UNIVERSITY OF ILLINOIS
GRADUATE COLLEGE
DIGITAL COMPUTER LABORATORY

TECHNICAL PROGRESS REPORT

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GENERAL LABORATORY INFORMATION

May, 1958

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PART I

HIGH-SPEED COMPUTER PROGRAM

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. Transistor Circuits

During the past month an effort was made to find new designs for EXCLUSIVE OR circuits. Up to now most of the circuits proposed in the literature, and tried by this Laboratory, used an emitter-base crosscoupled arrangement, preceded by restandardizing amplifiers. This gave rise to at least two collector delays, and as a consequence, to long operation times. A new circuit was tried which is based on an entirely different principle. In essence, a difference amplifier is used, modified in such a way that over some small voltage interval both transistors can be on and then conduct approximately equal currents. The latter effect is obtained by inserting between the constant current source and the emitters a resistor of appropriate value.

Figure 1 shows the circuit. Assume that negative logic is used. When both inputs are 0, or if both inputs are 1, the transistors T_1 and T_2 share equally the current from the constant current emitter source. The collector loads are chosen such that under these circumstances, each collector is held at -4 v by the bumping diode. For different inputs--i.e., a (0,1) or (1,0) combination--one or the other of the transistors T_1 and T_2 will be cut off; the other one thus conducts the full current. The (negative) OR circuit, formed by the remaining two collector diodes, therefore, only gives its more negative -1- output when the incoming signals differ. This output goes into a level shifting diode which drives an output emitter follower.

Figure 1
DIFFERENCE-AMPLIFIER EXCLUSIVE-OR

Preliminary tests indicate that about 0.8 v difference can be allowed between nominally equal inputs, and that about 1.2 v difference will be required between nominally different inputs. The resistor values given are only approximate and will be improved after a more careful analysis. No times are available yet, but since only one collector delay is involved, the speed should be approximately that of a NOT circuit.

The design of a flipflop which supplies complementary outputs and has an operation time of about 12 nps to both outputs (one of which is a last moving

point and the other one not) has been completed. The arrangement shown in Figure 2 is simply a modified Schmitt trigger with the complemented output taken from the collector of what is ordinarily the emitter follower. The use of a single output point may be considered either an advantage or a disadvantage, depending on the particular application. The possibility of combining the circuit with an AND-OR diode gate driven by a simplified inverter is being investigated.

Figure 2

SCHMITT TRIGGER WITH COMPLEMENTED OUTPUTS

Diodes: D1 → Q5-250
D2 → Q10-600

Resistors: Tolerance, $\pm 3\%$
1/2 watt unless otherwise specified

Power Supplies: Tolerance, $\pm 3\%$ on voltages

Transistors: GF-45011; $0.93 \leq \alpha_{DC} \leq 1.0$

Operation Time: 11 to 12 μs , average

The high-speed tester for transistors has been put into use, and the first modifications have been made. It is used currently for the testing of all incoming Western Electric transistors. A four-bit (eight-flipflop) shifting register using breadboard layout has been completed. The speed being limited by the shifting oscillator, no speed conclusions can be drawn, but a comparison of reliabilities can be made with respect to the older plug-in unit register.

(N. Johnson, Sylvian Ray and N. Wiseman)

2. Control Studies

A method of allowing the program to be interrupted automatically is being planned. This facility is especially useful for code-checking, sequencing the operation of input-output and auxiliary storage devices, and sensing conditions which happen so rarely that continual programmed testing would be wasteful of time. Frequent operations, such as the storage of words during block transfers between the core memory and drum or magnetic tape units, should not use the program-interrupt facility since too much core memory time would be used up. Therefore, the program-interrupt method should be flexible and economical, even if somewhat slow. Except for one or two panel switches, the programmer should have complete control over the conditions which he chooses to cause an interruption. In practice, library subroutines to take remedial steps in case of impurity in block transfers, and to assist in code checking, would probably be used by almost all programmers. Also, when the programmer elects that a certain condition should not cause interruption, he should be able to test for that condition.

(W. Gear, D. Gillies and R. Farrell)

3. Test Equipment

Two 20-transistor 100 mw transistor testers were designed and put into operation. These devices subject the transistors under test to 10 ma (at $V_{cb} = 10$ v) while taking a measure of the largest V_{eb} fwd. of the group. When this measure exceeds a preset value, a flipflop is set and an alarm buzz is given.

To provide control over diode and transistor forward drop measurements, it was found necessary to acquire better low voltage measuring equipment. A 40,000 ohm/volt meter was constructed and calibrated from a secondary standard. It is accurate to within ± 4 mv at a reading of 0.4 volt.

(K. Smith)

4. Arithmetic Unit

A logical circuit was designed which forms $Y = 3X$ where X and Y are binary numbers with digits x_i and y_i . This circuit is simpler than the obvious solution of adding X to $2X$.

The performance of a representative stage of this circuit is described by the table below, in which c_{i-1} and k_{i-1} are carries from stage i to the next more significant stage ($i-1$).

Variable	x_i	c_i	k_i	y_i	c_{i-1}	k_{i-1}
Weight	+3	+1	+1	+1	+2	+2
(0)	0	0	0	0	0	0
(1)	0	0	1	1	0	0
(2)	0	1	0	1	0	0
(3)	0	1	1	0	0	1
(4)	1	0	0	1	0	1
(5)	1	0	1	0	1	1
(6)	1	1	0	0	1	1
(7)	1	1	1	1	1	1

Since the outgoing carries have equal weight, several assignments are possible for cases (3) and (4). However, only the one shown and the one for which the roles of c_{i-1} and k_{i-1} are interchanged lead to redundant conditions. For the assignment shown above, the situation $c_{i-1} = 1$, $k_{i-1} = 0$ never occurs in the output. Since these outputs are the inputs to the next stage, the corresponding situation never occurs at the inputs. Since, furthermore, both carries into the least significant stage are 0, states (2) and (6) are redundant.

The simplified output functions are, then:

$$y_i = x_i \oplus \bar{c}_i k_i$$

$$c_{i-1} = x_i k_i$$

$$k_{i-1} = x_i \vee c_i$$

The equivalent of the tripling circuit is required for the realization of the base 4 division method described in Report No. 82.

(G. Metze)

5. Input-Output and Auxiliary Storage

In the April report, mention was made of a possible method of increasing the pulse packing density on magnetic tape by using several clock channels in place of the usual single clock channel. An essential assumption was that tape skew and related effects were in fact limiting factors in holding packing densities down to the low levels now commonly used. Some reassurance on this point appeared in the April 1958 IBM Journal of Research and Development, in which R. A. Skov¹ described an increase in packing density made possible by partial elimination of some of the mechanical causes of tape skew and flutter.

An estimate of the complexity of the extra circuitry required by multi-clock playback can be obtained from the diagram of the necessary circuit logic. Such a diagram is in preparation and will be described in a separate report. It appears that the equivalent of approximately 450 extra diodes, plus about 70 flip-flops, would be required to resynchronize sixteen information channels on the basis of four information channels to one clock channel.

(R. Cummins)

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1. Skov, R. A., Pulse-Time Displacement in High-Density Magnetic Tape, IBM Journal of Research and Development, V2, N2, April, 1958.

PART II

MATHEMATICAL METHODS

1. Iterative Methods for Solving Systems of Linear Equations. (Supported in part by the Office of Naval Research Under Contract N6ori-07130)

The iterative method described in the February 1958 Technical Progress Report involves the equations

$$\gamma_1 = G \gamma_0$$

$$\gamma_{k+1} = 2b_{k+1} (G \gamma_k + Hy - \gamma_{k-1}) + \gamma_{k-1}$$

$$b_{k+1} = \frac{1}{2 - \mu^2 b_k}$$

$$b_1 = 1$$

and μ a number such that

$$\mu^2 \geq \max_{|x| \neq 0} \frac{x' G G x}{x' x} \quad \text{Within a computer}$$

these equations are replaced by

$$\bar{\gamma}_1 = \bar{G} \times \bar{\gamma}_0$$

$$\bar{\gamma}_{k+1} = 2\bar{b}_{k+1} \times (\bar{G} \times \bar{\gamma}_k + \overline{(Hy)} \div \bar{\gamma}_{k-1}) + \bar{\gamma}_{k-1}$$

$$\bar{b}_{k+1} = -\frac{1}{2} \div (-1 + \frac{\mu^2}{2} \times \bar{b}_k)$$

where the bars indicate digital numbers, and the pseudo-multiplication and pseudo-division are indicated by $\times$ and $\div$, respectively.

A difference equation for the quantity $\bar{\gamma}_k - \gamma_k$ has been derived and solved. The solution will be used to determine the effect of round-off on the accuracy of the solution and on the rate of convergence.

(G. Golub)

2. Hydrodynamic Flows With Shocks (Supported in part by the National Science Foundation under Grant G-2794)

The computationally simplest integration formula for the equations of hydrodynamics is that of P. D. Lax. However, this formula has the disadvantage that it uses a "staggered" lattice, i.e., if the lattice points are $x = k\Delta x$ ($k = 0, 1, \dots$) at $t = n\Delta t$, then they are $x = (k + 1/2)\Delta x$ at $t = (n+1)\Delta t$.

On the other hand, the direct replacement of derivatives by differences on a rectangular lattice leads to an unstable formula:

$$\rho_k^{n+1} = \rho_k^n + \frac{1}{2} r (\rho_{k-1}^n u_{k-1}^n - \rho_{k+1}^n u_{k+1}^n)$$

$$\rho_k^{n+1} u_k^{n+1} = \rho_k^n u_k^n + \frac{1}{2} r [(\rho_{k-1}^n u_{k-1}^{n2} + p_{k-1}^n) - (\rho_{k+1}^n u_{k+1}^{n2} + p_{k+1}^n)]$$

$$\rho_k^{n+1} E_k^{n+1} = \rho_k^n E_k^n + \frac{1}{2} r [(\rho_{k-1}^n u_{k-1}^n E_{k-1}^n + p_{k-1}^n u_{k-1}^n) - (\rho_{k+1}^n u_{k+1}^n E_{k+1}^n + p_{k+1}^n u_{k+1}^n)]$$

where $p_k^n = p(\rho_k^n, E_k^n + \frac{1}{2} u_k^{n2})$. However, it has been found that a slight modification of this formula results in a stable formula. The modification is to replace ρ_k^n , $\rho_k^n u_k^n$, and $\rho_k^n E_k^n$ in the right hand sides of the first, second and third equations, respectively, by $\theta \rho_{k-1}^n + (1-2\theta) \rho_k^n + \theta \rho_{k+1}^n$, $\theta \rho_{k-1}^n u_{k-1}^n + (1-2\theta) \rho_k^n u_k^n + \theta \rho_{k+1}^n u_{k+1}^n$, and $\theta \rho_{k-1}^n E_{k-1}^n + (1-2\theta) \rho_k^n E_k^n + \theta \rho_{k+1}^n E_{k+1}^n$. The modified system is stable for

$$\frac{1}{2} r^2 v_\mu^2 \leq \theta \leq \frac{1}{2}$$

where $v_\mu = |u_0| + a_0$, $a_0 = \sqrt{\gamma(2-1)(E_0 - \frac{1}{2} u_0^2)}$ is the sound speed,

Since this system is stable for a range of values of the parameter θ , θ can be chosen in an optimal fashion to satisfy some other criterion, e.g., representation of shock profiles. The shock width $2\sigma_n$ is found to be given by

$$\sigma_n^2 = n(2\theta - r^2 v_0^2) (\Delta x)^2$$

where v_0 is the shock speed. This formula, however, is only valid if ρ_k^n is a monotonic function of k , which it is not, in particular, for $\theta = \frac{1}{2} r^2 v_0^2$.

(C. Farrington)

3. Determination of Flows Behind Shocks (Supported in part by the National Science Foundation under Grant G-2794)

Calculations are continuing on the flow behind the shock described in the April Technical Progress Report, the shock with the essential singularity whose inclination is given by the equation

$$\begin{aligned}\alpha(S) &= \alpha_0 & 0 \leq S \leq S_* \\ \alpha(S) &= \alpha_0 + K(S-S_*)^{1/2} & S_* \leq S \leq 2S_*\end{aligned}$$

The streak lines behind the shock are being determined by solving the equations

$$\frac{\partial a_1}{\partial T}(S, T) = \cos \xi_2 \quad \frac{\partial a_2(S, T)}{\partial T} = \sin \xi_2$$

The function $\xi_2(S, T)$ is determined from the integration of the flow equations.

These results will be used to calculate the isopycnal contours $\rho = \text{constant}$ which will be compared to experimental interferograms of Mach reflections.

(Y. Chow)

4. Relativistic Field Equations (Supported in part by the National Science Foundation under Grant G-2794)

For a spherically symmetric space time, the line element may be written as

$$ds^2 = e^{2\varphi} dt^2 - \frac{1}{c^2} (e^{2\chi} dr^2 + r^2 d\theta^2 + r^2 \sin^2 \theta d\varphi^2).$$

In this coordinate system the Einstein field equations are

$$R^\mu_\nu - \frac{1}{2} \delta^\mu_\nu R = -kc^2 T^\mu_\nu$$

where

$$k = \frac{8\pi G}{c^2},$$

G is the Newtonian gravitational constant; c is the velocity of light; T^μ_ν is the stress energy tensor; R^μ_ν the Ricci tensor and R is the scalar curvature.

When the line element is static, that is, φ and χ depend on r alone, these equations reduce to the following system of ordinary differential equations:

$$\frac{c^2}{r^2} - c^2 e^{-2\chi} \left[\frac{1}{r} \left(\frac{1}{r} + 2 \varphi_r \right) \right] = + k c^2 T_1^1$$

$$\frac{c^2}{r^2} - c^2 e^{-2\chi} \left[\frac{1}{r} \left(\frac{1}{r} - 2\chi_r \right) \right] = k c^2 T_4^4$$

$$(T_1^1)_r - \varphi_r (T_4^4 - T_1^1) = 0$$

where the subscript r denotes the derivative with respect to r.

For a perfect gas

$$T_{\nu}^{\mu} = \sigma u^{\mu} u_{\nu} - \frac{p}{c^2} \delta_{\nu}^{\mu} \quad \text{and}$$

$$\sigma = \rho \left(1 + \frac{\epsilon}{c^2} + \frac{p}{\rho c^2} \right)$$

where p is the pressure, ρ is the density and $\epsilon = \epsilon(p, \rho)$ is the caloric equation of state of the gas.

If we make the transformation

$$e^{-2\chi} = 1 - \frac{2Gm(r)}{c^2 r}$$

the field equations may be written in the following dimensionless form

$$\varphi_R = \frac{u_c}{R^2} \frac{(M + u_c P R^3)}{1 - \frac{u_c M}{R}}$$

$$M_R = t \left(1 + \frac{\epsilon}{c^2} \right) R^2$$

$$P_R = -t \left(1 + \frac{\epsilon}{c^2} + U_c \frac{P}{t} \right) \varphi_R$$

where u_c is given by $u_c = \frac{kT_c}{\mu H c^2}$, T_c being a temperature, k Boltzmann's constant and μH the mass of a molecule making up the gas,

$$\rho = \rho_c t$$

ρ_c being a constant of the dimensions of a density, $p = p_c P$

with

$$p_c = u_c \rho_c c^2$$

and

$$R = \alpha r$$

$$\alpha^2 = \frac{c^2 u_c}{4\pi \rho_c G}$$

$$M = \frac{GM}{\alpha c^2 u_c}$$

These equations are being integrated to find P and M as functions of u_c for various caloric equations of state where further it is assumed that the entropy of the gas is everywhere the same. The latter condition enables one to express t and ϵ as functions of P.

(H. Mimm)

4. Program Library (Supported by the Office of Naval Research under contract N6ori-07130).

P 18 Output for the Data Plotter. This subroutine enables the user to plot a series of points with the off-line data plotter. A tape is punched by Illiac which may either be read by the data plotter to plot points, or printed in tabular form if read by the standard printer.

(W. Gear)

SWITCHING CIRCUIT THEORY

A new system has been devised for controlling the gate drivers and other signals which sequence the operations of a computer. One must assume that the correct sequencing of the gates has been described by a change chart showing a chronological ordering of the gates but allowing the possibility of concurrent operation. The present system provides a rule for substituting logical elements for the symbols in the change chart in such a way that the desired sequencing is achieved.

The diagram shows two identical logic structures side-by-side. Each structure starts with an input line that splits into two paths. The top path goes through an OR gate to a box labeled DRIVER 1 (or DRIVER 2). The bottom path goes through an inverter (labeled $\bar{c}$) to the same output box. The output of each driver box then splits again into two paths. One path goes through an OR gate to a common output line. The other path goes through an inverter (labeled $\bar{c}$) to the same common output line. This configuration suggests a bus or arbitration system where multiple drivers can communicate through OR gates and inverters.

Drivers are assumed to invert the signal and the sequencing circuit will cause driver 1 to gate first, followed by the gating of driver 2. In the quiescent condition, all OR and $\bar{C}$ elements produce the output "1". A "1" arriving at the top input to the first $\bar{C}$ element will initiate the gating.

If driver 1 is to initiate the concurrent gating of drivers 2 and 3, we use the circuit shown in Figure 2.

Figure 2

By simple analogy, we may extend the above system to include more than two concurrent gates.

If drivers 1 and 2 are both required to precede driver 3, the circuit shown in Figure 3 may be used.

Figure 3

Again, we may extend the system to more than two drivers preceding 3 by simple analogy.

If the same gate is to be used in more than one point in a change chart, we may form a circuit of the type shown in Figure 4 connecting the independent portions in the same manner as before.

Figure 4

Again, we may extend the circuit to a more general case.

The above design techniques have been checked for speed independence by use of the Illiac. If a cycle containing only two gates occurs in the change chart, however, the $\bar{C}$ elements must be replaced by OR NOT elements in order to ensure correct sequencing.

This system has the additional advantage that conditional causations in the change chart may be realized quite easily since such conditions (for example, conditions derived from a decoded instruction) may be inserted directly into the OR elements preceding the affected gate drivers.

PART IV

ILLIAC USE AND OPERATION - GENERAL LABORATORY INFORMATION

Machine Use

During May, specifications were presented for 11 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 1150.

1150 T Psychology. Parental Attitudes Affecting Over- and Under-achievement. This problem involves the analysis of the attitudes of parents of fifth grade students who have been pre-selected according to whether they are over-achievers or under-achievers in school. A number of previous studies have indicated that the degree to which a child utilizes his intellectual ability in the schoolroom is critically dependent on attitudes held by his parents. This study seeks to clarify the nature of these attitudes. The first step in the analysis involves a factor analysis of 72 rating scales by which the parents describe themselves, their spouses, and their children. A centroid factor analysis, and quartimax rotation will be used for this analysis. The next step will be the computation of factor scores for the various self-other descriptions. Finally the D-statistic will be computed for a few selected self-other descriptions.

1151 Computer. Print for Data Plotter. A library subroutine is to be prepared which will simplify the use of the data plotter.

1152 T Electrical Engineering. Theoretical Solutions for Spiral Antennas. Illiac will be used for the numerical evaluation of expressions for the far fields and the arm currents of the equiangular spiral antenna.

1153 T Electrical Engineering. Diffraction Pattern of a Number of Ribbons of Finite Width. The solution for a ribbon in presence of a unit strength filament source is obtained as a function involving Mathieu functions in elliptic cylindrical coordinates. The integrated effect of one ribbon in the presence of the other is obtained by integrating this over the whole width of the strip, i.e. if π_3 is the

solution then the actual result is given by

$$A = \int_{\text{strip}} \pi_3 I \, dz$$

The integration has to be performed numerically by the computer, but before the integration can be taken up, it is necessary to obtain the eigenvalues and eigenfunctions for Mathieu equations of given arguments which can be evaluated from a continued fraction expression and the recursion formula.

1154 T Structural Research. Computation of Elastic Moment Coefficients in a Reinforced Concrete Box Culvert. By means of a modified moment distribution method, equations have been obtained for computing the elastic moment coefficients in a reinforced concrete box culvert, taking into account the actual thicknesses of the members, assuming the corners to be infinitely stiff.

1155 T Theoretical and Applied Mathematics. Moving Mass on String. This program evaluates a series expression, giving the motion of a mass on a string.

1156 Sociology and Anthropology. Academicians' Conception of Academic Disciplines. In a preliminary study of conceptions of academic fields of endeavor, responses on 18 semantic differential scales for each of 6 selected academic disciplines have been obtained from 160 University of Illinois faculty members. As a part of the analysis of results, a factor analysis will be made of responses for each of the six disciplines.

1157 T Animal Science. Nitrogen Utilization by Sheep. A study has been made of the utilization of non-protein nitrogen (urea) as opposed to N utilization from soybean oil meal and N in dried activated sewage sludge. The utilization of these various sources of N is measured in terms of growth and feed efficiency with lambs.

1158 Civil Engineering and Theoretical and Applied Mathematics. Large Deflections of Circular Plates. The governing differential equations for large deflections of symmetrically-loaded circular plates are non-linear equations which have been solved rigorously for only a few special types of loading and boundary conditions. A

procedure has been devised which will yield solutions for any types of loading and boundary conditions. The governing differential equations are solved by the method of infinite series. Substitution of these assumed series with unknown coefficients V_j, U_j , into the differential equations yields two recurrence relationships of the following form:

$$V_{n+2} = -\frac{2n}{n+2} V_{n+1} - \frac{n(n-1)}{(n+1)(n+2)} V_n - \frac{J}{(n+1)(n+2)} \sum_{i=0}^n U_i U_{n-i}, \quad n=0,1,2,\dots$$

$$U_{n+2} = \frac{-2n}{n+2} U_{n+1} - \frac{n(n-1)}{(n+1)(n+2)} U_n + \frac{1}{(n+1)(n+2)} \sum_{i=0}^n V_i U_{n-i}, \quad n=0,1,2,\dots$$

These recurrence relationships, together with the boundary conditions, form a system of transcendental equations, the solution of which permits the evaluation of the unknown coefficients in the series. The solution of these transcendental equations can be found on Illiac using an iterative procedure.

1159 T Finance. Factors Affecting Equity Financing. The problem is to determine the important factors which have affected equity financing of large American business corporations from 1946 to 1956. Multiple correlation will be found.

1160 Physics. Motion of a Particle in a Periodic. It is proposed to study systematically the solution of the non-linear differential equation

$$\frac{d^2 x}{dt^2} + U(t) \alpha x^3 = 0,$$

where α is a constant, and $U(t)$ the periodic function:

Of particular interest is the study of the solution of the equation around the singular points, and the investigation of the possibility of "islands" in the phase plane. The numerical integration of the equation will be carried out using the Runge-Kutta method (Library Routine F1).

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

TABLE I

	Hrs:Min
Regular Maintenance	32:54
Unscheduled Maintenance	5:24
Drum Engineering	41:48
R.A.R.	7:47
Leapfrog	41:21
Wasted	:00

Use by Departments

Computer	34:27
Physics	40:32
Control Systems Lab.	83:50
Structural Research	46:22
Struct. Res. (AF 464)	21:30
Theor. and Ap. Mech. (ORD 593 IC)	1:40
Psychology	15:08
Psychology (I.D.P.W. 44-32-66-312)	:57
Psychology (U.S.P.H. 1774)	:10
Psychology (U.S.P.H. M1733)	1:20
Electrical Engineering	6:23
Elect. Eng. (NOBSR 64723)	2:36
Elect. Eng. (SC 74898)	2:59
Elect. Eng. (Boeing Aircraft)	6:00
Chemistry	30:00
Agriculture	15:01
Mech. Eng. (CONVAIR)	:12
State Water Survey	3:52
Inst. of Com. Res. (9067 C)	:14
Michigan State University	2:58
University of Utah (Psychology)	4:39
U. S. Navy (Personnel Research)	:28
Classes	41:09
Demonstrations	:30
Miscellaneous	22:34
	514:45

Error Frequency and Analysis

The machine is normally used for "engineering" and maintenance between 7 a.m. and 11 a.m., and for a check of its performance between 5:30 p.m. and 6:30 p.m. of each weekday. Since the periods between 7 a.m. and 11 a.m., together with certain irregular periods, such as 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 a.m. and 7 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 a.m. and 7 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 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 May.

TABLE III

Memory	2
Reader	1
Control	4
Drum	5
Unknown	3
Input-Output	1
Scope	<u>3</u>
Total	19

TABLE 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
5/1/58	19:59	:01	1	(1) Input-Output automatic swith inoperable	0	:40	0
5/2/58	19:32	:28	2	(1) Drum failure (2) Unknown	0	:38	0
5/5/58	19:26	:34	2	(1) Drum failure (2) Memory failure 2^{-4} $0 \rightarrow 1$	0	:40	0
5/6/58	19:11	:49	2	(1) Intermittent filament in memory control chassis V-21 (2) Further manifestations of above difficulty	0	:57	0
5/7/58	17:43	2:17	5	(1) Further manifestations of above difficulty (2) Further manifestations of above difficulty (3) Drum failure (4) Unknown (5) Scope would not advance	0	1:36	0
5/8/58	20:00	:00	0		0	:39	0
5/9/58	20:00	:00	0		0	:46	0
5/12/58	19:59	:01	1	(1) Scope error	0	:43	0
5/13/58	19:53	:07	1	(2) Film advance not working in scope	0	1:08	0
5/14/58	20:00	:00	0		0	1:10	0
5/15/58	20:00	:00	0		0	1:13	0
5/16/58	20:00	:00	0		0	1:02	0
5/19/58	20:00	:00	0		0	1:35	0
5/20/58	20:00	:00	0		0	:40	0
5/21/58	19:01	:59	2	(1) Drum failure (2) Leapfrog memory error 2^{-4} $0 \rightarrow 1$	0	3:25	1

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
5/22/58	19:58	:02	2	(1) Light on reader "K" burned out (2) Unknown	0	1:00	0
5/23/58	20:00	:00	0		0	1:01	0
5/26/58	20:00	:00	0		0	:42	0
5/27/58	20:00	:00	0		0	:50	0
5/28/58	18:56	1:04	1	(1) Drum failure	0	:44	0
5/29/58	20:00	:00	0		0	:40	0
TOTALS	413:38	6:22	19		0	21:49	1

Reports and Seminars

Seminars

"Minimization of a Function of N Variables", by Professor D. B. Gillies, May 6, 1958.

"Continued Fractions and Their Use in Numerical Analysis", by Jack Goldberg, May 13, 1958.

"Some Remarks About 'Asynchronous' vs. 'Speed-Independent' Circuit Designs", by Dr. G. Metze, May 20, 1958.

"The Choice of Step Size in Runge-Kutta Type Integration Routines", by C. W. Gear, May 27, 1958.

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