illiac. In other cases, recursive probability equations may be written which allow on easy direct calculation of probabilities.

1061 T Psychology. An Investigation of the Perceptual Space Concept. An investigation of the existence, reliability and validity of the "Perceptual Space Concept" will be carried out. "Perceptual Space" (SP) is a conception proposed by Cronback, who for several years has worked in the area of social perception. A perceiver rates, judges or perceives a given number of other persons, each on the same rating scale of adjectives, e.g., dependable, tense, passive. This abstractly defines the SP of the perceiver. Operationally, the responses to the items of the rating scale are factor-analyzed, yielding orthogonal dimensions. If he describes a number of other representative items, the position they occupy in this space indicates the perceiver's map or space of the interpersonal world. The central tendencies, variabilities and shape of the distributions is characteristic of this judge.

1062 T Sociology. Community-Library Relationships. The problem consists of 26 variables, about 1/2 of which are community figures, such as percent in the labor force, and 1/2 of which are library figures, such as per capita circulation. The problem is to find what, if any, relationship exists between these two sets of variables, and which of them are significant.

1063 Civil Engineering. Analysis of Simple Truss. The problem involves the computation of the stresses in each member of statically determinate bridge or building trusses. The program consists of a series of logical decisions to correlate the shape and makeup of the truss with the stresses in the members. This is followed by the evaluation of the expressions giving the stress in the members.

1064 T. Chemistry. Solution of the Secular Equation for Molecular Vibrations. In the study of isotope effects in chemical reactions for molecules of most symmetry classes, the expression for the ratio of the rate constants can be reduced to a function solely of the normal modes of vibration of the reacting specie and the activated complex for both the normal molecules and their isotopically substituted counterparts. To calculate these normal modes, one will follow the so-called Wilson FG matrix method for which the secular equation can be represented as

$$\left| G - F^{-1}\lambda \right| = 0,$$

where G = kinetic energy matrix; F = potential energy matrix.

1065 Electrical Engineering. Non-linear Oscillation. This problem consists of solving a nonlinear differential equation which describes the flow of a viscous liquid in a tube. Such flows arise from consideration of acoustical problems involving second-order effects which are important at high-intensity levels. Although this differential equation can be solved by hand computing-machine operation for a short range of values of the parameters, it is not practical to solve this problem over a wide range of the values of the parameters by hand computing-machine methods. For numerical integration of the differential equation, $u' = \cos\theta - au^2$, a value of θ_0 is chosen such that ua is assumed zero. The next zero of u is determined by a new θ_0 and the integration is repeated until the periodicity is $180^\circ \pm .01^\circ$. The value of u is now printed as a function of θ .

1066 Psychology. A New Rotational Model for Factor Analysis. Schmid and Leiman (Psychometrika, 22:53-63, 1957) have developed a transformation which when applied to an oblique factor analysis solution in several orders, results in a single orthogonal rotated factor matrix. It is believed that the hierarchy of factors revealed by this transformation is particularly appropriate for most psychological

data. The purpose of this research is to use the technique in a series of problems which have been analyzed by other means and make a comparison of the results.

1067 Psychology. The Age Generality of Personality Factors Derived from Ratings, Questionnaires and Objective Tests. This study is designed to assess the generality of personality factors previously obtained in investigations of subjects at four different age levels (4, 6, 11 and young adult) by three different data-gathering procedures (rating, questionnaire, and objective test). Twelve sets of data are to be analyzed by correlating factor loadings on common marker variables within each medium across the various age levels for all possible pairs of studies.

1068 Sociology. Factors in Friendship and in Organizational Loyalties. Intensive interview and questionnaire data have been collected from 60 subjects in a prominent organization. The data include information on close friendships (numbers, dimensions, types) and on organizational activities, loyalties, and beliefs. The study hypothesizes a number of "friendship" factors (Problem 1), a number of "organizational loyalty" factors (Problem 2), and specific relations between these two sets of factors. These hypotheses will be tested.

1069 T Agricultural Economics. Comparison of Returns to Capital Between Areas of High and Low Soil Productivity. Two model farm situations have been selected: one on highly productive soils and one on soils of low productivity. A comparison will be made of the optional farm organizations with various amounts of capital available in each area. The method of linear programming will be used. The models employed will be dynamic in the sense that two production periods are being planned for each situation.

1070 T Psychology. The Perception of Self and Others by Normal and Hospitalized Subjects. One hundred and five normals and fifty-five mental patients were asked to rate themselves, a close friend, another close friend, a nonfriend, another nonfriend, others in general, and the ideal person. They used a rating scale consisting of 24 pairs of items (for example, one of the 24 pairs was: Friendly ____: ____: ____: ____: ____: unfriendly). They also used the same type of scale, using different items, however, to rate themselves, others in general and the

ideal person. The first operation for which the Illiac is needed is to compute the relationship between each rating and every other one by using a "D" statistic. This consists of obtaining the difference (D) between any two ratings (self and other, for example) and then computing the square root of the sum, for the 24 items, of the D's squared. There are $21 \sqrt{\sum D^2}$ that are to be computed for each person on the one scale and three on the other. The next operation for which the computer is to be used is to figure the intercorrelation among the 21 D's of the one scale and three of the other. This involves a total of 213 correlations.

1071 T Electrical Engineering. The Design of an Optimum Linear Coder and Decoder. Given the statistical power spectrum of the signal and the noise (noise power uncorrelated) to design the optimum linear coder and decoder so that the output will be the best rms approximation to the input or to the result of some linear operation on the input (such as the derivative of the input or prediction of the input). The problem is to be solved under the following restrictions: (1) The average signal power from the coder is prescribed. (2) The coder and decoder operators are linear and physically realizable (they are operators operating on the past and not on the future of the input). The method of solution is a modification of the standard methods of the calculus of variations (to take care of physical realizability) which leads to integral equations of the Wiener Hopf type. The solution of these equations for rational spectra leads to definite integrals (of the Poisson type).

1072 Structural Research. Calculation of Charts for the Rapid Evaluation of Structural Damage due to Atomic Blast Type Loadings. The program evaluates the peak pressure of an initially peaked, exponentially decaying force pulse which, acting on a single-degree-of-freedom system, will cause a given response of the system. The resistance is bi-linear. The program solves for the response at two given values of peak pressure and then interpolates for the desired response using Illiac Library Routine H-1. The response is obtained by Newmarks' method of integration and the code for this is similar to that used in Problem Specifications 426, 439, and 630. The results of this research are presented in charts which make possible the rapid evaluation of structural damage due to atomic blast type loadings.

1073 Psychology. Personality Structure in Delinquent Males. A questionnaire of demonstrated effectiveness in differentiating delinquents from non-delinquents has been administered to 240 delinquent male subjects and to 240 matched non-delinquent subjects. Separate factor analyses of each set of data and a statistical match of the two resultant sets of factors is now required for determination of structural aspects of personality in the delinquent and non-delinquent youths.

Table I shows the distribution of machine time for the month of October.

Table I	
	Hrs:Min
Regular Maintenance	36:00
Unscheduled Maintenance	8:26
Drum Engineering	44:53
R.A.R.	5:02
Leapfrog	46:42
Wasted	:00
<u>Use by Departments</u>	
Computer	16:02
Physics	27:47
Control Systems Lab.	109:24
Struct. Res.	116:24
Struct. Res. (AF 24994)	9:41
Psychology	34:40
Psychology (PH 1733)	5:54
College of Medicine	7:42
Electrical Engineering	3:31
Chemistry	21:28
Agriculture	16:32
Theor. and Appl. Mech. (ORD 593 IC)	:05
State Water Survey	10:33
Classes	13:28
Demonstrations	2:11
Miscellaneous	<u>18:16</u>
	556:13

Error Frequency and Analysis

The machine is normally used for "engineering" and maintenance between 7:00 A.M. and 11:00 A.M., and for a check of its performance between 5:30 and 6:00 P.M. of each weekday. Since the periods between 7:00 and 11:00 A.M., together with certain irregular periods like Saturdays and Sundays, are devoted to a heterogeneous group of functions, it is more instructive from an error standpoint to look at the periods between 11:00 A.M. and 7:00 A.M. of the next day in order to make an observation of the error frequency in the machine. This is the actual period when the machine is designated for use. With this in mind, a summary table has been prepared using the period between 11:00 A.M. and 7:00 A.M. of the next day. This table lists the running time when the machine was operating, the amount of time devoted to repairs because of breakdowns, and a number of failures while the machine was listed as running. During the 5:30-6:30 period (when the machine is checked) if no errors are found, the time is given to the "running" column. Each failure was considered to have terminated a running period and was followed by a repair period in preparing this table. Since the leapfrog code is our most significant machine test, the length of time which it has been used on the machine is listed separately together with the number of errors associated with that particular code. This information for the month is presented in Table II.

It is important to notice that any interruption of machine time that was not planned for is considered a failure in this table. In rare cases where the failure is not known until a later time, it is possible that no repair period is associated with the failure. This over-all system has been adopted because it makes it possible for a machine user to estimate directly the probability that the machine will be "running" at any instant of time and the probability of a failure during any given interval of running time.

Table III presents a summary of errors or interruptions for October.

TABLE III

Reader Errors	1
Punch Errors	3
Scope Errors	4
Drum Errors	5
Control Errors	1
Unknown Errors	<u>7</u>
	21

T A B L E II

DATE	RUNNING OK TIME	REPAIR TIME	INTERRUP- TIONS OR FAILURES STOPPING OK TIME	TYPES OF INTERRUPTIONS OR FAILURES CAUSING REPAIR TIME	WASTED	LEAPFROG	FAILURES STOPPING LEAPFROG
10/1/57	20:00	:00	0		:00	:49	0
10/2/57	19:58	:02	2	(1) Drum failure (2) Unknown	:00	:50	0
10/3/57	18:37	1:32	2	(1) Unknown (2) Unknown	:00	:41	0
10/4/57	19:57	:03	3	(1) Unknown (2) Scope error Film jammed (3) Scope error Film jammed	:00	2:01	0
10/7/57	19:59	:01	1	(1) Scope error Film jammed	:00	3:04	0
10/8/57	20:00	:00	0		:00	:40	0
10/9/57	18:07	1:53	2	(1) R ₃ push button bad, replaced (2) Unknown	:00	:56	0
10/10/57	19:59	:01	1	(1) Scope error Film jammed	:00	1:10	0
10/11/57	20:00	:00	0		:00	:47	0
10/14/57	20:00	:00	0		:00	1:20	0
10/15/57	19:20	:40	1	(1) Drum failure	:00	1:44	0
10/16/57	19:10	:50	1	(1) Reader error, wire broken to 1 hole "K"	:00	:46	0
10/17/57	19:59	:01	1	(1) Sprocket hole on tape not punched. Tape came from punch 4 on Illiac Punch Failure	:00	:56	0
10/18/57	19:42	:18	1	(1) Punch error, number 4	:00	1:05	0
10/21/57	20:00	:00	0		:00	1:02	0
10/22/57	20:00	:00	0		:00	1:23	0
10/23/57	20:00	:00	0		:00	:39	0
10/24/57	20:00	:00	0		:00	1:40	0
10/25/57	20:00	:00	0		:00	1:23	0
10/28/57	19:59	:01	1	(1) Unknown	:00	1:08	0

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T A B L E II (Continued)

DATE	RUNNING OK TIME	REPAIR TIME	INTERRUP- TIONS OR FAILURES STOPPING OK TIME	TYPES OF INTERRUPTIONS OR FAILURES CAUSING REPAIR TIME	WASTED	LEAPFROG	FAILURES STOPPING LEAPFROG
10/29/57	19:54	:06	1	(1) Drum failure	:00	1:05	0
10/30/57	19:57	:03	3	(1) Punch error Punch No. 4 (2) Unknown (3) Drum failure	:00	1:20	0
10/31/57	16:15	3:45	1	(1) Drum failure	:00	1:11	0
TOTALS	450:53	9:07	21	.	:00	29:00	0

Reports and Seminars

Seminars

"A Monte Carlo Program for Studying Crystal Statistics", by Dr. L. D. Fosdick, October 1, 1957.

"The Logical Organization of the New Computer", by Dr. D. B. Gillies, October 8, 1957.

"Statistical Study of a Switching Network", by Gene H. Golub, October 15, 1957.

"The Hydrogen Molecule (I)", by Dr. J. N. Snyder, October 22, 1957.

"Kinetic Theory of Gaseous Shock Waves", by Prof. A. T. Nordsieck, October 29, 1957.

Reports

Digital Computer Laboratory Report No. 80, "On the Design of a Very High-Speed Computer", October, 1957.

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