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October, November, December 1968

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DEPARTMENT OF COMPUTER SCIENCE
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN · URBANA, ILLINOIS

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1. CIRCUIT RESEARCH PROGRAM

(Supported in part by the Office of Naval Research under Contract NR 048-102/6-15-67 Code437, W. J. Poppelbaum, Principal Investigator).

Summary

John Esch has designed a general purpose computing "element" for the Stochastic Computing project. Under digital control it can generate any of the functions: a , b , a^2 , b^2 , $a + b$, $a - b$, $a \times b$, a/b , and is based on design equations described in an earlier report.

Potentiomatrix has been completed and its perpetrator, Bill Steiner, has departed, certificate in hand, for the fleshpots of Lockheed, Georgia. His summary is based on the more detailed, forthcoming D.C.S. Report No. 307.

Finally, David Ring discusses a number representation that might be useful to the work on Bundle Processing.

M. Faiman

1.1 Stochastic Computing (Project No. 03)

1.1.1 Design of a General Computing Element

In the Quarterly Technical Progress Report for January - March 1968, section 1.2.4, page 8, equations were derived for performing addition, subtraction, multiplication and division on CRPS's, using the two-wire ratio representation. For convenience, we summarize the results of that derivation.

A rational number, a ($|a| < 1$), is encoded into two CRPS's, A_n and A_d , representing numerator and denominator, respectively. Z_1 and Z_2 are two independent (statistically uncorrelated) representations of zero. Table 1 describes the required operations.

	Numerator	Denominator
Product	$P_n = A_n \oplus B_n$	$P_d = A_d \oplus B_d$
Quotient	$Q_n = A_n \oplus B_d$	$Q_d = A_d \oplus B_n$
Sum	$S_n = Q_n Z_1 \vee Q_d \bar{Z}_1$	$S_d = P_d Z_1 \vee Z_2 \bar{Z}_1$
Difference	$D_n = Q_n Z_1 \vee \bar{Q}_d \bar{Z}_1$	$D_d = S_d$

Table 1. Formulas for Arithmetic Operations

We require a stochastic computing element, having two CRPS inputs representing the numbers a and b , say, and three digital, controlling signals F , O and I , which generates a result, r , according to Table 2.

F O I	r
0 0 0	a
0 0 1	b
0 1 0	a^2
0 1 1	b^2
1 0 0	$a + b$
1 0 1	$a - b$
1 1 0	$a \times b$
1 1 1	a / b

Table 2. Coding for Stochastic Computing Element.

If the result is encoded into the two CRPS's R_ϵ , where $\epsilon = n, d$, then evidently.

$$R_\epsilon = \overline{FO}U_\epsilon \vee \overline{FO}U_\epsilon^2 \vee \overline{FO} +_\epsilon \vee \overline{FO} x_\epsilon \quad (1)$$

and the intermediate Boolean functions U_ϵ , U_ϵ^2 , $+_\epsilon$ and x_ϵ are given by

$$U_\epsilon = \overline{IA}_\epsilon \vee IB_\epsilon \quad (2)$$

$$U_\epsilon^2 = U_\epsilon \oplus \Delta U_\epsilon \quad (3)$$

$$+_n = \overline{Z}_1(I \oplus Q_d) \vee Z_1Q_n \quad (4)$$

$$+_d = \overline{Z}_1Z_2 \vee Z_1P_d \quad (5)$$

$$x_\epsilon = \overline{IP}_\epsilon \vee IQ_\epsilon \quad (6)$$

In equation (3), ΔU_ϵ denotes a delayed version of U_ϵ . A network to realize R_n and R_d is shown in Figure 1.

John Esch

Figure 1. Logic of General Stochastic Computing Element.

1.2 Potentiomatrix (Project No. 08)

1.2.1 Introduction

Potentiomatrix is an electronic system utilizing hybrid digital-analog circuitry for displaying an arbitrary family of equipotential lines. It uses the principle that certain areas clamped to fixed voltages in an infinite conducting plane give rise to a family of equipotential lines which are governed by the two dimensional Laplace's differential equation with appropriate boundary conditions.

It is somewhat helpful to think of the Potentiomatrix panel as representing a section of a grid of resistors which imitates the behavior of an infinite conducting plane. The panel lamps then represent nodes in the grid where four resistors are connected. Each of the 32×32 (1024) nodes in the central portion of the grid is connected to a pair of electronic circuits which are in turn connected respectively to a lamp in the panel and to a metal lamp socket which appears on the panel as a conducting ring around the lamp.

The circuits which are connected to the conducting rings through their inputs are the write circuits and they are used to clamp the appropriate nodes to the proper voltage values ($+10 = V_{B1}$, $-10v = V_{B2}$). The use of the write circuits corresponds to applying boundary conditions to Laplace's differential equation. Touching the brush pen to the conducting ring applies $+10v$ (through 510 ohms) to the input of the write circuit which applies V_{B1} or V_{B2} to the node in the grid. Touching 0v, which corresponds to a selective erase, resets the circuit and allows the node to float. In addition to these individual controls, there are two common busses, R+ and R-, which perform master erase functions by

resetting all of the write circuits.

The circuits whose outputs are connected to the lamps are the detector circuits and they are used to compare the voltages at their nodes in the grid with a common reference signal, V_S , which goes to all the detector circuits. If a node voltage is equal to the reference, V_S , within a preset tolerance E , the detector circuit, in conjunction with a clocking signal G , gates on the lamp for that node. It is evident that the lamps correspond to nodes in the grid which are each approximately at the value of the reference voltage, V_S , and therefore display an equipotential line.

The reference voltage, V_S , takes on successively the analog values V_{B1} , V_{B2} , V_{F1} , V_{F2} , V_{F3} , V_{F4} and V_{F5} . This is pictured in Figure 1. V_{B1} and V_{B2} are the voltage levels ($\pm 10v$) which generate the equipotential lines corresponding to the boundary conditions, and V_{F1} through V_{F4} are arbitrary voltage levels between V_{B1} and V_{B2} which are selected by the operator and which correspond to four intermediate members of the equipotential family. V_{F5} has a slightly different effect, which will be discussed in the next section. As the reference voltage, V_S , proceeds through its seven values, the lamps remain on so that each new equipotential line is displayed along with the old ones. After the seven lines have been displayed for a short time, a buss signal R resets all of the detector circuits, thereby turning the lamps off, and the cycle repeats.

Figure 1. Functional Diagram of Potentiomatrix

1.2.2 Ramp Circuit

In order to add motion to the Potentiomatrix display, a ramp generator has been added to the control circuitry in conjunction with V_{F5} . This circuitry allows the operator to place a time varying voltage as one analog value on the reference voltage, V_S , which has the effect of dynamically sweeping through any desired set of equipotentials on the display.

The circuit, shown in Figure 2, consists essentially of a uni-junction relaxation oscillator and two amplifiers for increasing the signal amplitude and drive. The three potentiometers, 500K, 50K, and 5K adjust the frequency, amplitude, and d.c. level of the signal respectively. The period of the signal is typically between .5 seconds and 2.5 seconds.

The output of this circuit is joined in an "or" circuit with the wiper on the F5 control potentiometer. Since an "or" circuit for analog signals selects the maximum of its input signals, the output of the ramp circuit can be controlled by the operator with the F5 potentiometer.

1.2.3 Boundary Conditions for Common Shapes

The usefulness of the Potentiomatrix system depends on the ease with which the shape of curved lines may be transmitted. Although no attempt is made to catalog a complete set of curves, a few of the more obvious ones must be listed so that the simplicity behind this technique becomes evident. In order to demonstrate the simple conditions needed to specify a desired curve, the complete set of conic sections is considered in these examples. The available voltages to which points in the conductive sheet may be fixed are V_{B1} , a positive boundary voltage, and V_{B2} , a negative boundary voltage of the same

Figure 2. Ramp Circuit

magnitude as V_{B1} . The curves generated by these arbitrary boundary voltages and the fixed boundary voltage at infinity are formed as equipotential lines in a conductive plane and are governed by Laplace's two-dimensional differential equation. Figure 3 accompanies the following examples.

(a) Circle

Circles are generated by a single boundary point at V_{B1} . Using this input point as a center, concentric circles of all radii are formed for voltages between V_{B1} and ground.

Circles are also generated by two separate boundary points, one at V_{B1} , and the other at V_{B2} . In this case, the circles are not concentric and are formed for voltages between V_{B1} and V_{B2} .

Circles are generated in still a third way by a straight line at V_{B1} and a non-colinear point at V_{B2} . In this case, the point forms an electrostatic image on the other side of the line. The circles are not concentric but are formed for voltages between V_{B1} and V_{B2} .

(b) Straight Line

A straight line is generated by two separate boundary points, one at V_{B1} , the other at V_{B2} . The straight line is the perpendicular bisector of a line segment joining the two boundary points and is formed at ground potential.

Straight lines are also generated by two parallel straight lines, one at V_{B1} , the other at V_{B2} . The straight lines are parallel to the boundary lines and are formed for voltages between V_{B1} and V_{B2} .

(c) Ellipse

Ellipses are generated by a straight line segment at V_{B1} . Using the end points of the line segment as foci, ellipses are formed for

Figure 3. Boundary Conditions for Conic Sections

voltages between V_{B1} and ground.

(d) Hyperbola

Hyperbolas are generated by a pair of semi-infinite colinear lines, one at V_{B1} , the other at V_{B2} . Using the end points of the lines as foci, hyperbolas are formed for voltages between V_{B1} and V_{B2} .

Hyperbolas are also generated by a straight line at V_{B1} and a semi-infinite non-intersecting perpendicular line at V_{B2} . In this case an electrostatic image is formed on the other side of the V_{B1} line. Hyperbolas are formed for voltages between V_{B1} and V_{B2} .

(e) Parabola

Parabolas are generated by a single semi-infinite straight line at V_{B1} . Using the end point of the line as the focus, parabolas are formed for voltages between V_{B1} and ground.

Bill Steiner

1.3 Large Screen TV Display (Project No. 09)

1.3.1 The Problem of Modulation and Deflection

Investigations are being made to determine the most suitable techniques for modulating and deflecting a light beam to be used for a large screen display. Three types of modulator have been studied so far, based respectively on interference, the Kerr/Pockels electro-optic effects and acousto-optic modulation. The last appears to be the most promising in terms of power consumption, reliability and cost.

The deflection problem is more critical since it involves questions of synchronization, resolution and linearity. A mechanical solution for the relatively slow vertical scan rate may be attractive, but a mechanism for the 15.75 kHz horizontal sweep has yet to be found.

M. N. Cooper

1.4 Bundle Processing (Project No. 21)

1.4.1 Number Representation

A two - bundle representation of rational numbers is being investigated, described by equations which are essentially similar to those of Table 1 in section 1.1.1 of this report. Not yet solved, however, is the "addition - attrition" problem in which successive additions cause the average number of active wires to be drastically reduced.

David Ring

2. HARDWARE SYSTEMS RESEARCH

(Supported in part by the Atomic Energy Commission under Contract US AEC AT (11-1) 1949, W. J. Poppelbaum, Principal Investigator.)

Summary

David Casasent, Doug Sand and Al Irwin describe resolution tests and equipment modifications on OLFT. Full details of the variable scan rate feature of VISTA and of the vidicon circuitry are given by David Rollenhagen. In Functional Encoding, Peter Oberbeck and Ed Carr write about solutions to the horizontal line problem and testing of the fast A/D converter. A block diagram of Transformatrix with an account of how it will perform a parallel, two dimensional Fourier Transform on random pulse sequences, as well as details of the system's input mechanisms, come from Larry Ryan, Orin Marvel and Yiu Wo. Larry Wallman discusses a fundamental change in the design of the lenticular screen for the 3D Television project. Finally, the status of the system design for Stereomatrix is reported on by Shiv Verma and Richard Cheng.

M. Faiman

2.1 OLFT (Project No. 12)

2.1.1 Pattern Resolution

A first - order perturbation analysis of the light - valve modulation characteristics has been completed and will be issued as Report No. 303. One of the results of this analysis indicates that pattern resolution should be rotationally anisotropic (relative to the polarization of the incident light). Thus, for example, if a bar pattern is written on the crystal, the visible intensity or contrast of the resulting picture is dependent on the direction of the bars. This result is a consequence of the biaxial characteristics of the linear electro-optic effect in $\bar{4}2m$ crystals.

This first - order approximation indicates that the resolution anisotropy should be significant in "strength", suggesting that the resolution in two dimensions might be considerably improved by electronic "pre-emphasis" (simple high-pass filtering) along one dimension only.

To verify this theoretical analysis we have proposed a series of resolution tests using several available crystals. The selected pattern is a television raster containing uniformly spaced vertical bars. This pattern is not ideal but is simple to generate and easy to control and measure. The bars are square waves of variable spacing and are generated by a binary count-down from an astable multivibrator gated by the horizontal blanking pulse of the raster. The result is a pattern of constant "density" over all spatial frequencies, which is superior to the variable density of the traditional "shrinking-raster" method. To determine the angular variation in resolution, the pattern will be rotated by simply rotating the deflection coils around the electron gun.

The circuit which generates the bar pattern is shown in Figures 1 and 2. The gated "clock" (Figure 1) is a simple emitter-coupled astable multivibrator which generates a stable square wave at about 10 MHz. The clock is gated and phase-locked by the mixed blanking signal from a master television sync generator, and produces ~512 bars per horizontal line. The remainder of the bar generator is shown in Figure 2. The clock signal drives an 8 - bit binary counter which is reset by the blanking signal. A nine - position switch selects the desired number of bars per line and the resulting digital signal is converted to a clean square wave by transistors Q6 and Q7. The cable driver (Q8) completes the bar generator. The output of the bar generator does not contain a composite sync signal, so that sync must be supplied from the master sync generator.

Dave Casasent

Doug Sand

Q1-Q4: 2N709
 Q5: 2N2894A
 D1: 1N4151

(C ~ 60pf FOR ~9.5 MHz OR
 512 BARS PER HORIZONTAL LINE)

Figure 1. Gated Clock

2.1.2 Sync Separator Modification

The sync separator circuit discussed in a previous Quarterly Report proved to be too sensitive to variations in the level of the video signal. To correct this the sync-clipping stage was modified (see Figure 3) to include a peak detector (Q12) which gives stable sync-clipping for all video signal levels from 0.2 V to 4 V.

Al Irwin

Figure 3. Sync - Clipping Modification

2.2 VISTA System (Project No. 14)

2.2.1 Variable Scan Television Camera

2.2.1.1 Video Preamplifier

To accommodate the 64 possible scanning rates, a variable gain video preamplifier is required since the signal level is, to a first approximation, a linear function of the scan rate*. 64 different values of gain would be prohibitively complicated and costly, hence nine different ranges of scan rates were selected, each corresponding to a different value of gain. Table 1 presents the nine selected ranges. n is the factor by which the conventional scan rate, 15750 Hz, is reduced. These ranges were chosen mathematically to minimize the error in the ranges which results from providing nine instead of 64 gain values. The maximum gain error is approximately $\pm 21\%$.

<u>Range</u>	<u>Scan Rate Reduction Factor n</u>	<u>Gain Factor</u>
1	1	1
2	2	2
3	3 - 4	3.5
4	5 - 7	6
5	8 - 11	9.5
6	12 - 17	14.5
7	18 - 26	22
8	27 - 41	34
9	42 - 64	53

Table 1. Scan Rate Ranges.

*RCA Review R. E. Johnson, "Vidicon Performance Characteristics at Slow Scan Rates", March 1966, Vol. XXVII, No. 1, Pages 61 - 65.

Figure 1 is a simplified diagram of the Vidicon-preamplifier circuitry. The gain is adjusted by varying the value of R_V , rather than by controlling the gain in later stages of the preamplifier. This technique provides a control of the noise level by reducing the high frequency response as R_V is increased for lower scan rates. The majority of the noise originates as thermal noise in R_V . By increasing R_V , the R_VC time constant is also increased, where C is the capacitance between the target mesh and all other electrodes in the vidicon. This decrease in frequency response offsets the increasing noise level which varies as the square root of R_V .

The input resistance R_V is controlled by using a field effect transistor as a voltage controlled resistor. The voltage, in turn, is controlled by a resistor divider composed of a standard resistor and a Hewlett-Packard photocell-lamp combination. This arrangement offers excellent isolation between the controlling mechanism and the input resistance R_V , an important consideration at such low signal currents. This circuit is shown in Figure 2. A feedback signal is returned to the gain control circuit from the preamplifier in order to bootstrap the gate and null the effect of the gate-to-drain capacitance. This technique is discussed in more detail below where bootstrapping is applied to the preamplifier.

A field effect transistor was used at the input of the preamplifier for its high input impedance characteristics. This prevents attenuation of the already small signal level. Figure 3 shows the preamplifier circuit. Here Q_2 , used as an emitter follower, bootstraps the source and drain through C_1 and C_2 , respectively. An analysis of the circuit shows that such an arrangement eliminates the effect of

the gate to source and drain to source capacitances provided that the emitter follower voltage gain is unity. In a similar manner, the collector of Q_2 is bootstrapped through C_3 . The input capacitance to the preamplifier circuit was measured at approximately 0.8 pf. The input resistance is well over 10 Megohms. A combination of series and shunt peaking is employed in stages Q_5 and Q_6 .

In order to enhance television picture detail, conventional television preamplifiers employ a peaking stage to boost the high frequency response. This technique was employed in this preamplifier design, though not to the extent that it nulled the noise reduction effect described above. Here an additional complexity arose due to the variable gain feature of the preamplifier. As the upper frequency limit falls off with increasing R_V , as discussed above, the peak must shift accordingly. Thus a different pole-zero combination is switched into the circuit for each of the nine gain settings. This is shown in the emitter circuit of Q_7 in Figure 3. The networks switch simultaneously with the nine different values of R_V . The frequency response is thus flat to the nine different cutoff points. The other eight bandwidths are reduced from this figure by the gain factors listed in Table 1.

For a gain factor of 1, the voltage gain of the preamplifier is approximately 40 db.

2.2.1.2 Deflection Amplifiers

Due to the shifting nature of the television raster, direct-coupled deflection amplifiers are required to drive the plates of the electrostatic vidicon tube. The specifications called for 30 volts peak-to-peak deflection voltage per plate with an average voltage of 225 volts. An inverting and a non-inverting amplifier circuit were

designed using operational amplifiers and high voltage transistors as shown in Figure 4. The signal outputs are returned through feedback resistors to the inputs. One such pair of amplifiers is used to drive the horizontal plates, and an identical pair to drive the vertical plates. The linearity and response of the amplifiers are excellent over the entire range of scan rates.

2.2.1.3 Vidicon Protection Circuits

A circuit for protection against horizontal deflection failure was designed consisting essentially of a differentiating and threshold detector circuit. If the slope of the ramp deflection voltage falls below a certain minimum value (corresponding to the slowest scan rate), the derivative of this signal, a step voltage, will fall below the corresponding threshold voltage, triggering the blanking circuit and removing the target voltage. A different scheme was required for the stair-step vertical deflection waveform. In this case, the voltage change between steps is monitored at the conclusion of every horizontal sweep. If no change occurs, the vidicon blanking circuit is activated.

2.2.1.4 Range Discriminator Circuit

A range discriminator is required to decode the 64 possible scan rates into nine different ranges. Refer to Table 1. In the first two cases where there is a one-to-one correspondence between scan rate and gain, a digital decode is used. In the following cases, however, an analog approach is much less complex and costly. Here the digital signal corresponding to the selected scan rate is converted to an analog voltage. Using dual differential amplifier packages, a window corresponding to each digital range is selected. The output of each amplifier pair thus represents one of the nine different

ranges. A simplified circuit diagram of this arrangement is shown in Figure 5. The inverted outputs of the amplifier pairs drive the respective L'C' switches shown in Figure 3. In addition, these outputs drive a lamp intensity control circuit for controlling the gain as shown in Figure 2. An attractive feature of this scheme is that the integral nature of the scan rates allows the windows to be chosen such that no overlap occurs, and the scan rate numbers will always fall within one and only one window.

2.2.2 Variable Cutoff Low Pass Filter

An adjustable low pass filter will be inserted in the video line to determine the bandwidth of the video signal and to demonstrate picture degradation as the width of the pass band is reduced. A sixth order active filter was designed consisting of three second order stages cascaded. The parameters were chosen to provide a max flat filter, i.e. the complex conjugate poles were chosen to lie on the unit circle, separated from each other by thirty degrees. Refer to Figure 6. The amplifier gains A_1 , A_2 , A_3 , represent additional degrees of freedom. These values were kept within practical limits and were chosen to render the system stable.

Figure 7 shows the 10 MHz amplifier circuits used in stages 1 and 3. Stage two was a simple emitter follower-attenuator circuit and is not shown.

The cutoff frequency is adjustable over four ranges, spanning the limits of 16 KHz and 10 MHz. The sixth order system provides a cutoff slope of approximately 36 db per octave. The experimental gain versus frequency plots correlated extremely well with the theoretical plots.

2.2.3 Miscellaneous

A six-bit binary-to-binary coded decimal converter was designed and built to drive the Nixie tube bandwidth compression ratio display. In addition, camera power supplies and other miscellaneous supplies have been designed and built.

The camera is currently being built and assembled and will soon be operational. The variable persistence monitor has been received and installed in the system cabinet. The control panel is about to be wired.

David Rollenhagen

CIRCUIT

SMALL SIGNAL
EQUIVALENT

Figure 1. Vidicon Circuit and Equivalent

Figure 2. Gain Control Circuit

Figure 3. Preamplifier Circuit.

Figure 4. Direct Coupled Deflection Amplifier

Figure 5. Range Discriminator.

* A ROTARY SWITCH SELECTS ONE OF FOUR DIFFERENT VALUES FOR $C_1, K_1 C_1, C_2, K_2 C_2, C_3, K_3 C_3$ CORRESPONDING TO FOUR DIFFERENT RANGES. THE 4K POTENTIOMETER IS THE VERNIER.

Figure 6. Adjustable Sixth Order Low Pass Active Filter

Figure 7. 10 MHz Amplifier with Gain of Two

2.3 Functional Encoding (Project No. 15)

As mentioned in an earlier report, the video signal from the camera is differentiated before detection, in order to get rid of the effect of the curvature of the background video level. An unfortunate consequence of this fact is that the intersection of the scan with a horizontal, or nearly horizontal, line to be transmitted produces too small a signal to appear at the output of the differentiator, so that information is lost.

Two solutions to the problem are being examined. One is to eliminate, electronically or optically, the curvature on the background video level. This would allow the differentiator to be removed and a simple threshold detector could then pick up the intersection of the scan with the line. The alternative, possibly less attractive, method is to alternate the scan horizontally and vertically from one frame to the next. Operating a vidicon in this mode does not seem too difficult, but the two dimensional alignment problem on the receiving monitor would not be so easy to overcome.

2.3.1 A/D Converter

The A/D converter previously described has been built and tested. Oscillations have been observed on one of the circuit boards containing a large number of high gain differential amplifiers which compare the input signal with reference voltages. Moderate success has been achieved in controlling the amplitude of the oscillations, but they have not yet been eliminated entirely. It looks at present as if greater physical isolation between input and output paths is needed, and a new layout is being tried.

Ed Carr

Peter Oberbeck

2.4 Transformatrix (Project No. 17)

2.4.1 Two Dimensional Discrete Fourier Transform

Let $f(k, l)$ be the doubly periodic extension of a discrete input pattern, X_{kl} , such that:

$$f(k, l) = X_{kl} \quad , \quad k, l = 0, 1, \dots, N-1 \quad (1)$$

$$f(k + pN, l + qN) = X_{kl} \quad , \quad \begin{matrix} k, l = 0, 1, \dots, N-1 \\ p, q \text{ integers} \end{matrix} \quad (2)$$

We may then define a truncated Fourier series for the two dimensional discrete function $f(k, l)$ in the following manner:

$$f(k, l) = \frac{1}{N} \sum_{m, n=0}^{N-1} F(m, n) \exp[2\pi i (km + ln)/N], \quad k, l = 0, 1, \dots, N-1 \quad (3)$$

$$F(m, n) = \frac{1}{N} \sum_{k, l=0}^{N-1} f(k, l) \exp[-2\pi i (km + ln)/N], \quad m, n = 0, 1, \dots, N-1 \quad (4)$$

That expressions (3) and (4) do indeed form a Fourier Transform pair can be readily verified with the aid of the orthogonality relationships for the exponential function.

In addition to the Coordinate Transformation (QTPR - AMJ -1968), Transformatrix will be capable of realizing equation (4), a two dimensional discrete Fourier Transform, with $N = 32$. Since $F(m, n)$ is in general a complex quantity, Transformatrix will display any one of the three functions $|F(m, n)|$, $|\operatorname{Re}[F(m, n)]|$, $|\operatorname{Im}[F(m, n)]|$.

We now consider some of the properties of the discrete Fourier Transform. Through direct use of (4) we see that:

$$F(m, n)^* = F(32-m, 32-n) \quad (5)$$

Thus, for each output frame of $F(m, n)$ values that are to be calculated, only $\frac{1}{2}[(32)^2 + 4] = 514$ unique values need be determined with the other 510 values obtained through the use of (5). This reduces the

computation time by almost one-half.

Let the input picture be normalized such that $0 \leq f(k,l) \leq 1$. Then the range of values of $F(m,n)$ for $m = n = 0$ is 0 to 32. The range of values of $\text{Re}[F(m,n)]$ and $\text{Im}[F(m,n)]$ for non-zero m or n is 0 to ± 16 . Care will have to be taken to preserve accuracy through this relatively large range of values for the points in the output picture.

From (4) we have for $\text{Re}[F(m,n)]$ and $\text{Im}[F(m,n)]$;

$$\text{Re}[F(m,n)] = \frac{1}{32} \sum_{k,l=0}^{31} f(k,l) \cos(2\pi(km + ln)/32) \quad (6)$$

$$\text{Im}[F(m,n)] = -\frac{1}{32} \sum_{k,l=0}^{31} f(k,l) \sin(2\pi(km + ln)/32) \quad (7)$$

In order to form $|F(m,n)|$, $|\text{Re}[F(m,n)]|$, and $|\text{Im}[F(m,n)]|$ we represent $f(k,l)$, $\cos(2\pi(km + ln)/32)$, and $-\sin(2\pi(km + ln)/32)$ as Synchronous Random Pulse Sequences (SRPS) and use digital AND's to obtain the products in (6) and (7). The $f(k,l)$ values are already in the proper form ($0 \leq f(k,l) \leq 1$) to be represented by SRPS. However, the $\cos(2\pi(km + ln)/32)$ and $-\sin(2\pi(km + ln)/32)$ values range from -1 to +1 and a mapping is required. The type of mapping that will be used is:

$$P_{\cos}(km + ln) = \frac{1}{2}(1 + \cos(2\pi(km + ln)/32)) \quad (8)$$

$$\text{where } 0 \leq P_{\cos}(km + ln) \leq 1 \quad (9)$$

$P_{\sin}(km + ln)$ will be obtained by incrementing the argument of $\cos(2\pi(km + ln)/32)$ by $\pi/2$.

$$P_{\sin}(km + ln) = \frac{1}{2}(1 + \cos(2\pi(km + ln + 8)/32)) \quad (10)$$

$$\text{where } 0 \leq P_{\sin}(km + ln) \leq 1 \quad (11)$$

Multiplying the SRPS which represents $F(k,l)$ by the SRPS's which represent $P_{\cos}(km + ln)$ and $P_{\sin}(km + ln)$ and summing (in an analog manner) over all (k,l) we obtain:

$$\begin{aligned} \text{Re}[F'(m,n)] &= \frac{1}{32} \sum_{k,l=0}^{31} f(k,l) \left[\frac{1}{2}(1 + \sin(2\pi(km + ln)/32)) \right] \\ &= \frac{1}{2} F(0,0) + \frac{1}{2} \text{Re}[F(m,n)] \end{aligned} \quad (12)$$

$$\begin{aligned}\text{Im}[F'(m,n)] &= \frac{1}{32} \sum_{k,l=0}^{31} f(k,l) \left[\frac{1}{2} (1 - \sin(2\pi(km + ln)/32)) \right] \\ &= \frac{1}{2} F(0,0) + \frac{1}{2} \text{Im}[F(m,n)]\end{aligned}\quad (13)$$

The quantity $F(0,0)$ represents the average intensity of the input picture. Thus, for each (m,n) we have the result:

$$\text{Re}[F(m,n)] = 2\text{Re}[F'(m,n)] - F(0,0) \quad (14)$$

$$\text{Im}[F(m,n)] = 2\text{Im}[F'(m,n)] - F(0,0) \quad (15)$$

Reviewing the preceding equations it is seen that the crux of the problem is the generation of the coefficients, $P_{\cos}(km + ln)$ and $P_{\sin}(km + ln)$, as SPRS's. Several approaches for the generation of the (Fourier) coefficients were discussed in the QTPR-AMJ-1968. A block diagram of the scheme which was considered superior is found in Figure 1. The number in parentheses above each box indicates the number of identical circuits represented by that box.

As indicated in Figure 1, there is one five bit adder for each column of coefficients. Because of the periodicity of the cosine and sine functions, we are only interested in $(km + ln) \bmod 32$.

For a particular output point and a fixed column of coefficients, the indices m , n , and k are constant. Assume that $(km)_{32}$ and 0 are entered into the input registers of the k^{th} adder. The decoder converts $(km + ln)_{32}$ into $P_{\cos}(km + ln)$. Thus $P_{\cos}(km)$ is entered into the $l = 0$ five bit register of column k . Then the number $(km)_{32}$ is fed back into one of the input registers of the adder. The other register now contains n . Thus the output of the adder becomes $(km + n)_{32}$. The decoder generates $P_{\cos}(km + n)_{32}$ which is entered into the '1' register of column k . This process continues (with one input to the adder equal to n and the other input equal to the previous output) up to $l = 31$ for all 32 columns. The resulting five bit binary numbers stored in the 1,024 registers feed 1,024 D/A's. The output of each

Figure 1. Block diagram for the generation of Fourier coefficients as SRPS.

D/A is compared with a random analog voltage which is generated from a SRPS. The output of each comparator is a SRPS representing $P_{\cos}(km + ln)$. Recall that $P_{\sin}(km + ln)$ is obtained by initializing one of the input registers of the adders by a binary 8.

$$P_{\sin}(km + ln) = P_{\cos}(km + ln + 8) \quad (16)$$

Details of the individual circuits will be presented in subsequent reports.

2.4.2 Transformatrix Inputs

Two input mechanisms will be attached to Transformatrix: a slide projector, for testing and aligning circuitry and for demonstrating the coordinate and Fourier transformation properties of the system; and a 5" TV monitor with provision for line camera input, for demonstrating the dynamic capability of Transformatrix. The optical information from either of these devices is projected on to a square array of 1024 photoconductors, as shown in Figure 2. Circuits connected to the photoconductors (currently being tested) convert the sampled image points into SRPS's.

The chief reason for using a photoconductive matrix as an input transducer is that it solves, in an automatic fashion, the problem of converting the sequential nature of the TV display to a parallel one. A photoconductor responds asymmetrically to the leading and trailing edges of a light pulse, turning on - i.e. going into high conductivity - much faster than turning off. It is possible to obtain such devices with fall times long enough to "store" the (optical) information for one TV frame time. Care must be exercised, however, in not making the decay time so long as to blur the effect of rapidly changing images. Preliminary calculations indicate that a decay time of the order of 0.3 second will be commensurate with 16 gray levels of illumination in the range from about 0.1 to 1.0 foot-candle.

L. Ryan
O. Marvel
Y. Wo

Figure 2. Inputs to Transformatrix

2.5 3D Television (Project No. 19)

2.5.1 Special CRT

It has been decided to abandon the vertical scan system with the fibre optic faceplate and to pursue a system with a horizontal scan and an internal lenticular screen. The horizontal scan method can be used if the video signal applied to the monitor is composed of the video from two television cameras which has been chopped and mixed so that alternate left and right video information appears under each lenslet on the lenticular screen.

In as much as a special CRT is needed, suppliers have been contacted and several have been found who can make the tube, but none is willing to make the lenticular screen. The lenticular glass screen is to be 6" by 8" by approximately $3/32$ " and have $1/32$ " radius cylindrical lenses pressed into one side. This apparently can be done by machining a ceramic form and pressing the lenses in under heat. Ceramic material has been ordered to make the form and the work will be done in a shop at the University of Illinois.

The lenticular screen will have conducting stripes deposited on it, so that a feedback signal can be obtained from the electron beam as it scans them. This feedback will be used to synchronize the chopper-mixer so that the left-right information appears in the proper places under the lenses.

Specifications for the television cameras have also been written and quotes asked for.

L. H. Wallman

2.6 Stereomatrix (Project No.30)

2.6.1 System Design

The general scheme of Stereomatrix has already been presented in the previous report. It has been decided to use fast hybrid techniques for various functional units in the system. A block diagram for the system has been drawn up and critical elements such as hybrid multipliers and dividers have been investigated and ordered for laboratory evaluation.

As shown in Figure 1, the picture coordinates (triplets) are stored on a disc in the frame (x^0, y^0, z^0) . The section of this picture being displayed is stored in display memory, which is referred to as the display volume, and has coordinates (x^1, y^1, z^1) . These are each of 10 bits. They are transformed into the viewing screen frame (x^2, y^2, z^2) by the Coordinate Transformer (Figure 2).

The transformed coordinates in the viewing screen can be rotated about the x, y, or z axes, as desired by the viewer. However, before rotation is performed a scaling unit scales down the volume for ease in displaying it. The rotation can be performed either by turning a set of knobs provided on a control panel or rotational command obtained from the disc.

The rotated coordinates are used to generate a stereo pair for each incoming coordinate. However, these stereo pairs are only displayed when they lie in the window area of the display; otherwise they are rejected and a new set of data is requested. The windowing unit determines whether the obtained pair is in the window area or not and gives its decision to the Display Control unit. The latter controls the input data, bypasses the rotational unit if no rotation is desired and requests new coordinates if the old ones are out of the window area.

The intensity control unit provides the intensity signal to the

Figure 1. The Various Reference Frames of Stereomatrix

Figure 2. Block Diagram of Stereomatrix

laser display system if the stereo-pair lies within the window area.

Figure 3 shows the generation of the stereo-pair.

The problem which remains to be solved is a simple but adequate scheme for rotation of the picture being displayed.

Shiv Verma

Richard Cheng

Figure 3. Block Diagram of Coordinate Transformer

3. Computer Systems Research

Supported by the U. S. Atomic Energy Commission under grant U. S. AEC AT(11-1)1469, Part A. The work performed for this quarter is reported in the next six subsections. Publications and reports prepared or published this quarter include:

Reports Written

1. Dill, C. "A Graphical Search for Stiffly Stable Methods for Ordinary Differential Equations," Department of Computer Science Report No. 295 and Master's Thesis, University of Illinois, Urbana, Illinois 61801.
2. Dill, C., Ellis, C., Gear, C. and Ratliff, K., "The Automatic Integration Package for Ordinary Differential Equations," Department of Computer Science File No. 779, University of Illinois, Urbana, Illinois 61801.
3. Dill, C., Ellis, C., Gear, C. and Ratliff, K. "ODESSY-- Ordinary Differential Equation Solver System," submitted to Communications of the ACM.
4. Dill, C. and Gear, C. "A Graphical Search for Stiffly Stable Methods for Ordinary Differential Equations," submitted to Journal of the ACM.
5. Gear, C. "General Simulation and Modeling," Department of Computer Science File No. 785, University of Illinois, Urbana, Illinois 61801.

Papers Published

6. Gear, C. "The Automatic Integration of Stiff Ordinary Differential Equations," Proceedings IFIPS 1968, pp. A81-A85.
7. Richardson, F. K., Lo, T. Y. and Gear, C. W. "Computer Aided Programming System," in "Emerging Concepts in Computer Graphics," ed. Secrest and Nievergelt, W. A. Benjamin Book Company (1968), pp. 171-188.

Papers Presented Orally

8. Gear, C. "The Automatic Solution of Ordinary Differential Equations," presented to the Symposium on Mathematics, Computers and Computation, Oct. 1968, Urbana, Illinois.

C. W. Gear, Principal Investigator

3.1 Numerical Analysis--Ordinary Differential Equations

Considerable success has been enjoyed this quarter in this work. New stiff methods were found by a graphical search (Section 3.1.1) and considerable use of the techniques and programs has been made by other groups around the world. The basic numerical section is in use at Argonne National Laboratory and the Danish Atomic Energy Laboratory to solve reaction problems. The method is now being used in an electrical network analysis program by Calahan of the University of Michigan. A joint paper is in preparation. Part of the quarter was spent on applying the method to a complex set of equations obtained from the Kirkland group. A speed in excess of 100 was obtained with better accuracy. As a result of this, and of Calahan's tests, a number of other groups have sent for the program to test it on their problems.

All known remaining errors in the automatic package have been corrected and a letter has been sent out announcing the availability of tape copies of the program.

3.1.1 An Interactive Search for Stiff Methods (C. Dill)

An interactive graphic system for displaying stability functions useful in connection with the study of high order methods for solving stiff ordinary differential equations is now operational on the PDP-8/338. Known stiffly stable methods are predictor-corrector methods. The corrector may be written

$$\begin{aligned} & \alpha_k y_n + \alpha_{k-1} y_{n-1} + \dots + \alpha_0 y_{n-k} \\ & + h\xi \beta_k y'_n + \beta_{k-1} y'_{n-1} + \dots + \beta_0 y'_{n-k} \xi = 0 \end{aligned}$$

where $\alpha_k \neq 0$, $|\alpha_0| + |\beta_0| > 0$. Define

$$\rho(\xi) = \sum_{i=0}^k \alpha_i \xi^i \text{ and } \sigma(\xi) = \sum_{i=0}^k \beta_i \xi^i.$$

The stability function displayed is the locus of $-\frac{\rho(\xi)}{\sigma(\xi)}$ in the complex plane, with $\xi = e^{i\theta}$.

Given a k and the coefficients of the polynomial $\sigma(\xi)$, the coefficients of the polynomial $\rho(\xi)$ and thus the unique method of degree k are completely determined. The stiff stability properties of the method may be investigated by a visual examination of the displayed locus. The display is based on a user defined display window specified in terms of left and right boundaries relative to the real axis, and upper and lower boundaries relative to the imaginary axis. Communication to the system is by teletype and push-buttons. User input includes k , the coefficients of the polynomial $\sigma(\xi)$, and the display window boundaries.

Previous results showed the existence of stiffly stable methods of order up to six. The graphic system has been used to conduct a systematic search for methods of order greater than six. This search has led to the discovery of stiffly stable methods of orders seven and eight.

Defining optimality in terms of least amount of solution history data to be saved at each step of the corrector iteration, the optimal possibilities for orders seven through fifteen were tested with negative results for all orders except seven. Removing the optimality restriction allows the unique method determined by any stable $\sigma(\xi)$ to be a valid candidate for satisfying stiff stability requirements. No general results can be given, since the number of potential methods excludes the possibility of any type of exhaustive testing. Testing of large classes of methods tends to indicate the scarcity of stiffly stable methods of order greater than six. Methods of orders seven and eight were found, however, while examining some of the more likely classes of methods.

3.1.2 Automatic Differential Equation Solver (C. Dill, C. Ellis, K. Ratliff)

The following is a summary of changes which have been made recently:

1. The COMMON area in the program has been rearranged due to problems of adequate space for the COMMON variable.
2. The User Manual for the program has been revised and added to the card deck of the program for user convenience.
3. The provision in the Supervisor for specification of format for output (page headings and number of lines per page) was not functioning correctly since a standard heading was being used in all cases. This error has been corrected.

4. Another error was detected in the evaluation of partial derivatives when the differential equation is given using single letter variables for simplification of the equation. Since the values of the auxiliary variables are computed by the function evaluation subroutine (SUBFUN), these values when used in the partial derivatives, were often outdated. This is because they were evaluated using the values of the independent and dependent variables at the last call to SUBFUN. This has been corrected by calling SUBFUN immediately prior to the evaluation of the partial derivative matrix. This will not introduce much additional computing time since the matrix is seldom evaluated.
5. A bug has been found and corrected which was causing inaccurate evaluation of both the function and its partial derivatives. It was related to the number of registers used for computing these two things, and only occurred in the case of very complicated differential equations.

A few small changes have also been made in the method of integration. A master copy of the program has been made and is currently in the process of being transferred to a tape via the ASP card to tape program. This will facilitate making tape copies of the program in the future using the ASP tape to tape program.

3.1.3 Application of the Numerical Method (C. Gear, K. Ratliff)

A set of 26 equations describing the post-detonation reactions of the elements in the upper atmosphere was investigated this month. Previously, they had been taking 30 minutes of CDC 6600 CPU time. Our program would handle them in about 1.5 minutes of 360/75 time and there have been indications that its run time on the 6600 is negligible compared with the compile time. The complexity of the equations underlined the problem of determining corrector convergence, and it was necessary to modify the criterion and to require more frequent re-evaluation of the partial derivatives. They are now recalculated whenever the step or order changes as well as when convergence fails. (Calahan of the University of Michigan has found it advantageous to re-evaluate at every correction step because he is using a sparse matrix inverter which is fast for the type of equations arising in network analysis.)

3.2 Graphics

Two distinct thrusts were underway this quarter: the extension of the DEC 338 program to handle general purpose diagram constructions (it will be used as the graphical front end to the proposed simulation program--see File No. 785), and the preparation of programs for the 360 to replace those that used to exist on the Illiac II.

3.2.1 DEC 338 Software (T. Y. Lo)

The work on the implementation of the general purpose display package is proceeding with the coding and debugging of the routines to provide the facilities for a user to construct his own symbols. The symbols constructed in this step will be used as light-buttons to construct a model of his design problem in the next step. In addition to the features mentioned in the last quarterly report, a new feature is to be implemented into the package so that a user is able to use other light-buttons to form a part of a new light-button under construction. This feature of using light-buttons to be parts of a light-button is planned to be available also in the second step in using this display package, i.e. when the user is constructing a model of his design problem, he can replace a group of light-buttons (not necessarily different) and the connections among them with a new light-button to be defined by the user at this step. This feature will be very sueful when a user is constructing a rather complicated design model using some simple light-buttons that he has defined in the first step.

For example, when a user is constructing an electronic network, he may define a transistor symbol as a new light-button to represent a group of symbols so constructed as to be an equivalent circuit of the transistor. Then in constructing the network, the transistor symbol can be used to replace its equivalent circuit. In order to be able to handle these light-buttons properly, a lot of tables are constructed during both steps in using this display program. Since most of these tables are of variable length, it is worthwhile to compact them after the construction of light-buttons is done. At the time the user requires modification of his light-buttons, the tables will be scattered again so that necessary changes can be made on the tables easily.

A detailed description of this piece of program will be provided after the debugging and testing of the routines are completed.

CAPS 338 Software

The "ADD" operation of the flowchart editing system of CAPS has been implemented during this quarter in order to complete all the operations as described in appendix B of the Department of Computer Science Report No 257.

3.2.2 FPL-II (S. Wilkins)

The major part of the conversion and modification of the flowchart programming system has been completed. The largest incomplete section is decision processing.

Master Error Control Program

During the execution of a flowchart any number of unusual conditions may occur. These conditions must be recognized and corrected if possible, and the user must be informed of the actions taken by the system. The following table describes the errors that can occur and the action taken. The control of these exceptional conditions is now operational. Control of other exceptions will be added to the system as the need arises.

CODE	TYPE	MEANING	ACTION
8	Fixed-point overflow	Overflow occurred during fixed-point add or subtract	The format of the data is changed to floating-point and the operation is repeated as a floating-point operation. The user is not informed.
9	Fixed-point Divide	Quotient of a fixed-point divide cannot be expressed as a 32 bit integer	The format of the data is changed to floating-point and the division is repeated in floating-point mode. The user is not informed.
10	Illegal Operation	For the operations: ADD, SUB, MPY, DVD, SET, PRINT one of the following occurred 1)Operand not allowable type 2)Invalid mixed operands 3)Invalid operator	Error is unrecoverable. Current user is aborted. Provides message: "ILLEGAL OPERATION SYMBOL NO X* OPERATION Y** JOB TERMINATED"
11	Division by Zero	Attempted division by zero operand in fixed or floating-point mode	Error is unrecoverable. Current user is aborted. Provides message: "DIVISION BY ZERO SYMBOL NO X JOB TERMINATED"
12	Exponent Overflow	Characteristic overflows on floating-point ADD, SUB, MPY, DVD	Error is unrecoverable. Current user aborted. Provides message: "EXPONENT OVERFLOW SYMBOL NO X OPERATION Y JOB TERMINATED"
13	Exponent Underflow	Characteristic underflow in floating-point MPY or DVD	Error is recoverable. Result set to zero. Provides message: "EXPONENT UNDERFLOW SYMBOL NO X OPERATION Y RESULT SET TO ZERO"
14	Significance	Intermediate result of addition or subtraction is zero in floating-point mode	Error is recoverable. Result is set to zero. Provides message: "SIGNIFICANCE LOST SYMBOL NO X OPERATION Y RESULT SET TO ZERO"

* X symbol number
of flowchart symbol
currently being executed

** Y can have values
+, -, *, /, SET,
PRINT when applicable

The next stage in the development of FPL-II is the implementation of decision processing.

Decision Processing

The decision symbol, the diamond-shaped processing box, allows the user to specify alternate paths to be taken in his flowchart at execution time depending on the results of previous processing.

Two primitives are provided to be used with data to be tested in the text associated with the decision symbol.

In the post-fix notation currently implemented the primitives are:

1. SIGN

Used to test the sign of an arithmetic expression

ex. A SIGN (tests sign of data with name A)

AB + 2/ SIGN (tests sign of expression (A+B)/2)

Returns values corresponding to +, -, 0.

2. COMP

Used to compare the values of 2 variables or a variable and a constant.

Allowable data types for comparison are:

- a) FIX & FIX
- b) FIX & FLOAT
- c) FLOAT & FLOAT
- d) FIX & numerical constant
- e) FLOAT & numerical constant
- f) CHARACTER STRING & CHARACTER STRING
- g) CHARACTER STRING LITERAL (enclosed in single quotes) & CHARACTER STRING

ex. A B COMP (compares 2 variables of allowable types)

A 2 COMP (compares numerical variable with constant 2.)

A 'BCD' COMP (compares character string variable A with character string literal 'BCD')

Returns values corresponding to > (1st greater than 2nd)

< (1st less than 2nd)

=

The primitives are used in the following examples:

The paths to be taken as a result of the test are indicated by associating the symbol for the result with the appropriate arrow from the decision symbol.

(Not all the test values for a primitive need be used at a decision symbol.)

If one of the arrows from the decision symbol is left blank and the test fails for marked arrows then the path indicated by the blank arrow is taken.

If there are no blank arrows and the test fails for the marked arrows then processing stops.

3.2.3 360 Graphics Monitor (M. Michel)

The following summary of the current state of the 360/50-PDP8 interactive graphics monitor system consists of two parts. The first is a brief discussion of the general characteristics of communication between the PDP8, the PDP7, and the 360/50. Its purpose is to acquaint the reader with the mechanics of the communication problem involved and to provide him with a feeling for the situation. The second section describes the structure, functions, and utility of the monitor system as currently implemented and envisioned, and states the current status of the project.

3.2.3.1 Background Information for 360/50-PDP7-PDP8 Communication

A. PDP8 to PDP7 to 360/50

The PDP8 transmits or receives one character at a time to or from the PDP7 at a maximum rate of 100 characters per second. As soon as the PDP7 senses a carriage-return character from the PDP8 or when it has

received a total of 125 characters without getting a carriage-return character, the PDP7 considers the "line" of characters from the PDP8 to be completed. At this time, the PDP7 transmits a carriage-return followed by a line feed to the PDP8. The PDP7 then tries to send the line to the 360/50. When the 360/50 reads the line, and not before, the PDP7 sends a bell-character to the PDP8, signifying that the PDP8 may send another line. If the PDP8 should try to send characters to the PDP7 before receiving the bell-character, the PDP7 immediately sends a carriage-return line feed, '#WAIT', carriage-return, line feed sequence to the PDP8.

The format of the line sent to the 360/50 from the PDP7 is as follows:

```
A,B[125 data bytes]CR
0 1 2          126 127
```

Where A and B (bytes 0 and 1) are PDP7-360/50 control characters, byte 127 is always a carriage-return, and bytes 2 through 126 are data bytes. If the PDP8 had sent 50 characters followed by a carriage-return, the line would look like:

```
A,B[.....CR---Junk---]CR
0 1 2    51 52          126 127
```

B. 360/50 to PDP7 to PDP8

When the 360/50 sends data for the PDP8 to the PDP7, the data format is:

```
AB[N---124 data bytes]CR
01 23          126 127
```

Where A and B are PDP7-360/50 control characters, N is a control character for the PDP8 monitor system, and byte 127 is always a carriage-return. If 50 characters were to be sent to the PDP8, the line would be:

```
AB[N    CR---Junk---]CR
01 23 52 53 54          126 127
```

The PDP7 would send only bytes 2 through 53 to the PDP8, followed by an additional line feed [Note: when the PDP8 initiated a send, a line feed

and a bell were returned; when the /50 initiates a send, only a line feed is additionally sent to the PDP8].

After sending one line, the /50 cannot send another line until the first has been completely sent (character by character) to the PDP8. Note that the PDP7 assumes the PDP8 is a synchronous device; hence, the PDP7 sends characters to the PDP8 at a fixed rate and the PDP8 must accept them at that rate. In order to know when this has been accomplished, the program in the /50 must issue a READ operation. In this case, byte 1 ('B') of the input indicates the disposition of the last line. (On ordinary input, B = 0, meaning the line is a data line). The rest of the line is junk. If B is

- 1, then the output has all been transmitted to the PDP8.
- or 2, then the PDP8 has requested the PDP7 to stop transmission before the entire line was sent, i.e. the remainder of the line has been voluntarily lost;
- or 3, then the PDP8 has "signed off."

Hence, to send several lines to the PDP8, the program in the /50 must issue a read before every output operation (except the first) and check B for the proper setting.

C. Data Format

Since certain characters, such as carriage-return and linefeed cause the PDP7 to take some action, data--particularly object code--cannot be sent 8 bits at a time from the PDP8; nor is 8 bits really convenient considering the 12 bit word of the PDP8. In addition, the 360/50 cannot send data in its original form to the PDP7 either, since an inadvertant carriage return in the middle of the line would cause the PDP7 to stop transmitting to the PDP8. Hence, all data (except pure character data sent only to the time sharing system) is sent in a coded format, six data bits (half of a PDP8 word) per 8 bit character at a time. Since internal PDP8 characters are six bits and the transmitted form takes up 8 bits (1 byte), conversion in the 360/50 to EBCDIC is very neat and clean. Numeric data is reformed into 360/50 half words, i.e. one PDP8 word of 12 bits becomes 2 bytes. In the PDP8, each incoming data byte is stripped of the excess 2 bits and every 2 characters are packed into one PDP8 word.

3.2.3.2 Graphic Monitor System Overview and Status

A. Overview

The PDP8-360/50 monitor systems and 360/50 I/O macros have been designed to help reduce the bother and complication inherent in the 360/50-PDP7-PDP8 communication linkage. The package consists of communication and debugging structures embedded in a double ended monitor system, one end in a non-terminating partition in the 360/50, the other end permanently resident in bank 3 to the PDP8.

At the highest level, a user sitting at the PDP8 teletype uses the PDP8 monitor to communicate with the 360/50 monitor. On command, the PDP8 monitor enters one of several modes: it can become a simple console plugged into the time sharing system, or it can command the 360/50 to load a user module into the 360/50 graphics partition or to load data into PDP8 core, etc. The following types of operations are done at this level.

1. Using the time sharing mode, the user can create symbolic source and data files, enter jobs into the regular ASP job stream, etc. Output from these operations is transmitted back to the PDP8 and displayed on the 338 scope for easy viewing. Concurrently, the output can be routed to dectape, to disk (PDP8 or 2314) or 1403 printer for hardcopy version.

2. Using monitor-to-monitor communication, the user can call non-interactive, service programs into the graphics partition. As an example, PDP8ASM (a 360 program for assembly of PDP8 source code) could be called in to assemble a PDP8 program from a source file created by use of the time sharing facilities. The object code is stored on 2314 disks, the listing is sent to 2314 disk for "off line" printing and/or to 338 scope for immediate viewing (instant turn-around). The user notes his assembly errors, calls time sharing, changes some statements in the source file, recalls PDP8ASM to try again (the first object file and source listing can be overwritten, thus eliminating unneeded printout, et al). Depending on partition size the user could call in any program, enabling him to have instant turn-around, for example, for any language on the system, or for any analysis program, etc. The user can then command the 360/50 monitor to pass files to the PDP8 (source, object code, data, et al). These can be added to the PDP8 disk file or tape file (using dectape).

3. Interactive programs can also be called into the graphics partition (this was, naturally, the main intent all along). The usual sequence would be something like: assemble and perfect programs for the 360/50 and for the PDP8 in 1 and 2 above. Load the PDP8 programs into the PDP8 and add to decktape. Call in the new module just created into the 360/50; call in the new PDP8 programs. We now have user application programs running at both ends of the system.

Quite a different level of operation is now in effect; two application programs are communicating with each other and with the user. The 360/50 programs use the same I/O macros used by the 360/50 monitor. The PDP8 programs use the I/O routines of the PDP8 monitor, namely 'loader' and 'sender', for communication with the 360/50 and a system message 'SYSMSG' routine for communication with the user. The PDP8 monitor maintains control of the interrupt structure, sending control to user and system routines as appropriate. In particular, strict control is maintained over PDP8-360/50 communication; namely, PDP7 messages and 360/50 system messages are routed to a special buffer for display to the user. When these occur, certain functions such as transmission from the PDP8 to the PDP7 are inhibited until the user takes corrective action. This may include waiting, retrying the operation, cancelling the operation, specifying new parameters, adding parameters, etc. All PDP8 system routines are easily accessible to user routines via calling sequences or parameter settings. The user can get back to the monitor system at any time, either from his program or by a manual interrupt.

If a user bomb-out occurs in the 360/50, control is automatically passed to a resident debugging routine; this routine communicates with a special section of the PDP8 monitor and is completely transparent to a user program in the PDP8. In brief, the package allows the user to "scroll" around through 360/50 core, to pointer chase, to take "snaps," to patch 360/50 core, and to restart his 360/50 program, all from the PDP8/338.

B. Status

As of this date both monitor systems and the 360/50 I/O macros are written and are in "middle" to final debugging stages, i.e. they are usable but not for production operation. PDP8ASM converted from an assembler for PDP7 programs is usable but needs much polishing and several additional features for maximum utility. The debugging package has been specified but not yet implemented. One necessary component of the package is a text editor, which, hopefully, can be partly "stolen" from existing programs for the PDP8. An important aspect of this package is that it will be written as a user program for the system and will be carefully documented; hence, it will serve as a model demonstrating what can and has to be done in order to "hook into" the system. Several useful utilities for manipulating input/output between the PDP8, 360/50, printers, disk storage, etc., which would be made part of the monitors or callable by them in addition to the basic facilities of the system, have been considered but have not yet been implemented due to lack of time. Another very useful addition would be a 360 FORTRAN interface to the I/O so that FORTRAN programmers could utilize FORTRAN type I/O readily. Finally, a user program running under the PDP8 monitor must be written to interface the system with the flowchart interpreter system.*

*. Suggestions for additional features are welcome.

3.2.4 DRAWL-Graphics Display Language (J. Roman)

Batch-processing GDL was made fully operational and will shortly be made available to the general 360 user as a catalogued procedure. A manual describing the use of GDL has been completed and will be made available about the same time.

Work on an interactive version of GDL has been started and will use the PDP-8 and 338 equipment. Because of its large size GDL will reside in the 360/50 while input will come from PDP-8 via PDP-7 and output will be available at the teletype and 338 display unit. GDL has been modified to function in this environment and I/O routines to handle data transfer have been written and are now in the final testing stage. Since free-format input seemed necessary in an interactive environment, a translator routine has been written (also in the final testing stage) permitting free-format input at the teletype as well as some error-checking capabilities.

3.3 PLORTS Time Sharing

A test version of PLORTS Phase 0 (filing system and remote job entry) is now on the air. Several major holes in the system must be plugged before it is released to the users. A number of further modifications to ASP have been made. Pass I of the compiler/executor is now nearly complete. Work has continued on Pass II and Pass III, and the definition of the interface between them has been revised. The first version of the filing system is in use.

3.3.1 ASP (P. Boekhoff)

Two DSP's, PLORTS and FILE, have been added to the working ASP 2.0 system. These perform input from the PLORTS filing system to ASP and output to the filing system, respectively.

The PLORTS DSP is logically parallel to the stock RDR (card reader) DSP. It receives its input from the PLORTS filing system in Partition 1 of the 360/50 as a sequence of card images. When a terminal user (and there are several) enters the command

```
RUN JCLFILE,SOURCEX,JCLEND (zB)
```

the PLORTS executor in Partition 1 (ultimately Pass III; this is presently being simulated by a limited executor which handles filing and RJE commands) will read the named files and pass the concatenation thereof to ASP in Partition 0. The PLORTS DSP then generates a job number in a format compatible with that assigned by the department for jobs submitted at the routing room, returns this number to Partition 1 for transmission to the terminal as a job receipt, and "reads" the job from Partition 1 into the ASP input stream.

The FILE DSP is invoked via a /*PROCESS FILE statement and appropriate /*FORMAT statements in the input stream. It may be called by a job submitted at the routing room or by one entered at a terminal. Allowable parameters on the /*FORMAT FILE card are:

DDNAME=	dd name of dataset to be filed
DEST=	name under which the dataset is to be filed. FILE takes the PS# and user name from the job's /*ID card and adds (concatenates) the DEST= data thereunto. The DEST= parameter may be up to 32 characters.
CONTROL=SINGLE/DOUBLE/ <u>PROGRAM</u>	If this is omitted or PROGRAM is specified, the first character of each record is assumed to be a control (carriage or stacker select) character and is stripped off before the record is passed to Partition 1. Otherwise, the record is sent unchanged.

Any other parameters will be politely ignored.

The FILE DSP sends an ID record to Pl at the beginning of each dataset. If for example the /*ID card specified 153 and FILLMORE for PS# and user name, and the /*FORMAT card specified DEST=ST.YONKERS, the ID record would be

PS=0153ID=FILLMORE&ST.YONKERS

where 1 is a byte giving the length of the succeeding DEST data (in this case, 10). This dataset would then be filed as 0153.FILLMORE.ST.YONKERS by the filing system.

Most of this quarter's messing with ASP consisted of changes to Input Service to recognize these parameters for /*FORMAT FILE.

3.3.2 PASS I (J. Christopher)

The storage CSECTs and DSECTs have been modified. All commonly used V-type literals now appear in the PASSI DSECT, thus conserving storage. The line table and symbol table have been moved into the output storage section. The portion of the PASSI DSECT which is common to Pass II now appears first.

The following keyword-statement syntax check routines are presently debugged: ALLOCATE,IF,DO,CLOSE,RETURN,CALL,GO TO,OPEN,END,BEGIN,EXIT,STOP,KEYWORD, which recognizes statement-type keywords, and LHSIDE, which analyzes the lefthand side of assignment statements and all labels and determines whether a statement is a keyword statement or an assignment statement.

A minor bug on the outputting of operators in suffix notation has been corrected. The LHSIDE routine has been updated so that it checks for condition prefixes and ignores them. It determines the statement type in the following manner. If any identifier is seen, subscripted or not, the pointer to the first character of the identifier in the input buffer is stored, the identifier and subscript (if present) are analyzed as usual, and the following character is tested. If it is a colon, a label is assumed; if an equal sign, the lefthand side of an assignment statement is assumed; a comma is assumed to indicate multiple assignment, which is a fatal error. Otherwise a keyword type statement is assumed, and control passed to KEYWORD with the current character register containing the first character of the identifier. The input string pointer is backed up to the stored value. If a possible keyword is seen, i.e. an identifier consisting of more than six alphabetic characters, the character following it or following a proper nest of parentheses following the identifier is tested (a proper nest of parentheses is a string of characters, the first of which is a left parenthesis, the last a right parenthesis, and an equal number of left and right parentheses inbetween). If it is a comma, the action is as above. If it is a colon or equal sign, the possible keyword is assumed to be an identifier of more than six characters, and

is truncated to six and accepted and a message to that effect is produced. This is done by rescanning the identifier with the "identifier only" flag set. Otherwise, a keyword is assumed and since the identifier is already in the identifier buffer, control passes to the secondary entry point of KEYWORD which does not call IDENTFYR.

A structure similar to KEYWORD--an entry point which does not call IDENTFYR--has been added to ATTR, the attribute recognizer.

LINEND1 now interacts with GETCHR to produce the following results for nonblank characters after the first semicolon. Comments are scanned and ignored; if any other characters appear a warning is produced to the effect that input after the first semicolon on a line is ignored.

As a consequence of the above proviso, if an ELSE clause is given with an IF statement, it must occur on the next line of the program. The method for handling and outputting IF statements has been revised. The output format is

{statement type code} {label information} {expression}

{statement}, where {statement} is the statement following THEN.

After THEN or ELSE is seen a flag is set and a phony entry in the line table is constructed, and the rest of the statement is handled as a complete statement. If it is a keyword statement the type code is checked in the KEYWORD routine. If it is any of IF, DECLARE, END, PROCEDURE, ENTRY or ELSE, a fatal error is flagged, since these statements are presently not allowed to follow THEN or ELSE. Otherwise, the statement is analyzed and LINEND1 checks the THEN-ELSE flag and if set removes the phony line table entry.

The format for the output of DO statements has been revised. It is now the following. If the DO statement is DØ, the output is

{statement type code} {label information} X'00' {End-of-Statement}

the code byte is zero. If the DO statement is DØ WHILE (expression), the code byte is set equal to two, and is followed by

{expression} {End-of-Statement}.

Otherwise, a type of code of one is used for each specification. In this

case the format is

```
{identifier} {subscript (if any)} {expression} {pointer to  
secondary string location for TØ expression, if it occurs}  
{pointer to WHILE expression, if it occurs} {BY expression}
```

If TO occurs and BY does not in a specification, a default condition BY 1 is assumed. If either TO or WHILE is omitted the corresponding pointer byte is set to zero.

The OPEN statement format has also been revised. Each list produces a 3-byte attribute table as in a DECLARE statement, followed by the internal form of the file name. Unimplemented options are recognized and ignored. After a given keyword in an OPEN statement list is checked for unimplemented options, control is transferred to the secondary entry point of ATTR, and the attribute is handled as if it occurred in a DECLARE statement. At the end of the list, the attribute table is checked. If any attributes not legal in an OPEN statement occurred, an error message is generated to that effect.

The PROCEDURE statement routine is almost debugged. Its format has also been revised. After the label information occurs a byte which contains the OPTIONS(MAIN) and RECURSIVE bits. Then occurs a 3-byte attribute table, followed by the internal form of parameters, if any. After the parameter list has been output, each successive keyword is checked. If it is OPTIONS(MAIN) or RECURSIVE the appropriate bit is set. Otherwise, the attribute is handled as if it occurred in a DECLARE statement. At the end of the statement the attribute table is checked. If any attribute other than arithmetic or bit string is found, a fatal error is generated.

A routine to eliminate wasted space in the output buffer has been written and debugged for special cases, but reorganization of the buffers will be necessary for it to work generally.

Line numbers are now handled properly. Pass I is complete except for the following:

1. No special action is taken for unnumbered lines. Certain unnumbered statements will require special treatment for proper functioning of the interface between the compiler and the timesharing system.
2. Constants must be generated and output into the symbol table, and the symbol table pointers must be inserted into the Pass I output buffers.

3.3.3 PASS II (J. Christopher, A. Whaley)

The symbol table entry format has been revised. It is now 12 bytes in length.

BYTE 0

bits 0, 1, 2

0	constant
1	variable
2	statement label constant
3	dummy parameter
4	operator
5	entry name
6	procedure name
7	pseudo-invocation
0	character string
1	bit string
2	binary fixed
3	binary float
0	real
1	complex
0	nondimensioned
1	dimensioned
0	not assigned
1	assigned

3, 4

5

6

7

BYTE 1 (Character string or bit string) Length minus 1

BYTE 2

bit 0 (if = 1) parameter
 bit 1 (if = 1) *subscript
 bit 2 (if = 1) label variable

3, 4

5, 6

7

0	input file
2	output file
3	print file
0	automatic
1	static
2	controlled
0	single precision
1	double precision

BYTE 3 unused

BYTES 4+5 pointer to location in core
(not set for variables in Pass II)

BYTES 6+11 EBCDIC characters of identifier padded on the right with blanks, except for constants (in which case these bytes contain the value and as many bytes as needed are used) and dummy variables in which case these bytes contain EBCDIC blanks.

A "pseudo-invocation" is merely an occurrence of an identifier which has not been explicitly declared or has appeared as an entry name used in a CALL statement.

The Pass II expression analyzer MOVEX has been written. It transfers the expression from either Pass I output buffer into the Pass II output buffer. The address of the start of the input buffer is input in R3 as a parameter. The routine does the following. It inverts all identifiers into symbol table (SYMTAB) pointers. When an identifier is seen, it is converted to EBCDIC in a standard buffer (TRANBUF) and the input pointer (R3) is advanced beyond it. Then the routine SST is called, which searches the entire SYMTAB for the given identifier. If found the symbol table pointer is output into POLIII, the Pass II output buffer. If not found, the routine EXTEN is called which makes a pseudo-invocation symbol table entry for the identifier. If a symbol table pointer is given in the input string, the two leftmost bits are turned off and the pointer is moved into POLIII. The above is done until an End-of-Statement marker or an All-Zero byte not part of an identifier or SYMTAB pointer is reached.

All the table searching routines have been written. SST and SCB have been described previously.

A routine has been coded to handle all statement labels. In the case of a subscripted label, a pointer to the beginning of the statement in the Pass II output string is placed in the storage cell allocated for the given element of the array.

ENTRY names are handled similarly to label constants. Whenever an explicit declaration of an entry name is seen, and a symbol table search finds a pseudo-invocation entry for that name, the symbol table entry is converted to a PROCEDURE or ENTRY, as appropriate.

The Pass II PROCEDURE statement has been modified. It now begins by generating a GO TO which points to a generated statement-label-constant symbol table entry. A pointer to this entry is also placed in the ENTAB stack delimiter for the procedure. When the END statement for the procedure is encountered, ENDIIST fills the value of the label constant. This allows control to pass around the procedure. An ENTAB stack delimiter is now output for each ENTRY name in the PROCEDURE statement. All but the first have flag bits set, to indicate how many must be removed.

It has been necessary to add level numbers to PASSII for statement label constants, ENTRY names and PROCEDURE names. The level is kept in storage. Each time a new PROCEDURE or BEGIN block is encountered, this number is incremented by one and stored in the symbol table entry for all entry names of the block and label constants declared internal to the block. This level number serves two purposes. Upon reaching a statement which terminates a block during execution, all automatic storage for that block must be released, i.e. storage with the highest level number. However, when a statement is reached which terminates several blocks (a GO TO statement or END <procedure name>), the execution phase must release storage for all automatic variables with level numbers greater than that of the label in the GO TO or the procedure named in the END statement. Since all references are resolved in Pass II, the level numbers must be generated in Pass II.

A method has been devised for finding unresolved forward references in GO TO statements. It involves a routine called SBNEST, which expects two parameters--an identifier in TRANBUF, and a block table pointer in R13. It searches the block indicated by the pointer and all nested blocks for an occurrence of the identifier in TRANBUF. It has pass and fail exits.

The Pass II GO TO statement routine GOIIST has been written. For GO TO <identifier>, it translates <identifier>, and then uses SST to determine if the <identifier> has already been declared or referenced in a containing block. If so, a pointer to that symbol table entry is output. If SST does not find the identifier, however, the symbol table sections for

all block nests contained in the currently open block at that point in Pass I are searched for the given identifier. If it is a statement-label constant entry with no value, then a pointer to this is output since the entry was generated by a forward GO TO. Otherwise, a symbol table entry is generated for a statement-label constant with no value.

The subroutine FWBWI is employed which returns the block table pointer to the currently open block.

The action of GOIIST is simpler for a reference to a subscripted label variable. SST is called to find the identifier. If not found, a fatal error is flagged. If found, its type is checked. If it is not label array, an error results. Otherwise, the pointer is output. Statement-label variable references are handled as statement-label constant references.

The Pass II END statement pops the entry name stack and removes stack delimiters. A method for deciding which blocks it should close has also been devised. If END <entry-name> is seen, the symbol table is searched for the entry-name. If not found, an error condition is raised and compilation terminated. If found, its core pointer is compared with those for all blocks, and the "closed" bit is set for all blocks whose beginning indices are greater than or equal to that of the entry name.

The Pass II DECLARE statement routine has been flowcharted.

3.3.4 PASS III (A. Whaley)

Data conversion routines have been written to handle data type conversion for the entire PL1 timesharing system. These routines accomplish type conversion of all types necessary for processing assignment statements, for constructing print lines for input/output operations, and for performing number conversions on constants appearing on source program statements.

For ease of programming and to reduce program size, the four basic data types are handled as follows:

1. Binary Fixed Point. Only one data length, or "precision", is allowed for fixed point numbers. They are stored as 32 bit integers in two's complement form. No fractional precision may be associated with a fixed point number, as is allowed in the IBM version.

2. Binary Floating Point. Floating point data may be 32 or 64 bits, corresponding to standard 360 single and double precision.

3. Character Strings. Length of the string may be from 0 to 255 characters. The PL1 VARYING attribute may be used with character strings. Character strings are stored as EBCDIC characters.

4. Bit Strings. This is the only type handled in a non-standard fashion. Rather than storing a bit pattern, 8 bits per 360 byte, bit strings are kept in the original form in which they appeared on the source statement. This results in a character string consisting of the character representations of ones and zeros. For this reason, all string handling logic is similar, requiring only a check for valid characters in the case of bit strings. Valid lengths are from 0 to 255 bits (EBCDIC ones and zeros).

No other data types are handled in this subset of PL1. The conversion of these four types is handled by sixteen separate conversion routines. The appropriate one is selected on the basis of the type of input data and the desired type of the output data. Both length and type conversion are handled simultaneously.

Several of the sixteen routines are called individually by Pass I of the compiler to facilitate conversion of constants input on source statements. The format item operators and DATA- and LIST-directed transmission routines also invoke these sixteen routines to produce or decode character representations of the data types they handle.

During processing of assignment statements, only coded descriptors of the data involved are immediately available. Therefore, a central routine known as TYPCONV is called with two of these descriptors. The routine analyzes the descriptors, and constructs actual storage addresses and lengths and invokes the correct routine of the sixteen available to handle actual conversion. Allocation of storage is also handled if the destination descriptor indicates that this is necessary.

TYPCØNV also handles the conversion of complex data by forcing it to appear as two separate items of non-complex form.

3.3.5 Phase 0--RJE and Filing System (A. Whaley, N. Weidenhofer)

The test version of the Remote Job Entry system which uses the BLAM (Basic Line-numbered Access Method) filing system is now on the air on a permanent basis and functioning well enough to allow a user to build a file, modify it, and submit it to be run in the batch system. On the negative side, crashes are still frequent and file integrity is below the acceptable level. Programs to dump the contents of the disk on tape and reload it have been written and work most of the time. Since the dump and load programs have been written to deal with the saved files rather than with disk blocks (logically rather than physically oriented), they also serve to clean-up the files to some extent and compact them so that they occupy less disk space. As soon as they are more completely debugged their regular use should go far toward improving file integrity.

To log on to the timesharing system, the user should do the following:

1. Turn on the teletype and press the carriage-return key.

The system should respond:

```
#<console number> TIME SHARING ON  
ENTER PS#, USER NAME
```

2. The user must then type in his problem spec number. (leading zeros not required) and name by which he is known to the system. The user name is limited to eight alphanumeric characters--periods, blanks, and other special characters are not allowed and may not be "protected" by apostrophes.

The RJE system accepts the following commands:

```
RUN <file name>, <file name>,...
```

"RUN" concatenates the files named and transmits them, line-at-a-time to ASP to be submitted as a batch job. Each line of the several files is truncated or padded to eighty characters with the last eight characters being the line number.

DEST <file name>

"DEST" (DESTROY) causes the file named to be deleted from the user's catalog and the space used for it to be released for re-use.

LOGOUT

LOGOUT closes the user's catalog and logs the user out from the system.

OPEN <file name>

"OPEN" issues an open command to the file system so that the user can begin to build and/or modify the file named. If a file with that name does not already exist in the user's catalog, one is created.

CLOSE

"CLOSE" closes the file the user currently has open, allowing him to issue another "OPEN" or a "RUN" command.

LIST <line#> <line#>

"LIST" causes those lines in the file whose line numbers fall between the numbers specified to be copied to the user's terminal. Both line numbers are optional; if one is supplied, the file is listed from that line to the end. If neither is supplied, the entire file is listed.

DEL <line#> <line#>

"DEL" (DELETE) causes those lines whose numbers fall between the numbers specified to be removed from the file.

A line may be added to or changed in a file by typing the line preceded by the line number and a space.

Besides handling user's terminals, the RJE system accepts data from ASP, putting it into a user's file as described earlier. Each record in the data set transmitted by the FILE DSP is preceded by a line number generated by the file system and written into the user's file. The line numbers begin at 1.000 and are incremented by 1.000 for each record.

Among the holes to be filled are:

1. listing the user's catalog.
2. improving file integrity, especially around crashes

and several others

3.4 Computer Design

At a theoretical level, techniques are being explored for the "optimization" of microprogram control parameters, while at a practical level, a small remote graphics console is being designed.

3.4.1 Microprogram Optimization (L. Greninger)

Of the three ways mentioned in the last report for minimizing the number of bits of control memory necessary to hold a given micro-programming (minimize the number of instructions, minimize the width of the instructions, and maximize the multiple use of instructions), work this quarter concentrated in the first, minimizing the number of instructions. Since a formal automatic minimization of this sort takes too much time, work has been directed toward an interactive system where the messy and time consuming cases are handled with the aid of the user.

The system envisioned will use the PDP-8/DEC 338 as the man-machine interface but will run on the 360/75. The program to be minimized will be stored as a Sutherland flow graph. The user will draw on the CRT a flow graph F together with a second flow graph F'. The system will then locate all instances of F in the stored program and replace them each by an instance of F'. It will be possible to input a number of these flow graph pairs along with directions as to the order and circumstances under which they are to be applied to the stored program.

Once the system has done the requested substitutions it will display on the CRT the effects of each of the substitutions it has done. If the user sees an instance where some different substitution might have been done with better results, then he can stop the system, input a new

pair of flow graphs with new directions, and ask the system to try again.

When the user is finally satisfied that the program is minimal, the system will transform the flow graph of the program back into a sequence of instructions utilizing a minimum number of registers. It will also attempt to reformat the instructions so as to minimize their width.

The heart of this system is a graph storage and manipulation system. This system, called GRAPH⁴, is designed to handle the building, storing, and modification of graphs, subgraphs, and graphs of graphs, as well as subgraph recognition and extraction through template matching.

GRAPH⁴ is currently in its fourth iteration. It is being programmed in FORTRAN IV using WATFOR due to the excellent debugging facilities available. An attempt has been made to map the FORTRAN routines into macro calls, but the 360 macro format has proved too restrictive to make the resulting gain in efficiency worth the effort. Dissatisfaction with the 360 macro system lead to a survey of all literature available on macro systems. Many fine systems were found but none of them were done on the 360. Time limitations precluded writing a new macro system, so programming for GRAPH⁴ continues in FORTRAN IV.

3.4.2 Graphical Input Device to the Display Terminal (J. Rettig)

The A-D convertor which will be used to track our analog input device has been designed and built. The x and y analog voltages are converted during each sector gap time and the tracking cross is displayed during one of the sector gap times. The x and y display registers are used in the conversion. Therefore, the contents of these registers must be placed in temporary registers during the sector gap. During the sector times, the x and y analog input voltages will be compared with the x and y voltages applied to the display, and an interrupt will be generated when they are equal. During each sector gap a signal will be generated by the convertor to indicate that the A-D conversion is complete. At this time the CPU can obtain the position of the analog input device.

An incremented joystick has been built and will be tested as soon as the A-D convertor is working satisfactorily. The possible use of a resistance sheet as input to the display scope is also being considered. A 4" by 6" piece of stannic oxide coated glass has been tested. The resistance ($80 \Omega/\text{sq.}$) of this sample has been found to be uniform and the coating seems to be fairly durable. Currently, no satisfactory method has been found to make contact to the stannic oxide coating with negligible contact resistance. We plan on spraying contact pads of silver filled epoxy on the glass and clamping a piece of copper foil on top of the pad. We must also decide upon a suitable stylus to pick up the x and y voltage from the tablet. Three types of stylus are being considered: a lead pencil, a ballpoint pen, and a graphics pen.

Other types of resistive sheet material such as plastic with graphite embedded in it and glass with a chromium coating are also being considered. Glass has the advantage over the plastic sample of transparency. Thus, images can be projected onto it and traced. However, a scratch on the glass may cause a discontinuity in the current flow and in the x and y coordinate voltages. We have obtained a sample of the chromium coated glass and we plan to test the uniformity and durability of the surface.

Two possible methods exist for generating the x and y voltages across the length and width of the tablet. The first method is to attach diodes with series resistors several places along each edge of the resistance sheet. The series resistance can then be varied to compensate for contact resistance and for forward-biased diode resistance to insure equipotential lines which are parallel to the edge. If five contact points are applied along each edge, the effective area of the sheet is reduced by a strip along each edge which is .75 times the distance between contact points. The second method which could be used would be to lay an arc*

* A circular arc can be used because it was shown that if its radius is r/R (where r is the resistance per square of the sheet and R is the resistance per unit distance of the linear, shaped material) then the equipotential lines are straight and parallel.

of a material which has a low linear resistance (1 to 10 ohms/in.) along each edge of the tablet. The effective area of the tablet is reduced by the area of the tablet which is outside the arcs. The first method mentioned will be used on the first resistance tablet which is built. The second method mentioned would be desirable if arcs of a material with a low resistivity could be placed on the glass during the coating process.

3.4.3 General Description of Arithmetic Unit (R. Hostovsky)

Sixteen bit arithmetic unit shown as two eight-bit sections.

Generation of 3 bit Code for Incremental Display

The micro order APV has been designed for vector plotting. Small format Cartesian vector plotting uses the upper and lower parts of the ALU separately. Two's complement representation is implied here. Register X should be incremented if the upper ALU overflows (upper overflow OF_0 is the logical function $\bar{a}_0 \bar{b}_0 c_0$ where $a_0 b_0$ are sign digits of the operands ("0" = positive) and c_0 is the carry into the most significant stage of the adder;

Register X should be decremented if upper ALU underflows
(underflow UF_0 is $a_0 b_0 \bar{c}_0$);

Register Y should be incremented if OF_8 ;

Register Y should be decremented if UF_8 ;

Also the VP operation preserves the sign of an addition on overflow or underflow, i.e., do remains "0" after two positive numbers overflow the adder. Normally, overflow results in a negative representation of the "sum" (do = 1).

Thus, the upper and lower ALU add positive operands module 128 and the number of whole multiples of 128 is generating the incremental code.

ΔX and ΔY are 7 bits each, and they say by how much X and Y should be incremented, respectively.

For positive ΔX and ΔY overflows OF_0 and OF_8 will be generated at rates proportional to ΔX and ΔY , respectively, i.e., the original X and Y should be incremented proportionally to ΔX and ΔY . After 64 cycles there would be exactly ΔX overflows from the upper ALU and exactly ΔY overflows from the lower ALU. By cycle I mean the repetative addition of ΔX and ΔY to the former sum.

After each cycle OF_0 UF_0 OF_8 UF_8 are checked and the three-bit code is generated accordingly:

OF_0	UF_0	OF_8	UF_8	<u>3 bit code</u>
0	0	0	1	100
0	0	1	0	000
0	1	0	0	110
0	1	0	1	101
0	1	1	0	111
1	0	0	0	010
1	0	0	1	011
1	0	1	0	001

Micro-Code Outline (Arith/Logical Orders):

These orders add or perform a logical operation on the contents of two nominated registers and send the result to a third nominated register. Two's complement representation is used. Most of the machine registers are included so that many functions can be performed with these orders. For example, the core address being indexed by the contents of another register.

Another feature is the ability to repeat the same order or to backup and execute the previous one. This loop should be terminated upon satisfying some external condition.

- a. ABA. The basic arithmetic/logical order combines operands a and b by addition or by digitwise logical operations.

- b. ADR. Perform the same operation as ABA but in addition to it decrement a counter register R, so that in one micro order three operations are included: arith op, decrementing counter op, and repeat order. This goes on and on until R gets to some value, usually zero.
- c. APV. As discussed in separate paragraphs, APV keeps adding ΔX and ΔY to themselves in order to cause overflow (under-flow) and thus generating the three bit code for incremental display.

e.g. APV, U/L, RP, A+C $\leftarrow$ A

A register has been set at the beginning to zero. C contains ΔX (C_{0-6}) and ΔY (C_{8-14}).

d. ACO.

The same as ABA but only puts the micro program constant field in some designated register.

Transfer Order

This order executes register to register transfer.

Block transfers will be performed by this order. Data will be read from core to some read-write register M and data will be transferred to nominated register. The core will be addressed by some register N which will advance upon moving data to and from M.

Set Mode Register

Bits of register S are set independently.

These bits are available for the condition register.

3.5 Numerical Analysis, Library Development (L. Fosdick)

The first of a series of quasi-interactive programs for short numerical computations was designed, and programming is nearly completed. This program allows the user to easily perform matrix operations, including inversion and solution of linear systems of equations. It is called a quasi-interactive system because the nature of the interaction is rather limited: the program requests data, for instance, "Please type the value of $A(1,1)$ ", but it does not converse with the user during, say, the inversion calculation if an ill-conditioned system is detected. In general, the conversation between the system and the user is only for fixing certain parameters necessary for calling a standard library subroutine. Once the subroutine has been called no further conversation is permitted for that job. After this program has been put into operation, a similar program for numerical quadrature will be constructed.

Trouble with library subroutines that has been detected after installation of a new release of the operating system has stimulated us to construct a master library subroutine checker. This checker is now complete except for about six library routines which are not checked. The checker is designed to call every library routine (excluding FORTRAN supplied functions) three times using three different parameter sets and checks the results against known results at several adjustable thresholds of error. The number three is arbitrary and may be any other number. If there is an error exceeding threshold the word NO is printed, otherwise, O K is printed. Thus there is only a single line of output for each parameter set tested. It is hoped that this system will allow us to catch most errors caused by system changes or accidental destruction of our library.

Systematic timing of all of our library subroutines, except four subroutines, has been completed. This information is now being incorporated in the short form library routine write-ups.

3.6

The disk is capable of transferring 1360 word blocks to and from the memory with reliable results. No test has been made on the reliability of information when retrieved after an interval of more than 30 minutes, as of this time.

Transfers are accomplished by the use of four IOT instructions:

IOT 6551 gates memory block starting address to the disk address register from the accumulator.

IOT 6562 gates control and disk block address information from the accumulator to the disk registers.

IOT 6561 skips on disk done.

IOT 6552 . clears disk done.

Control word format is:

ACC. BITS	0123	45678	9	10	11
	DISK SECTOR	DISK TRACK	TR. DIR.	EXTENDED	ADDRESS
	1-12	0-15	1=READ 0=WRITE	2	1

IOT's 6551 and 6552 may be combined as microinstruction 6553 which transfers the address to the disk and clears disk done.

EXAMPLE PROGRAM FOR DISK READ AROUND

```

50-0200  STARTING ADDRESS OF DISK WRITE BLOCK
51-0410  WRITE CONTROL WORD (SECTOR 1, TRACK 1, TR. DIR. "0")
52-0200  STARTING ADDRESS OF DISK READ BLOCK
53-0415  READ CONTROL WORD (SECTOR 1, TRACK 1, TR. DIR. "1"
          EXTENDED MEM. BANK 1)

```

START

```

100-7200    CLEAR ACC.
101-1050    TAD 50 LOAD LOC 50 TO ACC.
102-6553    IOT TRANSFER ACC. TO DISK, CLEAR DISK DONE
103-7200    CLEAR ACC.
104-1051    TAD 51, LOC 51 TO ACC.
105-6562    IOT TRANSFER ACC. TO DISK
106-6561    SKIP ON DISK DONE
107-5105    JMP-1
110-7200    CLEAR ACC.
111-1052    TAD 52 TO ACC.
112-6553    IOT TRANSFER ACC. TO DISK, CLEAR DISK DONE
113-7200    CLEAR ACC.

```

114-1053 TAD 53 TO ACC.
115-6562 IOT TRANSFER ACC. TO DISK
116-6561 SKIP ON DISK DONE
117-5116 JMP-1
120-5100 JMP TO START
121-
122-

The disk at this time appears to have sustained a massive head crash. The clock tracks have been wiped out, and the whole disk unit has been shipped back to the manufacturer for repair.

An interface to Illiac III from the PDP-8 has been designed, built, and checked out. The cabling is in and final testing will be performed in the near future.

The graphic input terminal tracking cross generator logic has been built and wired in. It is currently in a check out state.

4. ILLINOIS PATTERN RECOGNITION COMPUTER: ILLIAC III
(Supported by Contract AT(11-1)-1018 with the U.S.
Atomic Energy Commission)

Illiac III is an experimental computer being designed and constructed by the Department of Computer Science as a first instrument to explore the potentialities of high speed image processing. Besides providing normal computational facilities, the machine includes a parallel processor for visual data processing (the Pattern Articulation Unit) and an extensive complement of visual input/output equipment.

4.1 Outline of Illiac III Programming Developments

The section numbers of the outline below correspond to section headings of this Progress Report.

4.2 Operating System

4.2.1 Data Acquisition and Display

4.2.1.1 Image Processing Package (IP^2)

4.2.1.2 Telecommunication Processing Package (TP^2)

4.2.2 Data Segmentation

4.2.3 Multiprocessing and Interrupt Handling

4.3 Translators

4.3.1 IBAL Assembler Language

4.3.2 PL/1

4.4 Experimental Image Recognition Procedures

4.4.1 Graph Transformation Grammars

4.4.2 Experimental Model

4.2 Operating System

4.2.1 Data Acquisition and Display

4.2.1.1 Image Processing Package (IP²)

As the basis for developing an adequate language for image description and recognition, a review of graphical languages and recognition models has been undertaken. Representative languages have been evaluated with respect to criteria we have established. No language or combination of languages satisfies all of our criteria.

Work is in progress on a language as powerful as existing languages and with additional capability of expressing varied modes of concept formation.

John C. Schwebel

4.2.1.2 Telecommunication Processing Package (TP²)

A task is the smallest unit operation which the computer may be requested to execute subject to a given deadline for completion. The command or instruction which causes the task to be executed is called a task directive. Accordingly task directives are commands or messages sent from the user's console to the computer to specify the next gross action the computer is to take.

The set of permissible directives defines a programming language — one that is directly interpreted by the supervisor program. All other languages available to the computer system are considered subservient to this Task Directive Language. For this reason the latter language has been kept as simple and transparent as possible so as not to needlessly burden the user.

A description of the language can be found in File No. 782, "Task Directive Language for the Illiac III Computer" by Linda M. Katoh, December 9, 1968.

4.2.2 Data Segmentation

In spite of draft notices, etc. this quarter, work continued on the problems of segmentation. In particular, a tentative design has been reached which appears well suited to multi-processing and/or multiprocessing. Work presently centers on specifying the exact effect of this design on the TP control design.

J. D. Wick

4.2.3 Multiprocessing and Interrupt Handling

During the past quarter, a scheme has been formulated to facilitate interrupt handling in multiprocessing environments. In particular, the hardware associates interrupts with the generating process and not the executing processor. In general this feature allows processors to be treated as an anonymous pool and should greatly reduce the necessity for inter-processor communication.

A paper setting forth the details as currently envisioned is now in progress.

R. M. Lansford

4.3 Translators

4.3.1 IBAL (Assembler Language)

Work was continued on Pass 1 of the IBAL translator during the quarter. The source program's block structure is incorporated into the structure and identifier table by including the block number as an attribute with the identifier's entry.

Subscript bounds are handled more completely. The string defining each bound is recognized and placed into the output string in the same manner as other program elements, with a tag which is also stored in the structure table along with the subscript's entry. The bound will be evaluated (or if it is variable, code will be produced to evaluate it) during a later pass.

Initial constants for identifiers are recognized as to type and pushed into a stack in more easily evaluable form, and a pointer to the constant is placed in the structure table. Some diagnostic messages regarding syntax of initial constants have been added.

It is anticipated that the only further major additions that will have to be made to Pass 1 are suitable indication of alternate access structures and conditional format items.

S. T. Baird

4.3.2 PL/1

During this quarter a set of nearly 450 productions for PL/1 was completed. In addition, the set of actions necessary to build tables during the Declaration pass was finished.

R. M. Lansford

4.4 Experimental Image Recognition Procedures

4.4.1 Graph Transformation Grammars

Work continued on the study of the precedence of image processing relations with respect to some specific graph transformations. The concept of a reversible transformation, i.e. an information lossless transformation, was defined. This concept was used to determine the relative precedence of our set of common image processing relations. One useful result is that the use of an information lossless transformation in a recognition procedure can be justified without regard to the particular application area or constituents involved.

4.4.2 Experimental Model

Experiments were conducted using a model in which an observer can sequentially view subparts of a scene, selectively choosing at each step the location of the next subpart in the sequence.

Line drawings of geometric figures, and slides from microscopic pathology were used as subject areas.

Strategies used by the subjects in selecting subpart placement were readily apparent in the highly structured area of geometric drawings but were not apparent in the examination of the random configuration of cells in human tissue. This may be due to the fact that continuous areas of the scene were the only subparts allowed in the selection process.

Further work with this model awaits the development of an adequate language to describe the structural and procedural aspects of recognition.

John C. Schwebel

4.5 Outline of Illiac III Computer System

The section numbers of the outline below correspond to section headings of this Progress Report.

4.6 Central System

- 4.6.1 Taxicrinic Processors
- 4.6.2 Fast Core Storage Modules
- 4.6.3 Arithmetic Units
- 4.6.4 Interrupt Unit
- 4.6.5 Pattern Articulation Unit
- 4.6.6 Exchange Net and Exchange Net Simulator
- 4.6.7 Status of the Main Frame Assembly

4.7 I/O System

- 4.7.1 I/O Processors
- 4.7.2 Channel Interface Units

4.8 Peripheral System

- 4.8.1 Secondary Storage System
- 4.8.2 Scan/Display System
 - 4.8.2.1 Scanner-Monitor-Video Control
 - 4.8.2.2 Prototype Scanner
- 4.8.3 Intermachine Link to DEC PDP-8 and 338 Display
- 4.8.4 Low Speed Terminal Network
 - 4.8.4.1 Low Speed Communications Net
 - 4.8.4.2 Low Speed Buffers
 - 4.8.4.3 Low Speed Terminals
 - 4.8.4.3.1 Monitor Selectric Typewriters (5)
 - 4.8.4.3.2 Monitor Magnetic Tape Module (5)
 - 4.8.4.3.3 Mod 33 ASR Teletype Sets
 - 4.8.4.3.4 Analog Instruments

4.9 Power Distribution

- 4.9.1 Primary DC Power Supplies
- 4.9.2 Power Distribution System
- 4.9.3 Control of Power Distribution Systems
- 4.9.4 A.C. Power Distribution System

4.10 Unassigned Equipment Pool

- 4.10.1 Circuit Card Inventory
- 4.10.2 Test Equipment Additions: Commercial
- 4.10.3 Test Equipment Additions: Custom-Designed

4.11 Documentation

- 4.11.1 Engineering Manual
- 4.11.2 Circuit Books
- 4.11.3 Logic Book
- 4.11.4 Wiring Tables
- 4.11.5 Opto/Mech. Design

4.12 Circuit Research and Development

4.6 Central System

4.6.1 Taxicrinic Processors

4.6.1.1 Documentation

Progress continues on the TP manual. The interrupt system description is currently being integrated into all sections of the manual.

4.6.1.2 Logical Design

The TP interrupt system is currently being integrated into the overall TP design. The various modifications to the control sequence flowcharts have been made. The basic operation of the Interrupt Control sequencing has been worked out and is currently being implemented.

4.6.1.3 Hardware and Wiring

One TP lower bay has been returned from the wiring vendor.

B. J. Nordmann

4.6.2 Fast Core Storage Modules

This quarter each Fabri-Tek core was checked out, on line, using SPEW (see 4.7.6). Some discrepancies were found as follows:

Core 66700

- 1) 1 wiring error
- 2) 1 bad Burndy contact

Core 66701

- 1) 1 bad IC on parity adder board
- 2) 1 bad IC on Y-driver adder board
- 3) 1 bad etch on receiver adder board

The first of two sets of modifications to the Fabri-Tek cores has been completed and checked out. The remaining set of modifications should be completed during February 1969. These modifications are required to make the core modules compatible with the Exchange Net.

Several on-line, error free runs were completed with each core and SPEU. During these runs, both data and parity were checked. Programmable data patterns were sequenced, by SPEU, such that every data pattern was used in every core address. A test at the byte read/write control bits was also incorporated in the sequencing.

S. P. Krabbe

4.6.3 Arithmetic Units

4.6.3.1 Logical Design

During the last quarter logical design of the A.U. control has continued. The control flowcharts, in a form which may be routinely mapped into logic, have been completed. Some refinement of these flowcharts takes place as the actual logic is specified.

As the detailed design of control logic continues, we are attempting to document the steps required in the transformation of flowcharts into logic (T.I. 7400 series). Such documentation will be of value to other designers and serve as a basis for the implementation of a computer program to perform this task.

4.6.3.2 Hardware and Wiring

Three configurations of control point boards have been specified and prototypes have been constructed. The three boards represent a varying tradeoff between flexibility and packing density.

Wiring tables for the 475 cards (per AU) of the processing hardware is now complete. Revisions made on the work prints during the course of wiring table preparation are now being transferred to the original drawings. The wiring tables are then being checked against the revised drawings.

D. E. Atkins

4.6.4 Interrupt Unit

No additional work was done on the design of the Interrupt Unit because of commitments of higher priority.

4.6.5 Pattern Articulation Unit

4.6.5.1 Logical Design

No work has been done on the design due to other commitments. It is hoped the design will be completed near the end of next quarter.

4.6.5.2 Documentation

No positive progress made during the past quarter.

4.6.5.3 Hardware and Wiring

The Display System has been debugged and all documentation brought up to date. The 32 Local Control cards are being fabricated.

Power wiring to Section 3 (Iterative Array) is partially complete. It is anticipated that a portion of the IA will be checked out during the next quarter.

R. T. Borovec

4.6.6 Exchange Net and Exchange Net Simulator

This quarter, wiring lists for the Exchange Net were completed and wiring was started.

SPEU (Simulator for Processor, Exchange, or Unit) checkout is complete. This last quarter, SPEU was used for the online checkout of our two Fabri-Tek core memory systems (see 4.7.2).

S. P. Krabbe

4.6.7 Status of the Mainframe Assembly

The following list of items describe mainframe progress during the last quarter.

1) Logical and power wiring completed on sections 1 and 3 lower (Iterative Array). These two half sections are now installed in the mainframe. This completes the Iterative Array.

2) Logical and power wiring completed on Section 6 (Taxicrinic Processor minus control). This section is now installed in the mainframe.

3) A request for bids on a false floor, for DCL 223, that overlaps the existing false floor in DCL 280, was issued this quarter.

4) DC power distribution has been started inside the mainframe of Illiac III.

This quarter, the following wiring lists were made using POOL I.

<u>Subsection</u>	<u>Section #</u>	<u>Number of Wires</u>	<u>Comments</u>
Taxicrinic Processor	6	9622	
Simplified Scanner (Row A)	33B	926	
Simplified Scanner (Row B)	33B	257	
Exchange Net	13	5377	
Exchange Net	14	7536	
IA Display	1 and 3	1552	No revision

S. P. Krabbe

4.7 I/O System

4.7.1 I/O Processor

The subsystem of the I/O Processor responsible for data transmission (the request service unit) has been reexamined this quarter. A preliminary design study was completed by John Hayes in 1967, but layout work was postponed because of the Taxicrinic Processor and Scanner-Monitor-Video Controller design activities. The Hayes design has been retained in form but has been considerably simplified.

A reorganization of that part of the IOP responsible for executing device independent commands is also underway. Besides certain simplifications in design, the main motivation of this latter work is to permit easy transplantation of modules of the Taxicrinic Processor control. For example the addressing structure of both boxes is common.

Present logical design activity is centered on realizing a first interface to core through a Channel Interface Unit, employing that subset of the IOP which is essential to the task.

B.H. McCormick

4.7.2 Channel Interface Unit (CIU)

Work in this area has been necessarily divided into three groups:

- 1) Documentation (4.8.2.1)
- 2) Logic Implementation (4.8.2.2)
- 3) Construction (4.8.2.3)

4.7.2.1 Documentation

While documentation is a continuing process through all work groups, in this instance we are referring to the processes of:

- 1) Complete perusal of earlier data for the purpose of separating documentation of historical interest only from that which can be used for implementation of the CIU as it will eventually exist. (Complete)
- 2) Upgrading of flowcharts, written data and logic diagrams for correction, streamlining, practicality, and ease of use. Since signal requirements, sequences and processes are now firm, this work is proceeding at a reasonable rate. (approximately 25% complete)

4.7.2.2 Logic Implementation

This consists solely of construction of logic diagrams for implementing processes designated by flowcharts and current written data.

Since firming up of processes designated in paragraph 4.8.2.1, and design, layout and acceptance of a firm Control Point circuit and printed circuit boards, this particular work group is proceeding rather faster than the documentation (approximately 60 to 70% complete)

4.7.2.3 Construction

This includes PCB selection, layout, generation of wiring lists; actual wiring; and mechanical construction. Work in this area must wait until documentation and logic implementation are nearly complete.

Therefore no work has been done on this particular group, with the exception of mechanical construction. Card drawers and racks were constructed some time in the past and are essentially complete.

J. V. Wenta

4.8 Peripheral System

4.8.1 Secondary Storage System

No developments are anticipated here until after October 1969 due to budgetary constraints.

4.8.2 Scan/Display System

4.8.2.1 Scanner-Monitor-Video Control

A flowchart description of the controller reflecting modularity and control point implementation is nearing completion.

Preliminary flowcharts have been drawn for the section of the control unit which will provide the standard IBM System/360 I/O Interface signals as defined by the appropriate IBM SRL. Several poorly defined sequences are under further investigation.

For the basic structure complete detailed drawings have been drawn for the counter structure. The register structure, the equality function, the theta function, and the input/output buffers have been completely specified. The remaining four functions are currently being specified.

A paper entitled "Scan-Display System of the Illiac III Computer" was accepted for presentation at the Spring Joint Computer Conference in Boston in May 1969. This paper describes the integrated system used for image acquisition and display that is under the supervision of the Illiac III Scanner-Monitor-Video controller. The major goal of the paper is to abstract the system parameters and to develop the relations among them.

L. Dunn
V. Tareski

4.8.2.2 Prototype Scanner

A simplified scanner has been built as a means of testing various logic and analog portions of the final SMV system. The simplified scanner scans a 512 x 512 raster in one of 64 selected areas of the object film, packs the gray level information into 32 bit words and stores this information in one of the Fabri-Tek memories. The same logic permits the stored information to be extracted, decoded and displayed on a monitor. The system is operational except for adjustments to be made in electrical and optical focusing, in timing of the DAC circuits and in photomultiplier signal conditioning filters.

J. L. Divilbiss

4.8.3 Intermachine Link to DEC PDP-8 and 338 Display

The PDP-8 link logic has been designed and debugged. One small error still occurs, namely the parity error flag is set whenever the space bar on the teletype is hit.

A series of programs, GRITS (General Interface Testing System), was written to facilitate checkout; a second series of programs is currently being developed to help in the checkout of the Herative array.

The work on a master system program which would allow the engineers to write code in a simple macro-like language has been temporarily halted due to the need of the project's programmer in another area.

R. T. Borovec

4.8.4 Low Speed Terminal Network

4.8.4.1 Low Speed Communications Net

No progress made during this quarter.

4.8.4.2 Low Speed Buffer

4.8.4.2.1 Low Speed Buffer Control

Because of changes from the original operating specifications, the design of this unit is being completely re-evaluated. The packaging and physical location of this unit is also being considered.

4.8.4.2.2 Buffer Memory

This unit has satisfactorily completed its initial testing phase and slight modifications are being made based upon the results of these tests.

4.8.4.3 Low Speed Terminal

4.8.4.3.1 Monitor Selectric Typewriters

There has been no changes in the status of these units during the past quarter.

4.8.4.3.2 Monitor Magnetic Tape Modules

The type of format and associated hardware required for these units is still being investigated.

4.8.4.3.3 Teletype Sets

(1) Mod 33 Teletype unit has been interfaced with the DEC PDP-8 to provide I/O with Illiac III.

4.8.4.3.4 Analog Instruments

No further design has been completed in this area due to prior design commitments.

R. G. Martin

4.9 Power Distribution

4.9 .1 Primary D.C. Power Supplies

All fire damaged power supplies have been repaired, tested and are now operational.

While it is evident that additional primary supplies will be needed as future current requirements are realized, initial sections of the machine will be adequately supplied by the units now on hand.

All primary distribution cables have been laid and connected to the distribution centers.

4. 9.2 Power Distribution System

4.. 9.2.1 Primary D.C. Distribution Center (Room 223)

The connection of modine channels, capacitors, buss bars and associated cables for (1) PAU wing (Section 3) has been initiated and will be completed by the next quarter.

4. 9.3 Control of Power Distribution System

The wiring of the card racks used to control the power distribution to section 3 of the mainframe has been started this past quarter.

4. 9.4 AC Power Distribution System

There have been no further additions or changes in this section during the past quarter.

R. G. Martin

4.10 Unassigned Equipment Pool

4.10.1 Circuit Card Inventory

The printed circuit cards required for the minimum version of the Illiac III have been allocated and are stored per section of the machine. Using this procedure, there should be no confusion as to the location and stock disposition of a particular type of card required for a given section of the machine.

In addition to the assigned printed circuit cards, there is approximately 4000 cards in open stock which will be used for prototype and new design testing.

4.10.2 Test Equipment Additions: Commercial

No additional commercial equipment obtained during this quarter.

4.10.3 Test Equipment Addition: Custom-Design

A storage core simulation tester has been constructed for the checkout of the Fabri-Tek fast core storage modules.

R. G. Martin

4.11 Documentation

4.11.1 Engineering Manual

This manual has been updated with the latest additions of new circuit drawings and engineering comments.

R. G. Martin

4.11.2 Circuit Books

Work was completed for release on thirty circuit cards. Work was either new circuit or variation of existing circuits. In addition eight change notices were processed on circuitry.

4.11.3 Logic Book

Work was completed for the EU and TM intermediate drawings. The TP logic was revised twice during this time. Power logic documentation is half completed.

4.11.4 Wiring Tables

No changes on the wiring tables were reported.

J. Otten

4.11.5 Opto/Mech. Design

From October 1, 1968, through December 31, 1968, twenty four (24) new detail, assembly and layout drawings have been made.

Four (4) additional drawings have been processed according to engineering change orders.

Six (6) work orders have been placed with our machine shop.

Opto/mechanical design of the manually-controlled microscope slide scanner was completed during this quarter.

S. Zundo

4.12 Circuit Research and Development

This quarter saw the completion (in final printed circuit form) of several analog and IC circuits.

1018-300-00	These two card types make up a digital to analog conver-
1018-306-00	sion system with speed and stability superior to com-
	mercially available units. Much time was spent in
	developing these circuits but our efforts seem well
	rewarded.
1018-301-00	Digital control of CRT beam brightness plus phosphor
	protection in the event of logic failure.
1018-302-00	A thirty section tapped delay line with receivers. Ten
	nanoseconds per tap.
1018-303-00	Sine and cosine function generators for use with the
1018-307-00	diquadripole lens.
1018-304-00	Integrated circuit control point logic and associated
1018-305-00	delay modeling circuit.
1018-308-00	High speed clock (4 NS risetime) for use with DAC buffers.
1018-309-00	A digitally controlled analog switch. Logic input deter-
	mines which of four analog inputs (+sine, -sine, +cosine,
	-cosine) appears on output.
1018-310-00	A logarithmic amplifier used in photomultiplier signal
	conditioning.

J. L. Divilbiss

4.13 Bibliography

During the past quarter the following reports and file numbers were issued:

Reports

Report No. 291 Flowerdew, Stanley J., "LEFT: A Language for Editing and Formatting Text, October 30, 1968.

File Numbers

File No. 780 Flowerdew, Stanley J., "Automatic Karyotyping: A Statement of the Problem and Summary of Image Processing Procedures", November 6, 1968.

File No. 782 Katoh, Linda M., "Task Directive Language for the Illiac III Computer", December 9, 1968.

File No. 550-118 Krabbe, S. Paul, "Specifications for Termi-Point Wiring of Section 6 (Taxicrinic Processing) of the Illiac III, November 29, 1969.

File No. 550-119 Krabbe, S. Paul, "Specifications for Wire Wrap of Section 13 (Exchange Net), November 6, 1968.

File No. 550-120 Krabbe, S. Paul, "Specifications for a 9" False Floor for DCL 223 that Overlaps the Existing False Floor in DCL 280, November 5, 1968.

File No. 550-121 Krabbe, S. Paul, "Specifications for Wire Wrap of Section 14", November 5, 1968.

Other Publications

Atkins, D.E., "Higher Radix Division Using Estimates of the Divisor and Partial Remainders," IEEE Transaction on Computers. Vol. C-17, No. 10, (October 1968), pp. 925-934.

4.14 Illiac III Staff¹

Senior Staff

Dr. James L. Divilbiss - Principal Research Engineer
Dr. Robert M. Lansford - Research Associate
Professor Bruce H. McCormick - Principal Investigator
Professor Sylvian R. Ray
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*Richard P. Harms
*Bernard J. Nordmann
*Val G. Tareski

Programmers

*Stuart T. Baird
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5. ILLIAC IV

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REPORT SUMMARY

The following major problems became apparent during this quarter.

Semiconductor Devices

As a result of detailed investigation and continuing pressure by Burroughs, information was obtained that Texas Instruments (TI) was in considerable difficulty developing the MSI devices for ILLIAC IV. The problems TI encountered fell into the categories of testing equipment and obtaining multilayer substraits. The ILLIAC IV MSI devices are 80 pin devices and the only available tester is a 44 pin tester. TI attempted to purchase other testers but the subcontractors were not able to produce. TI had contracted with American Lava to supply ceramic substraits. For a variety of reasons American Lava was not able to produce. As a result of the above problems, the PE contract with TI was terminated and an investigation began on replacing the MSI devices. The only solid technology base available to the ILLIAC IV Project were DIL's (Dual In Line). The decision was made to use the DIL's being produced by TI as part of the ILLIAC IV contract. This decision impacts the processing element as the PE was being designed with both MSI devices and DIL's. The Control Unit (CU) had not been designed with MSI devices. Burroughs is in the process of developing a new mechanical configuration for the processing element and making the appropriate modifications to the design to incorporate the details.

Memories Systems

A review of Burroughs' plans and projected cost in producing the thin film memories created a situation whereby the University felt obligated to require Burroughs to solicit bids from industry to provide backup for the thin film memories program. Burroughs issued a request for quotation to memory suppliers, including all the major semiconductor manufacturers. The responses were from semiconductor manufacturers and not a single thin film memory system was bid. In addition, the firm fixed price bids were approximately one-third (1/3) the cost of the proposed thin film system. As a result, the thin film memory program has been terminated at Burroughs and a procurement activity started for semiconductor memories. At this time, Motorola, TI, and Fairchild are providing quotations on ILLIAC IV memories.

Impact on Cost, Schedule and Performance

The retrenchment to a DIL technology will have impact on cost. This impact is in the process of being estimated by Burroughs. Schedule impact is estimated to be in the neighborhood of six (6) months which will provide the first quadrant of ILLIAC IV delivered to the University in June of 1970. The implementation with DIL's will result in a volume increase in the ILLIAC IV. It is estimated that an additional 15 feet will be required per quadrant row. As a result of the volumetric increase a slowdown in the clock system must occur. It is estimated the clock will slow down to about 60 nsec.

Plans for Next Quarter

The major efforts during the next quarter will be to complete the PE design using DIL's to award a contract for the PE memories and to provide detailed information of the above problems on cost, schedule and performance. There have been no significant personnel changes during the last quarter. Current funding is adequate to carry the Project through mid-March.

HARDWARE

5.1 Logic Debugging and Diagnostics

5.1.1 Simulation and Debugging of PE Logic

The logic simulation and debugging of the Processing Element design have been in progress during this quarter. Two programs were written, in this period, to assist in the procedure of debugging - one for counting the logic levels and the other for identifying Boolean equations of major PE signals.

5.1.1.1 Improvement of the Logic Simulator

A few changes were made in the logic simulator program to reduce its running time. The simulator, as well as the Assembled Code Translator, received some changes caused by the altered, sign bit convention.

5.1.1.2 Level Counting Program

A modified version of the logic simulation program, which counts the logic levels associated with the control logic of the PE, was written for the purpose of estimating the time delay and debugging the control logic design. The procedure call statements associated with the control logic were selected out of the logic simulator body, and the parameter type was changed from Boolean variable to integer variable. The new procedures for calculating the logical levels were for all package types, and some additional coding was done to complete the level counting program. It was developed according to a request from the Burroughs' PE designer.

5.1.1.3 Equation Generator Programs

The DEG (DIL Equation Generator) writes an equation for dual-inline packages in the PE. For the latch, DIL type 8, only the signal names are listed. The equation is written using the signal names associated with the package. Input to the program is the wire list which is scanned to separate DIL from MSI packages. The output of this program serves as input to the PE equation generator and can be used as a debugging aid.

The PEG (PE Equation Generator) develops an equation for P-signals in the PE control logic in terms of primitive inputs. A primitive input is a signal external to the PE or it is the output of a latch or an MSI package. The program is an extension of DEG in that it steps through the list of DIL equations generated in DEG and replaces any non-primitive input ~~signals~~ with the equation for the signal in terms of primitive inputs. The output of this program can be used as a debugging aid for the control logic of the PE.

5.1.1.4 Debugging

The simulator program was executed on test inputs from three sources:

- (a) card decks of single cases manually defined,
- (b) PE Exercisor test routines (from Burroughs) translated by the Assembled Code Translator, and
- (c) automatic extraction of microsequences from POSFILE (PE instruction timing sheets).

Mechanization of basic arithmetic instructions, including logical addition and subtraction, fixed point multiplication, and exponent arithmetic, was debugged with card decks. PEX routines for Boolean and shift instructions, mode register instructions, eight-bit mode arithmetic, and some other instructions have also been tested on the simulator. The POSFILE approach was used to debug normalization and floating-point arithmetic instructions. Approximately 50 errors were found by the simulator by the end of this quarter. The major instructions to be debugged in the next quarter include division and some arithmetic instructions with variants.

5.1.2 CU Logic Simulator System

5.1.2.1 Overview

Specifications have been drawn up for two simulator systems to assist in the logical design and debugging of the Control Unit. These are the CU Card Logic Simulator System and the CU Section Logic Simulator System. Although the construction of these simulators will be similar to

that of the PE Simulator described in the previous QPR, several improvements have been included which should yield much greater simulation efficiency. Among these are a capability for parallel simulation of many test cases at the same time and a new simulation control language to permit simple specification of complex simulations.

5.1.2.2 CU Card Logic Simulator System

The purpose of the CU Card Logic Simulator System is to assist in debugging CU printed circuit card designs and to calculate expected responses for various test cases. In addition, it will be used to develop card simulation procedures for inclusion into the CU Section Logic Simulator System. The card simulator system will also incorporate a capability for the modification of the CU Card Logic Simulator to simulate the effect of logic failures. This will help in developing input patterns to be used for production tests and off-line diagnostics of the CU cards.

The CU Card Logic Simulator System will consist of four major groups of programs: the simulator generator group, the data preparation group, the simulator itself, and the results display group. The simulator generator group of programs are similar to those for the PE simulator. They consist of programs which reduce the CU card to a directed graph, make preliminary level assignments, detect loops, perform final level assignments, and then generate the actual simulator body. Two improvements for increased simulation efficiency have been added: logical simulation of the dual-inline packages is performed by in-line coding rather than by time-consuming procedure calls, and loop members are simulated along an optimal (Hamiltonian) path (if one exists) rather than in random order as in the PE simulator.

Much of the CU card logic simulator is similar to the PE logic simulator. However, a new, more flexible simulator input/output system has been designed. Also, the simulator can operate in modes which are not physically realizable but nevertheless are of potential use in logic debugging (e.g., registers can be prevented from changing state and can be preset to any desired contents). Further, the simulator has been designed with two additional goals in mind: first, to provide parallel simulation of up to 47 independent test cases by taking advantage of the fact that the

B5500 performs Boolean operations on full (47-bit) data words, and second, to permit simulation of logic failures by simple modifications to the simulator body.

A new simulation test control language, TESLA, has been developed. This test language permits simple description of desired simulations. The language is very general; its later use with the CU Section Logic Simulator System is anticipated. One unusual feature of TESLA is the incorporation of language elements for simultaneous generation and control of many simulations, thus complementing the parallel simulation capability of the simulator itself.

Since testing and fault diagnosis for the actual CU cards will be performed on the PEX (with a CU card tester adapter), it is desirable to be able to simulate these tests. This will be done by providing a method for translating PEX programs into simulator input.

On December 2nd, a meeting was held with Burroughs designers at Paoli. The proposed card simulator system was reviewed, and several helpful changes and improvements (particularly to TESLA) were suggested. Since that meeting, the design of the CU Card Logic Simulator System has essentially been completed, and coding of the necessary routines has begun. CU cards will be simulated as soon as the necessary netlists become available, with precedence being given to cards from those sections of the CU which will be completed earliest.

5.1.2.3 CU Section Logic Simulator System

Preliminary specifications for the CU Section Logic Simulator System have been developed. It will simulate the logical performance of one entire CU section (FINST, ADVAST, ILA, MSU or TMU). The CU section simulator will incorporate the bodies of the card simulators as procedures. Actual parameters to these procedures will be variables corresponding to the backplane signals.

Each section will also have a functional simulator developed for it. This functional simulator will be identical to the (correctly functioning) CU section logic in external performance, but will hopefully be far simpler in internal construction and thus much more efficient. It will

be constructed, insofar as possible, from narrative descriptions of the desired section performance rather than from actual logic diagrams. Thus, it should be somewhat insulated from simple design errors and should provide a valuable performance standard and source of expected responses.

Since writing a correctly operating, functional simulator exhibiting the same full range of dynamic performance as the actual logic will be no simple task, a bootstrapping technique will be used to permit continuous interdependent upgrading and improvement of the five functional simulators until the desired level of performance is achieved.

An important advantage which will accrue from the development of the functional simulators will be the ability to use actual assembled ILLIAC IV code to test any (simulated) section of the CU. Functional simulation of the other sections will provide the necessary translation of input code into the actual commands and data which are sent to the section under test.

Because a correctly functioning card simulator system is a necessary preliminary to the development of the section simulators, only initial efforts at defining some of the more global aspects of the CU Section Logic Simulator System have thus far been possible. However, substantial portions of the section simulator system design should be completed during the next quarter as designer manpower becomes available and as operating experience with the CU Card Logic Simulator System provides valuable feedback to the design process.

5.1.3 PE Diagnostics Generation

5.1.3.1 Path Tests

The debugging of the expected response calculator for the path test was continued, and the corrections of several errors were made in this period. The path tests will be finalized after the debugging of the PE logic.

5.1.3.2 Combinational Tests

Due to the recent shift from the implementation of the PE in MSI packages to the DIL approach, the test patterns for combinational logic will be reworked in the next periods.

5.2 Design Automation

The major effort of the design automation group, during this quarter, was giving substantial programming support to Burroughs, Paoli, Pennsylvania. The Mohawk data set is continuing to be used for design automation production jobs.

A single board Post-Processor was written and debugged at the University. This Post-Processor, which has new and enlarged specifications, is capable of examining each wire on the PC Board. Work has also begun on a Post-Processor capable of handling the entire CU with inter-board wires.

SOFTWARE

5.3 Operating System

The operating system provides several services each of which is implemented by one or more program modules within the system. The user interface to the operating system is through the job parser which can be driven by any available input media such as tapes, card decks, user operated consoles, or other running B6500 programs.

The collection of programs and some of the data needed on the ILLIAC IV is performed within the B6500 by a program collector.

The scheduling of ILLIAC IV time is performed by three system modules: the disk file allocator, the data pre/post processor, and the job execution monitor. These three programs queue up requests for ILLIAC IV use and assign Disk IV space to them, move any files that are needed onto the disk before a run, save any files by moving them off the disk after a run, schedule the use of BIOM space, and allocate particular ILLIAC IV quadrants to the individual jobs.

There are two main ILLIAC IV resident modules, the loader and OS4. The loader loads program files on Disk IV into the array memory. OS4 provides the standard monitor functions and the I/O execution coordination routines needed by all users.

The running ILLIAC IV job requires at least two intercommunicating programs--the ILLIAC IV resident program and a B6500 resident job partner that coordinates B6500 actions with the ILLIAC IV program and provides all I/O support. Each job must have at least one job partner for all of its quadrants and each job may have as many job partners as it has separate quadrant code streams. A user may choose not to use the system-supplied job partner with the execution of his ILLIAC IV program and may write his own job partner.

The building of I/O descriptors, the initial recognition of interrupts, and the actual issuing of I/O commands to the hardware are functions of a set of routines in the B6500 MCP which are collectively known as the hardware supervisor. Since a user may write his own job partner,

the hardware supervisor also checks all of the I/O requests made by a job partner for validity before passing them onto the hardware.

Most of the modules named above are separately running B6500 ALGOL programs. They communicate with each other through the use of the in-core file facility provided by the B6500 MCP. The hardware supervisor routines (called "MCP intrinsics") are coded in ESPOL to facilitate both the issuing of I/O descriptors and the passing of interrupts to the correct job partner. The ILLIAC IV loader and OS4 are coded in the ILLIAC IV assembly language.

A preliminary version of OS4, the ILLIAC IV resident monitor, is being written and debugged. It soon will be published as a document.

5.4 Translator Writing System

5.4.1 Syntax Preprocessor (BNF → FPL)

During this quarter, the Floyd production and parser pseudo-order generator of the preprocessor were completely rewritten to implement improvements in the algorithm and effect the removal of empty productions and singly defined nonterminals by back-substitution.

The first stage of documentation, which describes the algorithm used in developing the syntax preprocessor, has been completed [1].

The first version of the syntax of Twinkle, a syntax specification language, was punched and partially debugged. During the next quarter, work on Twinkle will be stepped up since the syntax of Twinkle, with comments, will be the next stage of the documentation on the use of the syntax preprocessing portion of the TWS.

5.4.2 Parser (FPL)

The implementation of the improved BNF to FPL conversion algorithm necessitated changes in the parser interpreter. These changes were made and debugged which resulted in faster execution speeds.

The program CONVERT/TWS, which takes the table of parser pseudo-instructions generated by SYNPROF/TWS and converts them to ALGOL, was written and debugged. Prior to the latest changes it achieved parsing times

equal to the scanning times. Early in the next quarter, it will be updated to convert the most recent output from SYNPROF/TWS. A program is being contemplated which will automatically update the program CØNVERT/TWS to solve the problem of the long time lag between the improvements in the parsing algorithm and the correction of CØNVERT/TWS to handle them.

5.4.3 Semantics

During this quarter, the TWS-built ISL translator was completed and debugged. Consequently, the TWS system now has two complete ISL translators: (a) the "brute-force" ISL translator, and (b) the TWS-built ISL translator.

The advantages of (b) over (a) are basically two. First, the TWS-built ISL translator, having been implemented with the TWS system, is easily modifiable by anyone familiar with such a system. This is a very important feature, as it facilitates future extensions of ISL. Secondly, (a) implements a more sophisticated version of OSL than the basic ISL implemented in (b).

The main disadvantage of (b) over (a) is that (b) is considerably slower than (a), as could be expected, since (a) was very carefully optimized by hand. As the TWS system improves, however, it is hoped that the speed of (b) will approach that of (a), and (b) will become the only ISL translator. Tests are now being performed on the speed of the two translators.

Work is also continuing on the documentation of the language and by the end of next quarter a complete ISL manual should be available.

5.5 Compilers and Translators

5.5.1 Tranquil

During this quarter, work continued on the Pass 2 semantics for the Tranquil compiler. Progress on the Tranquil compiler has been delayed by the partial unavailability of the B5500. Documentation of Tranquil specifications and implementation techniques is now available in the form of three MS theses [2,3,4].

Routines which handle all storage allocation and compile time memory maintenance are fully coded and debugged. Some effort at improving the efficiency of the ALGOL coding of these routines has been initiated.

The complex substructure necessary for the analysis of assignment statements has been coded and debugged. Algorithms for code generation for assignment statements have been designed and are partially coded.

The code generation for SIM and SEQ statements has been completed. The algorithms for set storage allocation and usage have been revised to facilitate the usage of a set both as a mode bit pattern and as explicit numbers. The coding for the nondynamic cases of these revised schemes also has been completed. The algorithms are easily extendable for implementation of the dynamic costs.

Several straight forward but time-consuming routines of a general nature have been written. Among these are run-time arithmetic conversion routines for all combinations of conversions involving 32 and 64-bit floating point numbers, 48-bit signed integers, and both compile and run-time translations between set storage forms.

5.5.2 Glypnir

Features which allow routing and indexing have been implemented and debugged during this quarter. Several new debugging features have been added and a number of changes were made in the syntax to improve error detection and recover.

In addition, several changes were made in the semantics in an attempt to increase the speed and lower the core storage requirement, but these met with little success. B5500 mix time has been improved significantly, but the size and diversity of the compiler make it difficult to improve the computation time except by completely reorganizing the compiler.

The code which will implement subroutines has been completed but not debugged. The necessary changes which will allow the compiler to accept this code have been completed. However, due to a lack of PRT locations, a sizable delay may be necessary before this code can be inserted into the compiler.

The current compiler consists of approximately 8600 lines of ALGOL, has a core estimate of 15.8K words, and runs at approximately 350 cards per minute on the B5500.

5.5.3 Squash

Work has continued on the debugging aid for ALGOL, with expected completion in January 1969. An initial translator has been formed from the complete syntax and partial semantics. This is being debugged. The remaining semantic actions are being coded for incorporation into the translator early in January.

5.6 Scheduler and Simulators

5.6.1 Scheduler

The Scheduler for ILLIAC IV has been flow charted and a test version for the B5500 is being written. An up-to-date reference manual on the assembler was written and will be published by Burroughs. A special version of the assembler for use on the B5500-16PE ILLIAC IV at Paoli was written.

5.6.2 Simulators

During the past quarter, the new simulator was virtually completed. This simulator includes a simple loader that utilizes the loader pseudo-operations emitted by the assembler. Other features of the simulator are:

1. The simulator is half-load proof--the simulator may be restarted from a previous break-point if the execution is terminated.
2. Disk I/O facilities are included.
3. There will be a format and list facility to generate line printer output for debugging purposes.
4. There is an octal dump of all registers and memory.
5. A simulation scheduler has been written and demonstrated. The scheduler queues simulation requests and automatically initiates the simulator on a new job when it completes a previous job.

6. The simulator will multi-process well with other programs. A simulation, an ALGOL compile, and R/C (R/C is a multi-user text editor) have been successfully multi-processed.

The simulation ratio between B5500 execution time and simulated quadrant ILLIAC IV execution time is slightly less than 10^6 , which is somewhat better than was expected on the 7094.

5.7 Control Data ALGOL

A project to consider using the Control Data 6600 as the control computer for ILLIAC IV has been initiated. A study of the conversion of Burroughs' Extended ALGOL to Control Data ALGOL is now being made. An immediate goal is to have the assembler and simulator running on the Control Data machine.

Control Data ALGOL is essentially ALGOL 60 with the ACM proposed ALGOL 60 input-output conventions. Burroughs' ALGOL is an extension of ALGOL 60 with such constructs as partial word operators, imbedded assignments, bit-by-bit logical operations, and much exotic input-output. It also has such gross syntactic structures as WHILE statements, DO...UNTIL statements, and CASE statements.

A preprocessor for Burroughs' ALGOL is being written. This preprocessor is processing the gross syntactic differences, the DEFINE and FILL statements, and many minor character set problems. A simple parser to generate subroutine calls for imbedded assignments and partial word operators will be added. Presently, work is being done on an interpretive method of simulating the Burroughs STREAM PROCEDURES. Eventually, the output of the preprocessor must be modified by hand to implement input-output calls and to change certain other constructs, which are not readily machine convertible, into CDC ALGOL.

5.8 CAT

5.8.1 Mesh Storage

For non-core-contained partial differential equation problems, the mesh of data points is stored on ILLIAC IV disk rather than in fast memory. Blocks of the mesh are brought into fast memory one at a time for processing. After the processing of a block (kernel calculations) is completed, processing of the next block in sequence is started. If the blocks do not span either dimension of the rectangular mesh, then two sweeping sequences are possible: sweeping by rows of blocks and sweeping by columns of blocks. In sweeping by rows, all of the blocks in a row i are read from disk in sequence. Then the blocks in row $i + 1$ are read in the same sequence. This process continues until all blocks in n rows are read. Sweeping by columns is similar.

Some problems may require successive sweeps of the mesh in alternating directions. Storing the blocks on disk in such a way that latency is minimized is a problem which is further complicated by the necessity for interblock communication. For the kernel to update a block, edges from the four neighboring blocks are required.

A scheme has been formulated which allows sweeping in any sequence of directions (by rows or by columns). Blocks are read from disk; kernel calculations are performed; and the updated blocks are written on disk. The scheme will accommodate a wide range of rectangular mesh sizes. Many particular schemes have been found over a sample of mesh sizes and with a latency ≤ 0.12 (12% of total problem time). The report of the investigation will be completed in January of 1969.

5.8.2 Subset of CAT

A model is being developed for optimizing code which is amenable to solution by linear programming. The model allows for reordering of statements from the original code and for many forms of non-obvious data manipulation to minimize the time the processor(s) waits for I/O.

This method is completely general in that it assumes no particular machine configuration. The necessary information, such as computation time for the various operations and secondary memory cycle time, are parameters. The number of (binary integer) variables resulting from any non-trivial code, unfortunately, is large ($\geq 10^3$). Present efforts are involved in attempting to reduce this number.

APPLICATIONS

5.9 Mathematical Applications

5.9.1 Partial Differential Equations

In this quarter, the Tranquil version of an idealized particle-in-cell code for a plasma was completely debugged for syntax errors. The code is contained in ILLIAC IV Document No. 207 [5] which was written this quarter. Document 207 gives a description of an idealized particle-in-cell (PIC) code for a plasma.

The checkerboard storages scheme for the PIC codes was investigated at Los Alamos Scientific Laboratory. For 256 PE's using a 16x16 checkerboard on meshes of 20x100 or 30x100, the efficiency, due to distribution of particles, ranges from 33% to 43% for 30 time steps. If, instead of using 256 PE's, only 64 PE's are used, the efficiency ranges from 80% to 90%.

A preliminary investigation into alternate storage schemes for PIC type problems was completed this quarter. Written this quarter was another code and document concerning the modified successive overrelaxation (MSOR) method for solving both Laplace's and Poisson's difference equations [6]. The MSOR is much more efficient for small meshes on a parallel computer.

5.9.2 Generalized Ordinary Differential Equation Solver

The general aim of this work is to produce an ALGOL program which will be run on the B6500 and which will take some simple representation of a large system of ordinary differential equations as input and produce as output the ILLIAC IV machine code to perform the integration. Before generating the code, this program must decide the best method and storage allocation for the given problem. Since the program must also scan the input and do some compiling, one of the Translator Writer Systems on the B5500 is being used to build a scanner written in ALGOL. Work is proceeding on the algorithms necessary to perform this task and in studying the types of methods available. In the main, however, the methods will already exist as

skeleton codes which will be completed to form the desired machine language program.

5.9.3 Multidimensional Compressible Hydrodynamics

New methods for the solution of multidimensional, compressible, hydrodynamic flow problems are being investigated. In particular, methods having greater parallelism than those currently in use are desired. Much of this quarter was devoted to gaining experience with existing Eulerian methods and various velocity and density weighting schemes including OIL, donor, and Rich without the use of artificial viscosity. Also, preliminary results on a new continuous rezone technique have been obtained.

The above described techniques have been applied to test problems on the B5500. The test problems were selected from a report by Hicks of AFWL in which he describes several one-dimensional shock problems having analytic solutions [7]. The results obtained from "the shock tube problem" (V of the Hicks' report) are satisfactory. Greater difficulty has been encountered with the collision of two shocks (VI of the Hicks' report); although, the results obtained are comparable to those given by Lax-Wendroff.

5.9.4 Eigenvalues

5.9.4.1 Matrix Storage Methods

5.9.4.1.1 Matrix Storage for Jacobi's Method

A new method of matrix storage has been developed for Jacobi's method of finding eigenvalues for a matrix [8]. The storage method used is a variation of the triangular skew method. To illustrate this method, look at an 8x8 matrix stored in this manner:

$a_{1,1}$	$a_{1,2}$	$a_{1,3}$	$a_{1,4}$	$a_{1,5}$	$a_{1,6}$	$a_{1,7}$	$a_{1,8}$
$a_{2,8}$		$a_{2,2}$	$a_{2,3}$	$a_{2,4}$	$a_{2,5}$	$a_{2,6}$	$a_{2,7}$
$a_{3,7}$	$a_{3,8}$		$a_{6,6}$	$a_{3,3}$	$a_{3,4}$	$a_{3,5}$	$a_{3,6}$
$a_{4,6}$	$a_{4,7}$	$a_{4,8}$		$a_{6,7}$	$a_{7,7}$	$a_{4,4}$	$a_{4,5}$
	$a_{5,5}$	$a_{5,6}$	$a_{5,7}$	$a_{5,8}$	$a_{6,8}$	$a_{7,8}$	$a_{8,8}$

In this storage method, each pair of successive diagonal elements is separated by one PE. The diagonal element $a_{\frac{n}{2}+1, \frac{n}{2}+1}$, in this case, $a_{5,5}$, is

an exception in that it is separated from the previous diagonal element by 2 PE's. The elements beginning with $a_{\frac{n}{2}+2}$, $a_{\frac{n}{2}+2}$ form a wedge in the lower part of the matrix, as illustrated in the diagram above.

Assume that the origin of the matrix storage is the storage location of the element $a_{1,1}$ in the beginning. Call this location (0,0).

After each shuffling of the second row and column, the origin is moved two locations to the right and one down. After one shuffling, the origin would be at (1,2) and after two shufflings, the origin would be at (2,4). The origin is again at (0,0) after $\frac{n}{2}$ shufflings. The effect of this on

the updated matrix is to make the last two columns the first two columns of the new matrix, and make the last row the first row:

	1				2
	3				4

	4			3	
	2			1	

In this way, the elements of the updated matrix retain the same relationships as in the previous matrix.

Since the matrix has to be symmetric for Jacobi's method, this storage scheme allows all elements to be stored in an economical way. More precisely, for an $n \times n$ matrix, only $\frac{n}{2}+1$ rows of memory are required.

5.9.4.1.2 Matrix Storage for QR - Algorithm

Because the ordinary QR-algorithm is extremely inefficient for ILLIAC IV, a modification which does many origin shifts (instead of the customary two) in a single iteration, is being developed. The effect of the modification is to fill the matrix and allow a full Householder reduction at each step, making the method much more suitable for ILLIAC IV. Numerical experiments indicate that, although it is slower than ordinary QR by a factor of two, the accuracy of the eigenvalues from the two methods is equivalent.

5.9.4.2 Extended ALGOL Codes and Programs

Several codes and programs were written in Extended ALGOL. Codes have been written during this quarter, for Bessel function of first kind $J_p(x)$ and Arctan (x) . A program for finding the eigenvalues and the eigenvectors for a symmetric matrix by using Jacobi's method was written in Extended ALGOL. Also written was a program to evaluate a matrix inversion by partitioning.

5.9.5 Polynomial Root Finding

During this quarter, an algorithm for determining whether a given square has a root in it was developed. There is a lemma in complex analysis which states:

$$S_n = \frac{1}{2\pi i} \int_C z^n \frac{f'(z)}{f(z)} dz = \sum_{e=1}^v z_e^n ;$$

where z_i ($i = 1, 2, \dots, v$) are all the zeroes of $f(z)$ which lie in the interior of the closed contour C . If $N = 0$, then S_0 either has a value of zero or some positive integer which corresponds to the number of roots of the polynomial in the contour. S_0 may then be approximated by the

trapezoidal rule. Thus, the algorithm consists of subdividing a given square region into 64 smaller squares, integrating on each of the squares, and repeating the process on those squares yielding a positive integration.

A Tranquil code for polynomial root finding is being debugged. When this is completed, a document will be written.

5.9.6 Special Functions Subroutine Library

Investigation was begun on writing subroutines in double precision or 128-bit mode. Meanwhile during this quarter, work continued on the development of a special functions subroutine library. A new 64-bit subroutine has been written for arctangent of a quotient of two numbers. The signs of the divisor and dividend determine in which quadrant the result will be. It was decided that the dividend should be in the A register and the divisor in the B register.

Also, codes have been written in the 32-bit mode for the exponential, sine, cosine, natural logarithm, arctangent, and square root functions. All codes previously mentioned in Quarterly Progress Reports have been written in ILLIAC IV assembly language. They have been successfully assembled and are waiting to be simulated. Documentation concerning all 32-bit and all 64-bit special function subroutines is being prepared and should be completed shortly.

5.9.7 Random Number Generators

In this quarter, work began on the investigation of different random number generators for ILLIAC IV. The most popular computing scheme to generate random numbers uses the congruential relation

$$x_{i+1} \equiv ax_i + c \pmod{m},$$

in which x_0 is a positive integer, called the starting value; a is integer, called the multiplier; c is another integer; and m is a fourth integer, called the modulus, which is positive and greater than the other three in magnitude. When $c = 0$, the method is called multiplicative congruential; otherwise, it is called mixed congruential.

The advantages of the two methods will be discussed in a forthcoming document. The main concern of the document will center on the possible choices of the four parameters which will enable the random numbers to satisfy the statistical tests required of them.

5.9.8 Significant Digit Arithmetic

The work to implement significant digit arithmetic (SDA) on ILLIAC IV was begun this quarter. From the viewpoint of error analysis, the conventional normalized floating point arithmetic has several facets, and confusion often results from the failure to distinguish how many significant digits the evaluated result has. However, SDA operations, which are performed using unnormalized floating point arithmetic, are intended to facilitate the identification of significant digits in the result. In other words, the object of SDA is to keep track of as many significant digits throughout the whole arithmetic operation as there are given in the initial values.

During this quarter, some basic ideas for implementing Metropolis-type SDA on ILLIAC IV were proposed, and several versions for operating SDA have been tried. These results, including the mathematical basis and the assembly language codes for multiplication and division, are summarized in a document which will be printed soon.

5.9.9 Long Codes

In this quarter, the stability behavior of the autonomous system $\dot{x}(t) = Ax(t)$, where A is a constant matrix, was studied [9]. Also studied was the linear Hamiltonian system which is derived from the above general system. The algebraic condition on A is $A = J.S$ where $J = \begin{smallmatrix} 0 & I \\ -I & 0 \end{smallmatrix}$, and S

is the time independent symmetric matrix $(H_{x_v x_{v+n}})$, $v = 1, 2, \dots, m$,

where $m = \frac{n}{2}$.

During this quarter, an elementary algorithm was suggested for finding the eigenvalues of the constant matrix A . A fundamental matrix X

is to be built up from n-linearly independent observation vectors at a given time t , $x_1, x_2, \dots, x_n$. The matrix A is formed by the multiplication $\dot{X}X^{-1}$. Once the matrix A is formed, the QR-algorithm would be used to determine the eigenvalues, and consequently, the stability behavior of the system.

Furthermore, the stability behavior of the general linear systems $\dot{x}(t) = A(t)x(t)$ was studied in detail. The elements of $A(t)$ are assumed to be continuous in t and periodic with the same period, and the nature of the solutions of such systems described by the Floquet theory [10,11,12].

The stability criteria of the associated linear Hamiltonian systems,

$$\dot{x}_v = H_{x_{v+n}}, \quad \dot{x}_{v+n} = -H_{x_v} \quad v = 1, 2, \dots, m$$

where $\dot{x}(t) = J.S(t)x(t)$, were investigated by using the novel approach of J. Moser [13]. In his paper, Moser showed that the eigenvalues of the monodromy matrix of a special fundamental matrix of the system

$$\dot{x}(t) = J.S(t)x(t)$$

constitute the invariants of the above system. A stability criterion could be easily established in the case of distinct eigenvalues; however, in the degenerate cases, one needs to refine the stability criterion. This may be done by establishing an additional set of invariants of the system, and the conditions of stability can be expressed in terms of the additional set of invariants.

5.10 Linear Programming

5.10.1 Introduction

Much of the work involved in the development of the LP system is of a continuing nature, and topics discussed in the last QPR have been subject to re-examination and revision from time to time. This condition will continue to occur. During this quarter considerable progress was made by the LP group. Formal definitions of the LPS algorithm and the

associated data manipulations were almost completed. Some of the LP procedures were coded in ILLIAC IV assembly language and other coding is in progress. The progress to date is summarized below.

5.10.2 Data Input

The initial steps required to define and develop a formal language for use in matrix generation were taken. The requirements for a meaningful matrix-generation system were examined, and there will be a major effort in this area in the near future.

5.10.3 Preprocessing of Data

The procedures necessary to pack and store input data have been defined. The non-zero coefficients will be assigned to specific PE's and will be tagged accordingly for subsequent disk storage. The preprocessing will be done on the B6500.

5.10.4 Storage

The data storage procedure has been well defined and is as follows. Since individual columns of the coefficient (A) matrix are needed for d_j (reduced price) computation, for updating with previously computed n (product form inverse) vectors, and for subsequent entry into the basis, each column should be stored so that its non-zero coefficients are distributed across PE's. This is attained by first assigning rows to adjacent PE's, starting with the most dense, in such a manner as to evenly distribute the non-zero elements of A between PE's. This is subject to the constraint that elements of a given row can be assigned to only one PE. The coefficients of the rows assigned to each PE are then sorted by columns within the given PE. This storage scheme assures that operations done on columns will be done in parallel, since the elements of a given column will be stored in several PE's.

5.10.5 The LPS Algorithm

Progress in connection with the algorithm has been significant. The procedures for d_j computation, multiple pricing, pivot selection,

and vector updates using the product of previously generated n-vectors have been coded in ILLIAC IV assembly language. The mathematical procedures involved in right-hand side ranging, parametric programming, and bounding of variables have been examined and flow charted. An intensive examination of inversion techniques for use in the needed REINVERT subroutine has been initiated, and it is continuing. The subject of tolerances on computed values has been approached, and will be more carefully examined.

5.11 Radar Processing Applications

Efforts during this period have been devoted to the Kalman Filter Code debugging, to understanding a new, simpler version of Kalman Filtering developed by Lincoln Labs, and to converting the code for the designation mode to 32-bit floating point operation. Work began on programming Fast Fourier Transform in 32-bit floating point for ILLIAC IV to be used in the discrimination mode and on investigating the problems in radar scheduling and the effects on using ILLIAC IV for the scheduling.

Progress in the debugging of the Kalman Filtering program in ILLIAC IV assembly language has been slow. There is presently no assembler simulator that can handle the 32-bit floating arithmetic which is used in the Kalman programs. The program has been assembled on a comparable assembler and is essentially ready for the execution simulator. To facilitate faster and easier debugging of the assembly language code, the Kalman Filter Program has been written in ALGOL to run on the B5500 computer. This program will supply data for checking out each section of the assembly language program. The ALGOL program is running, but it is not completely debugged. With the aid of data supplied by Lincoln Labs, this program should be working by early February. At that time, it is probable that the ILLIAC IV assembler and simulator for 32-bit mode arithmetic will be in operation. The ILLIAC IV assembly language of the Kalman Filter can then be debugged by using the simulator and data generated for the ALGOL version.

The Tranquil version of the Kalman Filter written for ILLIAC IV will not be debugged until the compiler is completed to the point that it can handle all the Tranquil statements used in the program. This will not

be accomplished for sometime; however, when complete, it will be a good test case for using higher level language as opposed to assembly language on ILLIAC IV for radar processing.

A new version of the Kalman Filter which uses only approximately $1/2$ to $2/3$ the time of the old version has been developed by Lincoln Labs. It does everything in spherical coordinates instead of the combination of spherical and cartesian coordinates. This new version will be programmed in ILLIAC IV assembly language using 32-bit floating point arithmetic.

The designation mode which was in fixed point arithmetic (described in ILLIAC IV Document 173 [14]) is being reprogrammed by the new graduate student into 32-bit floating point arithmetic. This mode uses a .1 second and a 1 second filtering technique of a cloud in respect to cloud center to try to filter objects from shaft.

The Fast Fourier Transform (FFT) is being programmed for ILLIAC IV as a subroutine using 32-bit floating point arithmetic. It will be set up in the following two forms: 1. returns from the same object are spread across PE's, and the different object on which data is obtained goes down memory of each PE; and 2. the objects are spread across PE's, and data on each goes down memory. Many different forms of discrimination make use of FFT, and it will be needed for ILLIAC IV.

The radar scheduling problem and the efficiency of doing this portion of the radar processing task on ILLIAC IV is being investigated. Several portions of this problem seem to be sequential; therefore, it may be more efficient to handle a large part of the task on a standard computer which is controlling ILLIAC IV. However, the interplay of the two computers on this problem is being studied.

5.12 Seismic Signal Processing

During this quarter, a study of the programming requirements necessary to compile a seismic signal processing package was undertaken. This resulted in defining the specifications for approximately twenty-five programs. Several of these programs, such as those involving matrix manipulations, may be able to incorporate current programs from other study areas.

This investigation has indicated that to make the seismic programs most functional, they must be written so that they can be used in areas other than seismic processing with a minimum amount of modification. Some of the specialized seismic programs will have applications in other areas--such as programs for convolution, filter design, deconvolution, power spectrum analysis, and correlation analysis.

5.13 Weather

The finite difference portions of the General Circulation Model Benchmark provided by the National Center for Atmospheric Research have been coded in a combination of Tranquil and assembly language. These arithmetic subroutines must be connected by a machine language control program which will provide necessary parameters and which will make adjustments for unusual grid spacing caused by mountain blocking and stability criterion near the poles.

5.14 Graphics

5.14.1 Introduction

The graphic activity is divided into software and hardware sections. The software activity is concerned with developing algorithms and techniques to apply ILLIAC IV to graphic problems. A specific task is presented in the following software section. The hardware activity is concerned with the peripheral equipment for the ILLIAC IV computer. This equipment will be used to generate output which will be used by the programmer for debugging his program and providing graphic output in the form of contour maps and various graphs. Consideration is also being given to providing a graphic terminal to provide program status to the operators.

5.14.2 Software

A problem of particular, current interest in the area of computer graphics is the so-called hidden line problem. This problem is concerned with computer determination of the visible and invisible parts of three dimensional objects when viewed from an arbitrary point.

A simple, fast algorithm is essential because there are many applications in which it is desired to view a moving object of a CRT. However, the problem has proved to be unusually complex. The following two structures are mainly concerned:

1. three dimensional polyhedra consisting of irregular and opaque polygons, where only line segments with end-point pairs, one pair for each line, are assumed as the input data because of the construction of three dimensional objects from line drawing and
2. three dimensional objects including curved surfaces decomposed into a lot of triangles, where each decomposed triangle of the curved surfaces must be completely specified as the input data.

The algorithm for polygon generation is completely specified, and the list structure format is used for data structure of pictures.

To motivate the description of the algorithm of the hidden line problem, the factors which determine whether or not which parts of objects are visible can be considered. In the case of a single polyhedron, call it the local hidden line problem. For a compound structure of polyhedra, locally visible polygons of a polyhedron may become invisible or partially invisible by the polygons of another polyhedron. Call this the global hidden line. In either case, if the relationship between two polygons is determined, the hidden line problem may be solved. The relationship between two polygons is defined as follows:

- (a) One is enclosing the other;
- (b) One is involved by the other; or
- (c) There is no intersection between them.

The program is being implemented on B5500. Additional documentation will be provided by a masters thesis being written in this area. The thesis should be available next quarter.

5.15 Statistical Packages

During this quarter, design was begun for a statistical system for ILLIAC IV. The orientation of the system will be toward techniques which are applicable to large-scale data bases and which are used repeatedly. This is in apposition to a multiplicity of small techniques which are oriented toward editing data or output or which are convenience programs with little computational content. It is intended that the computation aspects of the statistical system will rely heavily upon matrix operations generated by the matrix algebra group, when feasible.

The following functions have been chosen as a basic set:

- (a) Data transformation,
- (b) General Matrix operations,
- (c) Correlation,
- (d) Multiple Regression,
- (e) Analysis of Variance
(by itself regarded currently as a very significant problem),
- (f) Principal Axis Factor Analysis,
- (g) Autocorrelations, and
- (h) Frequency counting and Distribution Analysis.

It is expected that a limited number of functions may be added to this list in the future.

Under consideration, also are tools or languages for dealing with large scale data structures more complicated than the rectangular arrays customarily used for input to the above techniques. This system is still in the speculative stage.

5.16 ILLIAC IV Education

5.16.1 Introduction

The ILLIAC IV education for this quarter consisted of organizing and presenting two courses of instruction--one covering B5500 and

ALGOL material and the other covering material concerned with the ILLIAC IV machine, its languages, and its applications. In addition, the education group has been updating educational material for the use of the ILLIAC IV staff and persons interested in the ILLIAC IV. This quarter also saw an attempt to organize all programs written or being written for ILLIAC IV into a library, which is to be available to anyone interested.

5.16.2 B5500 and ALGOL

This course was offered to acquaint ILLIAC IV personnel with the B5500 and ALGOL. The topics covered in this course were: the basic elements of ALGOL and special B5500 Extended ALGOL features, descriptions and instructions for use of the peripheral units, a detailed description of I/O, and a discussion of the master control program of the B5500.

5.16.3 CS 491-D

This course was a graduate seminar course CS 491-D, which was offered to ILLIAC IV personnel. (It will be offered University-wide for the spring semester.) This course included a discussion of the hardware of ILLIAC IV, coverage of its assembly language and Tranquil, a discussion of the Assembler, and extensive coverage of ILLIAC IV applications.

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6. NUMERICAL METHODS, COMPUTER ARITHMETIC AND ARTIFICIAL
LANGUAGES (Supported in part by the National Science
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6.1 Computerized Mathematics

Except for a few final tests, the assembly language theorem-proving program was completed this quarter. We have written the program so as to require only minor modifications to perform hyper-resolution or resolution with merging, two modified procedures based on resolution. We plan to implement these during the next quarter.

We have been making corrections on our EOL program. We hope to be able to finish it during this quarter and then collaborate with J. Nievergelt of this department, who is in charge of the EOL project, to test the efficiency and find the weak areas of the EOL language by observing the operation of the two theorem-proving programs.

Along theoretical lines, using the methods given in my masters thesis, we have been considering ways of reducing proof trees to a canonical form. The simplest form would be a vine, i.e., from each node there emanates a branch with only one clause. Let (A,B) indicate a resolvent of clause A with clause B. Then a vine can be written $((...((A,B),C), ...), X), Y)$ where A, B, C, ... X, Y are clauses. By reducing proof trees to a special form, it is hoped the search for a proof will be simplified. We know this reduction is not always possible because of a problem called merging. Suppose the clauses $A:p,q$ and $B:p,\sim q,r$ were resolved. The result is $C:p,r$ and the two literals p merged. If we now resolve C with $D:\sim p,s$, the result is r,s . If D was the root of a vine, the next step would be to rewrite the deduction

$((A,B),D)$ as either $((A,D),B)$ or $((D,B),A)$ to obtain the end result r,s .

However, because of the merge, the only way to rewrite that deduction to obtain p,s is $((A,D),(B,D))$, which is still not of vine form. Thus, if the merge literal is used to resolve again, the vine structure cannot be obtained. We will continue our research in this area in the next quarter.

(L. J. Henschen)

6.2 Numerical Solution of Singular Integral Equations

During the quarter work was initiated on the consideration of techniques for the numerical solution of singular integral equations.

The results on convergence and error bounds for approximate solutions of integral equations by Anselone and Moore ("Approximate Solutions of Integral and Operator Equations," J. of Math. Anal. and Appl., Vol. 9, (1964), pp 268-277) were studied together with other associated papers by Anselone in this area. In a later paper (P. M. Anselone, "Uniform Approximation Theory for Integral Equations with Discontinuous Kernels," SIAM J. Numer. Anal., 4 2(1967), pp 245-253) he extends these results from continuous kernels to kernels which are discontinuous but still Riemann-integrable.

Atkinson ("Numerical Solution of Fredholm Integral Equations of the Second Kind," SIAM J. Num. Anal., 4, 3(1967), pp 337-348) extends the general result still further to weakly singular kernels using generalized quadrature formulas based on product integration.

However, none of these papers appear to offer an immediate generalization to the case of a strongly singular kernel (Cauchy kernel) and work is now beginning on a study of Muskhelishvili ("Singular Integral Equations," P. Noordhoff N. V., Groningen, Holland (1958)) in order to determine whether techniques for the analytical solution of singular integral equations might be exploited to obtain a uniform approximation theory for strongly singular kernels, as was suggested by Anselone in a recent lecture.

(A. W. McInnes)

6.3 Study of Methods of Selection of Quotient Digits During Digital Division

This study concerns a class of division technique in which redundancy is introduced into the representation of the quotient thus permitting quotient digits to be selected by inspection of estimates of the full-precision divisor and partial remainder. For example, a radix 256 quotient digit (8 bits) may be generated knowing only the first 11 bits of the divisor and the first 12 bits of the partial remainder.

A major goal of this work is to develop quotient selection mechanisms, and then to perform cost-effectiveness studies of the most promising. Two major classes of techniques have been proposed: (1) direct table look-up, and (2) table look-up of the inverse of the estimate of the divisor followed by a multiplication of the inverse and the estimate of the partial remainder.

Research during this quarter centered upon the first class of techniques -- direct table look-up. An algorithm was developed and coded in FORTRAN IV which will generate an estimate of the logic requirements. The basic factors which determine the logic requirements and which serve as parameters to the program are as follows:

- 1) The radix
- 2) The range of the divisor
- 3) The direction of the truncation error in the estimate of the divisor and partial remainder, i.e., strictly positive, strictly negative, or either positive or negative
- 4) The amount of redundancy permitted in the quotient. The allowable quotient digits belong to the set $\{0, \pm 1, \pm 2, \dots, \pm n\}$. A measure of redundancy is the ration $n/(r-1)$ where r is the radix.

The program (QUotient SElection -03) has been completed and run for several variations of parameters. Production runs with other combinations of parameter values are continuing. To date it has been found that for a divisor (d) range given by $1/2 \leq d < 1$, an error in the estimate of the partial remainder of $\pm 1/16$, and a redundancy ratio $n/(r-1) = 2/3$, the cost of logic is approximately proportional to $2.7r^2$.

(D. E. Atkins)

6.4 Automatic Function Generation*

In arithmetic processors the cost and size reduction and increasing reliability of integrated circuit logic elements permits the replacement of programmed subroutines by built-in function generators. This research is a study of the efficient generation of elementary functions frequently required in a scientific binary computer. These functions include division, square rooting, exponentiation, computation of logarithms, and evaluation of elementary circular functions. Only the fractional part of a floating point operand is being considered. The basic technique is to reduce function evaluation to a sequence of comparisons, additions, and shifts. If a shift requires much less time than an addition, then the speed is a direct function of the number of additions required. It is proposed to reduce the number of additions required, averaged over all allowed operands, to a (near) minimum.

* The research on this topic is reported here because of its pertinence to the goals of NSF Grant GJ-217. Mr. DeLugish is a candidate for the degree of Doctor of Philosophy in Electrical Engineering, with support from the Department of Electrical Engineering. It is anticipated that some computer use will shortly become necessary, to be supported by NSF Grant GJ-217.

Algorithms for division, exponentiation, and computation of natural logarithms have been devised. Although an analysis to determine the actual efficiency of these algorithms has yet to be attempted, it appears that each can be completed in slightly more than $R/3$ addition cycle times, where R is the length of the fractional part of the operand. These algorithms require storage of a small number (approximately R) of precomputed constants.

Research is continuing on an algorithm for square rooting.

(B. G. DeLugish)

7. SWITCHING THEORY AND LOGICAL DESIGN

This quarter was spent in preparing the following reports of our work:

1. Logical design of an optimum network by integer linear programming - Part II, by S. Muroga and T. Ibaraki
2. An implicit enumeration program for zero-one integer programming, by T. Ibaraki, T. K. Liu, and C. R. Baugh and S. Muroga
3. An optimum network design using NOR and NOR-AND gates by integer programming, by C. R. Baugh, T. Ibaraki, T. K. Liu and S. Muroga
4. A code for zero-one integer linear programming by implicit enumeration, by T. K. Liu.

A computer program which can be used for general $(0,1)$ - variable integer programming program has been prepared, based on the implicit enumeration method with modification and introduction of new ideas. The program was initiated for logical design but it can be used for any other $(0,1)$ - variable integer programming problems. The program is named ILLIP (Illinois Integer Programming.) The basic ideas are discussed in the above report 2 and the programming manual is available as the above report 4 which is Liu's Master degree thesis.

S. Muroga

8. SOUPAC SECTION
(Statistically Oriented Users Programmers and Consultants)

During the time period from October 1 through December 31, 1968, there were 710 consultations arranged with members of the SOUPAC Section, and this averages to be more than eleven appointments per day. Most of these discussions were concerned with the utilization of the IBM 7094 SSUPAC collection of programs, and a counter in SSUPAC indicated more than 7500 references during the time period. In addition more than 100 manuals of instruction for SSUPAC were distributed.

Despite this continuing interest in SSUPAC, much of the effort of the Statistical Consultants was devoted to writing programs for the IBM 360 SOUPAC collection of statistical and data manipulative procedures. During December, seven of the individual programs of SOUPAC were announced as operational: Autocorrelations, Biserial Correlations, Zero-level Correlations, Multiple Correlations, Matrix Operations, Multiple Discriminant Analysis, and Varimax. Of course adequate documentation for the programs does not exist. Nevertheless, two brief descriptions, entitled "Description and Organization of SOUPAC" and "Introduction to SOUPAC", were reproduced and made available for distribution.

Kern W. Dickman
Project Director

9. IBM SYSTEM/360 SERVICE

(Supported in Part by the National Science Foundation under Grant No. NSF-GP-7634.)

9.1 Log Summaries

Table I - IBM 360/20

Summary of Use

October, 1968

Unscheduled Engineering	38:56
Scheduled Engineering	4:05
Maintenance	2:47
Production	272:53
Operator Training	:56
Idle	47:51
Air-Conditioning	:47
Total	<u>368:15</u>

Table II - IBM 360/20

Summary of Machine Errors

October, 1968

2560 MFCM	<u>21</u>
Total	<u>21</u>

Table I - IBM 360/50-75

Summary of Use

October, 1968

Unscheduled Engineering	35:00		
Scheduled Engineering	53:31:07		
Maintenance	1:51:22		
Idle	<u>3:08:00</u>		
		Subtotal	59:05:29
Total Use			
Training and Education		130:46:40	
System Improvement and Modifications		99:05:48	
System Updating		54:04:58	
University Administrative Overhead Use		1:11:10	
Overhead		17:49:15	
Refund		39:20	
Customer Use			
In System	137:43:41		
Special Short Shots	<u>1:44:06</u>		
Customer Use Total		<u>139:27:47</u>	
		Total Use	<u>443:04:58</u>
		Total Time	<u>502:10:27</u>

Table II - IBM 360/50-75

Summary of Errors

October, 1968

2540 Card Reader Punch	<u>1</u>
Total	<u><u>1</u></u>

IBM 360/75 TABLE III OCT., 1968

DEPT	NUMBER OF RUNS			NUMBER OF SPECS			IBM 360/75 USAGE IN HH:MM:SS		
	T AND E ²	RES	TOTAL	T AND E ²	RES	TOTAL	T AND E ²	RES	TOTAL
AAE	670	60	730	5	2	7	7:21:30	2:50:26	10:11:56
ACCY	321	17	338	1	3	4	1:17:38	0:18:27	1:36: 5
AGE	328	56	384	3	2	5	5:58:24	0:33: 5	6:31:29
AGEC	0	224	224	0	7	7	0: 0: 0	3:40:59	3:40:59
AGRON	449	246	695	1	7	8	1:33:44	1:21:21	2:55: 5
ANS	0	44	44	0	2	2	0: 0: 0	0:15:28	0:15:28
ARCH	157	0	157	2	0	2	0:49:19	0: 0: 0	0:49:19
ASTR	0	121	121	0	5	5	0: 0: 0	1: 4:37	1: 4:37
BECSR	0	9	9	0	1	1	0: 0: 0	0: 4: 8	0: 4: 8
CE	575	147	1726	11	36	47	8:30: 7	18:41:52	27:11:59
CHE	81	715	796	5	24	29	0:21:49	15:56:22	16:18:11
CRC	0	29	29	0	1	1	0: 0: 0	0:22:25	0:22:25
CCS	16206	217	16423	15	10	25	74:38:22	6:25: 3	81: 3:25
DS	0	22	22	0	1	1	0: 0: 0	0:13:19	0:13:19
DUE	32	0	32	1	0	1	0: 5:19	0: 0: 0	0: 5:19
ED	0	81	81	0	2	2	0: 0: 0	1: 2: 1	1: 2: 1
EDADM	0	35	35	0	1	1	0: 0: 0	0:54:40	0:54:40
EDPSY	48	0	48	2	0	2	0:13: 4	0: 0: 0	0:13: 4
EE	1653	789	2442	14	33	47	12:56:15	9:16:11	22:12:26
ENGADM	0	90	90	0	2	2	0: 0: 0	1: 1:47	1: 1:47
ENGCS	0	19	19	0	1	1	0: 0: 0	0:11:35	0:11:35
ENH	311	0	311	1	0	1	1: 6:54	0: 0: 0	1: 6:54
ENGRDV	0	6	6	0	1	1	0: 0: 0	0: 1:42	0: 1:42
FT	0	12	12	0	2	2	0: 0: 0	0: 5:54	0: 5:54
GENE	164	0	164	4	0	4	0:46:39	0: 0: 0	0:46:39
GEOG	0	17	17	0	2	2	0: 0: 0	0:20:31	0:20:31
GEOL	42	22	64	3	2	5	0:20:43	0:14:41	0:35:24
GER	0	0	0	0	1	1	0: 0: 0	0: 7:56	0: 7:56
GSBA	377	0	377	3	0	3	2:39:13	0: 0: 0	2:39:13
HORT	0	14	14	0	1	1	0: 0: 0	0:16:56	0:16:56
ICR	0	72	72	0	1	1	0: 0: 0	0:54:35	0:54:35
IE	7	0	7	1	0	1	0: 4:59	0: 0: 0	0: 4:59
ILLCF	0	2	2	0	1	1	0: 0: 0	0: 0:37	0: 0:37
ILLDMH	0	289	289	0	1	1	0: 0: 0	10:10:30	10:10:30
INADM	0	2	2	0	1	1	0: 0: 0	0: 0:14	0: 0:14
MATH	0	7	7	0	2	2	0: 0: 0	0: 6:12	0: 6:12
MATRL	0	701	701	0	23	23	0: 0: 0	11:38:26	11:38:26
MCBIO	0	16	16	0	1	1	0: 0: 0	0: 7:26	0: 7:26
ME	2566	183	2749	15	9	24	10:54: 5	2: 5:38	12:59:43
MMPE	0	76	76	0	2	2	0: 0: 0	1:44:33	1:44:33
NHS	0	60	60	0	2	2	0: 0: 0	1:41:41	1:41:41
NUCE	105	140	245	3	6	9	0:33:55	1:46:32	2:20:27

CIR	0	224	224	0	1	1	0: 0: 0	2:10: 1	2:10: 1
CRME	0	2	2	0	1	1	0: 0: 0	0: 1: 5	0: 1: 5
PHYB	0	60	60	0	1	1	0: 0: 0	1:21:11	1:21:11
PHYCS	9	609	618	1	14	15	0: 8:54	7:13:21	7:22:15
PHYX	0	1055	1055	0	6	6	0: 0: 0	22:37:13	22:37:13
FLPA	0	13	13	0	1	1	0: 0: 0	0: 2: 4	0: 2: 4
POLS	12	19	31	1	1	2	0:11:35	0: 2:10	0:13:45
PSYCH	2	4	6	1	2	3	0: 0:37	0: 0:58	0: 1:35
REC	0	5	5	0	1	1	0: 0: 0	1:28:20	1:28:20
SCONS	0	70	70	0	1	1	0: 0: 0	0:52:23	0:52:23
SGS	0	240	240	0	2	2	0: 0: 0	1: 9: 3	1: 9: 3
SOC	0	3	3	0	1	1	0: 0: 0	0: 1:19	0: 1:19
SRL	0	111	111	0	3	3	0: 0: 0	1:21: 6	1:21: 6
SWS	0	65	65	0	5	5	0: 0: 0	1:51:54	1:51:54
TAM	5	126	131	1	8	9	0: 1:47	1:15:34	1:17:21
VPP	0	1	1	0	1	1	0: 0: 0	0: 0: 7	0: 0: 7
WPGU	0	2	2	0	1	1	0: 0: 0	0: 1:16	0: 1:16
ZOOL	63	50	153	1	5	6	0:11:48	0:52:38	1: 4:26

SUBTOTAL	24587	7839	32426	95	253	348	130:46:40	137:43:41	268:30:21
DCSSYS ³	0	3559	3559	0	21	21	0: 0: 0	99: 5:48	99: 5:48
OVRHED ⁴	0	6788	6788	0	1	1	0: 0: 0	17:49:15	17:49:15
REFUND ⁵	0	11	11	0	1	1	0: 0: 0	0:39:20	0:39:20
SSUAD ⁶	0	52	52	0	1	1	0: 0: 0	1:11:10	1:11:10
XDCS ⁷	0	291	291	0	3	3	0: 0: 0	54: 4:58	54: 4:58
XMAINT ⁸	0	14	14	0	4	4	0: 0: 0	59: 5:29	59: 5:29
XSSS ⁹	0	278	278	0	1	1	0: 0: 0	1:44: 6	1:44: 6

TOTAL	24587	18832	43419	95	285	380	130:46:40	371:23:47	502:10:27
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- 1 See list of departmental codes following
- 2 Training and Education
- 3 System Improvement and Modifications
- 4 System Use in Excess of User Estimated Usage
- 5 Rerun of User Jobs Due to Machine or System Error
- 6 University Administrative Overhead Use
- 7 System Updating
- 8 System Maintenance
- 9 Special Short Shots

Table I - IBM 360/20

Summary of Use

November, 1968

Unscheduled Engineering	10:35
Scheduled Engineering	11:08
Maintenance	4:22
Production	260:36
Operator Training	11:59
Idle	<u>174:20</u>
Total	<u>473:00</u>

Table II - IBM 360/20

Summary of Machine Errors

November, 1968

2560 MFCM	12
2203 Printer	1
Faulty paper	<u>1</u>
Total	<u>14</u>

Table I - IBM 360/50-75

Summary of Use

November, 1968

Unscheduled Engineering	9:30:00		
Scheduled Engineering	26:24:06		
Maintenance	4:28:13		
Air Conditioning	2:05:00		
Idle	<u>20:00</u>		
		Subtotal	42:47:19
Total Use			
Training and Education		121:00:49	
System Improvement and Modifications		91:37:23	
System Updating		52:56:31	
University Administrative Overhead Use		1:18:56	
Overhead		15:19:00	
Refund		29:52	
Customer Use			
In System	127:18:03		
Special Short Shots	<u>1:52:10</u>		
Customer Use Total		<u>129:10:13</u>	
		Total Use	<u>411:52:44</u>
		Total Time	<u>454:40:03</u>

Table II - IBM 360/50-75

Summary of Errors

November, 1968

2540 Card Reader Punch	1
50 CPU	2
1050 Console Typewriter	<u>1</u>
Total	<u><u>4</u></u>

IBM 360/75 TABLE III NOV., 1968

DEPT ¹	NUMBER OF RUNS			NUMBER OF SPECS			IBM 360/75 USAGE IN HH:MM:SS		
	T AND E ²	RES	TOTAL	T AND E ²	RES	TOTAL	T AND E ²	RES	TOTAL
AAE	575	173	748	5	4	9	6:24:41	3:52:20	10:17:1
ACCY	205	6	211	1	1	2	0:45:33	0:5:33	0:51:6
AGE	144	69	213	6	3	9	3:43:0	0:45:24	4:28:24
AGEC	0	263	263	0	11	11	0:0:0	6:14:3	6:14:3
AGRON	500	148	648	1	7	8	2:22:47	0:57:10	3:19:57
ANS	0	78	78	0	2	2	0:0:0	0:53:48	0:53:48
ARCH	196	1	197	3	1	4	1:12:4	0:0:52	1:12:56
ASTR	0	65	65	0	5	5	0:0:0	0:41:51	0:41:51
BECBSR	0	33	33	0	1	1	0:0:0	0:29:29	0:29:29
CE	1429	896	2325	14	42	56	9:26:8	19:8:38	28:34:46
CHE	544	812	1356	5	27	32	3:21:59	15:28:55	18:50:54
CRC	0	42	42	0	1	1	0:0:0	0:19:23	0:19:23
CSL	0	16	16	0	2	2	0:0:0	0:6:23	0:6:23
DCS	12475	284	12759	16	9	25	55:46:52	11:41:43	67:28:35
DS	0	6	6	0	1	1	0:0:0	0:7:29	0:7:29
DUE	2	0	2	1	0	1	0:0:19	0:0:0	0:0:19
ECON	0	5	5	0	2	2	0:0:0	0:31:47	0:31:47
ED	0	16	16	0	3	3	0:0:0	0:11:49	0:11:49
EDPSY	72	0	72	2	0	2	0:26:38	0:0:0	0:26:38
EE	2809	565	3374	14	28	42	17:47:18	5:14:19	23:1:37
ENGADM	0	56	56	0	2	2	0:0:0	0:45:7	0:45:7
ENGCS	0	55	55	0	1	1	0:0:0	0:59:24	0:59:24
ENGH	291	0	291	1	0	1	0:35:57	0:0:0	0:35:57
ENGRDV	0	6	6	0	1	1	0:0:0	0:2:34	0:2:34
FT	0	23	23	0	3	3	0:0:0	0:8:49	0:8:49
GENE	456	0	456	4	0	4	2:46:46	0:0:0	2:46:46
GEOG	0	49	49	0	2	2	0:0:0	0:21:27	0:21:27
GEOL	160	22	182	3	1	4	1:8:35	0:8:9	1:16:44
GER	0	4	4	0	1	1	0:0:0	0:2:30	0:2:30
GSBA	290	0	290	3	0	3	2:0:55	0:0:0	2:0:55
HORT	0	1	1	0	1	1	0:0:0	0:3:24	0:3:24
ICR	0	92	92	0	2	2	0:0:0	1:0:3	1:0:3
IE	48	0	48	1	0	1	0:16:15	0:0:0	0:16:15
ILLCF	0	3	3	0	1	1	0:0:0	0:1:49	0:1:49
ILLDMH	0	222	222	0	1	1	0:0:0	4:36:26	4:36:26
INADM	0	18	18	0	1	1	0:0:0	0:7:6	0:7:6

MATH	0	28	28	0	1	1	0: 0: 0	0:10:23	0:10:23
MATRL	0	574	574	0	22	22	0: 0: 0	10:23: 7	10:23: 7
MCBIO	0	10	10	0	1	1	0: 0: 0	0: 3:48	0: 3:48
ME	1790	250	2040	19	9	28	9:16:19	2:25: 2	11:41:21
MKTG	0	10	10	0	1	1	0: 0: 0	0: 2:22	0: 2:22
MMPE	0	53	53	0	2	2	0: 0: 0	2:56:54	2:56:54
NHS	0	11	11	0	1	1	0: 0: 0	0:17:24	0:17:24
NUCE	27	197	224	3	9	12	0:10: 4	1:32:39	1:42:43
DIR	0	77	77	0	1	1	0: 0: 0	0:40:55	0:40:55
ORME	0	10	10	0	1	1	0: 0: 0	0: 3: 3	0: 3: 3
PHYB	0	87	87	0	2	2	0: 0: 0	2:18:21	2:18:21
PHYCS	106	603	709	3	14	17	0:16:44	10:22: 3	10:38:47
PHYX	0	916	916	0	27	27	0: 0: 0	17:30: 9	17:30: 9
PLPA	0	26	26	0	1	1	0: 0: 0	0: 4: 1	0: 4: 1
POLS	20	14	34	1	1	2	0:30: 1	0: 6:53	0:36:54
PSYCH	0	53	53	0	4	4	0: 0: 0	0:29:19	0:29:19
REC	0	20	20	0	2	2	0: 0: 0	0:26:18	0:26:18
SCONS	0	27	27	0	1	1	0: 0: 0	0:33:26	0:33:26
SGS	0	202	202	0	3	3	0: 0: 0	1: 1:14	1: 1:14
SOC	0	9	9	0	1	1	0: 0: 0	0: 3:23	0: 3:23
SRL	0	75	75	0	4	4	0: 0: 0	2:11:54	2:11:54
SWS	0	49	49	0	4	4	0: 0: 0	1:10:23	1:10:23
TAM	94	150	244	4	10	14	2:36: 5	1: 5:28	3:41:33
USGS	0	4	4	0	1	1	0: 0: 0	0: 3:53	0: 3:53
VPP	0	1	1	0	1	1	0: 0: 0	0: 0: 9	0: 0: 9
WPGU	0	5	5	0	1	1	0: 0: 0	0: 3:18	0: 3:18
ZOOL	22	25	47	1	2	3	0: 5:49	0:20:18	0:26: 7

SUBTOTAL	22255	7515	29770	111	294	405	121: 0:49	127:18: 3	248:18:52
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DCSSYS ³	0	3084	3084	0	24	24	0: 0: 0	91:37:23	91:37:23
OVRHED ⁴	0	3471	3471	0	1	1	0: 0: 0	15:19: 0	15:19: 0
REFUND ⁵	0	20	20	0	1	1	0: 0: 0	0:29:52	0:29:52
SSUAD ⁶	0	56	56	0	1	1	0: 0: 0	1:18:56	1:18:56
XDCS ⁷	0	106	106	0	3	3	0: 0: 0	52:56:31	52:56:31
XMAINT ⁸	0	17	17	0	5	5	0: 0: 0	42:47:19	42:47:19
XSSS ⁹	0	304	304	0	1	1	0: 0: 0	1:52:10	1:52:10

TOTAL	22255	14573	36828	111	330	441	121: 0:49	333:39:14	454:40: 3
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- 1 See list of departmental codes following
- 2 Training and Education
- 3 System Improvement and Modifications
- 4 System Use in Excess of User Estimated Usage
- 5 Rerun of User Jobs Due to Machine or System Error
- 6 University Administrative Overhead Use
- 7 System Updating
- 8 System Maintenance
- 9 Special Short Shots

Table I - IBM 360/20

Summary of Use

December, 1968

Unscheduled Engineering	54:26
Scheduled Engineering	4:40
Maintenance	3:26
Production	312:07
Operator Training	:15
Air-Conditioning	1:30
Idle	<u>70:21</u>
Total	<u>446:45</u>

Table II - IBM 360/20

Summary of Machine Errors

December, 1968

2560 MFCM	27
2203 Printer	<u>6</u>
Total	<u>33</u>

Table I - IBM 360/50-75

Summary of Use

December, 1968

Unscheduled Engineering	20:13:00		
Scheduled Engineering	34:58:06		
Maintenance	:13		
Idle	<u>3:00:00</u>		
		Subtotal	58:11:19
Total Use			
Training and Education		143:00:58	
System Improvement and Modifications		87:39:44	
System Updating		10:02:53	
University Administrative Overhead Use		32:18	
Overhead		21:06:01	
Refund		1:56:34	
Customer Use			
In System	114:50:37		
Special Short Shots	2:05:34		
Customer Use Total		<u>116:56:11</u>	
		Total Use	<u>381:14:39</u>
		Total Time	<u>439:25:58</u>

Table II - IBM 360/50-75

Summary of Errors

December, 1968

75 CPU	1
75 Core	1
50 CPU	2
50 Main Frame	2
2540 Card Reader Punch	1
1052 Console Typewriter	<u>1</u>
Total	<u>8</u>

IBM 360/75 TABLE III DEC., 1968

DEPT ¹	NUMBER OF RUNS			NUMBER OF SPECS			IBM 360/75 USAGE IN 4H:MM:SS		
	T AND E ²	RES	TOTAL	T AND E ²	RES	TOTAL	T AND E ²	RES	TOTAL
AAE	600	190	790	5	5	10	5:50:54	6:43:21	12:34:15
ACCY	0	0	0	1	0	1	0: 1: 0	0: 0: 0	0: 1: 0
AGE	109	52	151	7	3	10	1:36: 3	0:44:12	2:20:15
AGEC	50	225	275	1	10	11	0:24:41	3:33:52	3:58:33
AGRON	303	150	453	1	5	6	2:34:24	1: 7:13	3:41:37
ANS	0	51	51	0	2	2	0: 0: 0	0:10:34	0:10:34
ARCH	162	7	169	3	1	4	1: 9:30	0: 2:55	1:12:25
ASTR	0	44	44	0	5	6	0: 0: 0	0: 5: 8	0: 5: 8
BECBSR	0	29	29	0	1	1	0: 0: 0	0:21:59	0:21:59
CE	2067	920	2987	15	39	54	12:53:47	8:18:52	31:12:39
CHE	384	771	1155	6	22	28	2:56: 5	13:45: 2	16:41: 7
CRC	0	17	17	0	1	1	0: 0: 0	0: 5:18	0: 5:18
CSL	0	9	9	0	1	1	0: 0: 0	0: 3:37	0: 3:37
DCS	6709	224	5933	17	12	29	75:44:36	8:58:12	84:42:48
DS	0	29	29	0	2	2	0: 0: 0	0:14:30	0:14:30
DUE	27	0	27	1	0	1	0: 3:51	0: 0: 0	0: 3:51
ECON	31	5	36	1	2	3	0:29:27	0:13:15	0:16:12
ED	0	38	38	0	3	3	0: 0: 0	0:24:56	0:24:56
EDPSY	29	0	29	2	0	2	0: 8:14	0: 0: 0	0: 8:14
EE	1915	551	2466	15	27	42	9:54: 1	4:36:43	14:30:44
ENGADM	0	42	42	0	2	2	0: 0: 0	0:41:49	0:41:49
ENGCS	0	36	36	0	1	1	0: 0: 0	0:27:39	0:27:39
ENGH	172	0	172	1	0	1	0:24:44	0: 0: 0	0:24:44
ENGRDV	0	0	0	0	1	1	0: 0: 0	0: 0:26	0: 0:26
FT	0	34	34	0	3	3	0: 0: 0	0:11:59	0:11:59

	GENE	235	0	235	3	0	3	1:49: 6	0: 0: 0	1:49: 6
	GEOG	0	107	107	0	2	2	0: 0: 0	0:41:51	0:41:51
	GEOL	219	105	324	3	2	5	4: 5:56	0:27:23	4:33:19
	GER	0	1	1	0	1	1	0: 0: 0	0: 2:23	0: 2:23
	GSBA	586	0	585	3	0	3	3:10:18	0: 0: 0	3:10:18
29	ICR	0	62	62	0	2	2	0: 0: 0	0:49:51	0:49:51
	IE	8	0	8	1	0	1	0: 2:53	0: 0: 0	0: 2:53
31	ILLDMH	0	118	118	0	1	1	0: 0: 0	6:14: 9	6:14: 9
	INADM	0	18	18	0	1	1	0: 0: 0	0: 8:39	0: 8:39
32	MATH	0	4	4	0	2	2	0: 0: 0	0: 1:48	0: 1:48
	MATRL	0	366	365	0	17	17	0: 0: 0	8:23:25	8:23:25
35	MCBID	0	2	2	0	1	1	0: 0: 0	0: 0:50	0: 0:50
	ME	2219	194	2413	18	8	26	14:28:41	3: 2: 5	17:30:46
36	MKTG	0	17	17	0	1	1	0: 0: 0	0: 6:41	0: 6:41
37	MMPE	0	0	0	0	2	2	0: 0: 0	0: 1:20	0: 1:20
38	MUSIC	0	7	7	0	1	1	0: 0: 0	0: 3:28	0: 3:28
	NHS	0	0	0	0	1	1	0: 0: 0	0: 2:41	0: 2:41
39	NUCE	61	186	247	2	9	11	0: 9:44	2:15:39	2:25:23
40	DIR	0	52	52	0	1	1	0: 0: 0	0:20:55	0:20:55
41	ORME	0	12	12	0	1	1	0: 0: 0	0: 4:16	0: 4:16
	PHYB	0	118	118	0	2	2	0: 0: 0	3:24:26	3:24:26
42	PHYCS	111	408	519	4	13	17	0:22:44	7:36:19	7:59: 3
	PHYX	0	601	601	0	26	26	0: 0: 0	14:41:19	14:41:19
43	PLPA	19	0	19	1	0	1	0: 1:55	0: 0: 0	0: 1:55
44	POLS	26	24	50	1	1	2	0:21:22	0:11:37	0:32:59
45	PSYCH	0	48	48	0	3	3	0: 0: 0	0:33:41	0:33:41
46	REC	0	3	3	0	1	1	0: 0: 0	0: 1:16	0: 1:16
47	SCONS	0	65	65	0	1	1	0: 0: 0	0:23:46	0:23:46
48	SGS	0	201	201	0	1	1	0: 0: 0	0:48:59	0:48:59

SRL	0	72	72	0	5	5	0: 0: 0	0:48:14	0:48:14
SWS	0	142	142	0	6	6	0: 0: 0	2:39:43	2:39:43
TAM	154	41	195	4	8	12	4:13:17	0:28:30	4:41:47
USGS	0	10	10	0	1	1	0: 0: 0	0: 5:32	0: 5:32
VPP	0	4	4	0	1	1	0: 0: 0	0: 0:57	0: 0:57
WPGU	0	1	1	0	1	1	0: 0: 0	0: 0:55	0: 0:55
ZOOL	15	6	21	1	1	2	0: 5:45	0: 1:51	0: 7:36

SUBTOTAL	16211	6419	22630	117	273	390	143: 0:58	114:50:37	257:51:35
DCSSYS ³	0	3044	3044	0	25	25	0: 0: 0	87:39:44	87:39:44
OVRHED ⁴	0	3311	3311	0	1	1	0: 0: 0	21: 6: 1	21: 6: 1
REFUND ⁵	0	45	45	0	1	1	0: 0: 0	1:56:34	1:56:34
SSUAD ⁶	0	32	32	0	1	1	0: 0: 0	0:32:18	0:32:18
XDCS ⁷	0	96	96	0	2	2	0: 0: 0	10: 2:53	10: 2:53
XMAINT ⁸	0	31	31	0	4	4	0: 0: 0	58:11:19	58:11:19
XSSS ⁹	0	360	360	0	1	1	0: 0: 0	2: 5:34	2: 5:34

TOTAL	16211	13338	29549	117	308	425	143: 0:58	296:25: 0	439:25:58
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- 1 See list of departmental codes following
- 2 Training and Education
- 3 System Improvement and Modifications
- 4 System Use in Excess of User Estimated Usage
- 5 Rerun of User Jobs Due to Machine or System Error
- 6 University Administrative Overhead Use
- 7 System Updating
- 8 System Maintenance
- 9 Special Short Shots

IBM 360/75 TABLE III 4TH QTR, 1968

DEPT¹ NUMBER OF RUNS NUMBER OF SPECS IBM 360/75 USAGE IN HH:MM:SS

	T AND E ²	RES	TOTAL	T AND E ²	RES	TOTAL	T AND E ²	RES	TOTAL
AAE	1845	423	2268	15	11	26	19:37:5	13:26:7	35:3:12
ACCY	526	23	549	3	4	7	2:2:11	0:24:0	2:26:11
AGE	581	177	758	16	8	24	11:17:27	2:2:41	13:20:8
AGEC	50	712	762	1	28	29	0:24:41	13:28:54	13:53:35
AGRON	1252	544	1796	3	19	22	6:30:55	3:25:44	9:56:39
ANS	0	173	173	0	6	6	0:0:0	1:19:50	1:19:50
ARCH	515	8	523	8	2	10	3:10:53	0:3:47	3:14:40
ASTR	0	230	230	0	16	16	0:0:0	1:51:36	1:51:36
BECBSR	0	71	71	0	3	3	0:0:0	0:55:36	0:55:36
CE	4475	2563	7038	40	117	157	30:50:2	56:9:22	86:59:24
CHE	1009	2298	3307	16	73	89	6:39:53	45:10:19	51:50:12
CRC	0	88	88	0	3	3	0:0:0	0:47:6	0:47:6
CSL	0	25	25	0	3	3	0:0:0	0:10:0	0:10:0
DCS	35390	725	36115	48	31	79	206:9:50	27:4:58	233:14:48
DS	0	57	57	0	4	4	0:0:0	0:35:18	0:35:18
DUE	61	0	61	3	0	3	0:9:29	0:0:0	0:9:29
ECON	31	10	41	1	4	5	0:29:27	0:18:32	0:47:59
ED	0	135	135	0	8	8	0:0:0	1:38:46	1:38:46
EDADM	0	35	35	0	1	1	0:0:0	0:54:40	0:54:40
EDPSY	149	0	149	6	0	6	0:47:56	0:0:0	0:47:56
EE	6377	1905	8282	43	88	131	40:37:34	19:7:13	59:44:47
ENGADM	0	168	168	0	6	6	0:0:0	2:28:43	2:28:43
ENGCSST	0	110	110	0	3	3	0:0:0	1:38:38	1:38:38
ENGH	774	0	774	3	0	3	2:7:35	0:0:0	2:7:35
ENGRDV	0	12	12	0	3	3	0:0:0	0:3:50	0:3:50
FT	0	69	69	0	8	8	0:0:0	0:26:42	0:26:42

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GENE	855		855	11		11	5:22:31	0: 0: 0	5:22:31
GEOG		173	173		5	6	0: 0: 0	1:23:49	1:23:49
GEOL	421	149	570	9	5	14	5:35:14	0:50:13	6:25:27
GER		5	5		3	3	0: 0: 0	0: 3: 3	0: 3: 3
GSBA	1253		1253	9		9	7:50:26	0: 0: 0	7:50:26
HURT		15	15		2	2	0: 0: 0	0:20:20	0:20:20
ICR		226	226		5	5	0: 0: 0	2:44:29	2:44:29
IE	63		63	3		3	0:24: 7	0: 0: 0	0:24: 7
ILLCF		5	5		2	2	0: 0: 0	0: 2:26	0: 2:26
ILLOMH		629	629		3	3	0: 0: 0	21: 1: 5	21: 1: 5
INADM		38	38		3	3	0: 0: 0	0:15:59	0:15:59
MATH		39	39		5	5	0: 0: 0	0:18:23	0:18:23
MATRL		1641	1641		52	62	0: 0: 0	30:24:58	30:24:58
MCBIO		28	28		3	3	0: 0: 0	0:12: 4	0:12: 4
ME	6575	627	7202	52	26	78	34:39: 5	7:32:45	42:11:50
MKTG		27	27		2	2	0: 0: 0	0: 9: 3	0: 9: 3
MMPE		129	129		6	6	0: 0: 0	4:40: 7	4:40: 7
MUSIC		7	7		1	1	0: 0: 0	0: 3:28	0: 3:28
NHS		71	71		4	4	0: 0: 0	1:56:24	1:56:24
NUCE	193	523	716	8	24	32	0:53:43	5:34:50	6:28:33
OIR		353	353		3	3	0: 0: 0	3:11:51	3:11:51
ORME		24	24		3	3	0: 0: 0	0: 8:24	0: 8:24
PHYB		265	265		5	5	0: 0: 0	7: 3:58	7: 3:58
PHYCS	226	1620	1846	8	41	49	0:48:22	25:11:43	26: 0: 5
PHYX		2572	2572		59	59	0: 0: 0	54:48:41	54:48:41
PLPA	19	39	58	1	2	3	0: 1:55	0: 6: 5	0: 8: 0
PDLS	58	57	115	3	3	6	1: 2:58	0:20:40	1:23:38
PSYCH	2	105	107	1	9	10	0: 0:37	1: 3:58	1: 4:35

REC	0	28	28	0	4	4	0: 0: 0	1:55:54	1:55:54
SCONS	0	162	162	0	3	3	0: 0: 0	1:49:35	1:49:35
SGS	0	643	643	0	6	6	0: 0: 0	2:59:16	2:59:16
SUC	0	12	12	0	2	2	0: 0: 0	0: 4:42	0: 4:42
SRL	0	258	258	0	12	12	0: 0: 0	0: 2:34	0: 2:34
SWS	0	256	256	0	15	15	0: 0: 0	5:50: 0	5:50: 0
TAM	253	317	570	9	26	35	6:51: 9	2:49:32	9:40:41
USGS	0	14	14	0	2	2	0: 0: 0	0: 9:25	0: 9:25
VPP	0	6	6	0	3	3	0: 0: 0	0: 1:13	0: 1:13
WPGU	0	8	8	0	3	3	0: 0: 0	0: 5:29	0: 5:29
ZDOL	100	121	221	3	8	11	0:23:22	1:14:47	1:38: 9

SUBTOTAL	63053	21773	84826	323	820	1143	394:48:27	379:52:21	774:40:48
DCSSYS ³	0	9687	9687	0	70	70	0: 0: 0	278:22:55	278:22:55
OVRHED ⁴	0	13570	13570	0	3	3	0: 0: 0	54:14:16	54:14:16
REFUND ⁵	0	76	76	0	3	3	0: 0: 0	3: 5:46	3: 5:46
SSUAD ⁶	0	140	140	0	3	3	0: 0: 0	3: 2:24	3: 2:24
XD ⁷	0	493	493	0	8	8	0: 0: 0	117: 4:22	117: 4:22
XMAINT ⁸	0	62	62	0	13	13	0: 0: 0	160: 4: 7	160: 4: 7
XSS ⁹	0	942	942	0	3	3	0: 0: 0	5:41:50	5:41:50

TOTAL	63053	46743	109796	323	923	1246	394:48:27	1001:28: 1	1396:16:28
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1 See list of departmental codes following

2 Training and Education

3 System Improvement and Modifications

4 System Use in Excess of User Estimated Usage

5 Rerun of User Jobs Due to Machine or System Error

6 University Administrative Overhead Use

7 System Updating

8 System Maintenance

9 Special Short Shots

TABLE III
November-December, 1968
IBM 1800

<u>DEPT</u>	<u>NO. OF RUNS</u>			<u>USAGE IN HOURS.MINS.SECONDS.</u>		
	T and E	RES.	TOTAL	T and E	RES.	TOTAL
EE	0	4	4	0	17.12	17.12
DCS	Dec. 81	0	81	01.33.28	0	01.33.28
<hr/>						
SUBTOTAL	81	4	85	01.33.28	17.12	01.50.40
DCSSYS	0	97	97	0	04.37.46	04.37.46
<hr/>						
SUBTOTAL	0	97	97	00.00.00	04.37.46	04.37.46
TOTALS	81	101	182	01.33.28	04.54.58	06.28.26

9.2 Research Problem Specifications

During the fourth quarter of 1968, 143 problem specifications were submitted to the Department for computation on the System/360. The following brief descriptions of these problems have been prepared for inclusion in this report by those submitting them. T indicates a calculation associated with a thesis.

1908 Theoretical and Applied Mechanics. Finite Element Analysis of Concrete Stresses. The finite element analysis is used to predict shrinkage stresses in reinforced concrete. (H. Rejali)

1909 T Mechanical Engineering. Pulsating Flow of Water. Pulsating flow across orifices. (Thomas Sytko)

1916 Agricultural Economics. Optimal Irrigation Plans. Programs will be developed and solved for selected Illinois farm situations involving irrigation investments. Coefficients, objective function weights, and right-hand sides will be varied in sensitivity analysis to determine those factors most important in determining an optimal investment in irrigation. (E. R. Swanson)

1920 T Computer Science. Separable Boolean Functions. The set of Boolean functions can be classified by three different separability criteria.. Thus enumeration of properties of a separable, pseudo-separable, and marginally separable switching functions will be conducted. (Baugh)

1921 T Civil Engineering. Iterative Design Analyzer. Analyzer suitable for iterative design of skeletal structures. (R. Ertas)

1922 Physics. Neutron Resonance Analysis. Continuation of previous research on neutron resonance analysis, aiming toward a program suitable for simultaneous correlated analysis of fission, capture, and total cross sections. (F. T. Adler)

- 1923 Coordinated Science Laboratory. Cognitive Memory Project. Various data bases will be processed to be used as input to the computer facilities at CSL. The basic problem is to design a sophisticated question-answering system based on natural language input/output. (R. T. Chien)
- 1924 T Materials Research Laboratory. Data Analysis for Thermo-electric Power. This computer time will be used for least squares analysis of thermoelectric power data. (C. M. Wayman)
- 1926 Mathematics. Design Construction. Combinatorial designs are constructed by enumerating certain sub-designs and using a computer to attempt a completion to a full design. (E. T. Parker)
- 1929 Civil Engineering. Study of the Hydrology for Models of the Great Lakes. Quantitative analysis of precipitation, evaporation, and runoff for each of the Great Lakes and the Great Lakes as a system are to be made in order to provide a better understanding of these relationships for future management of the water resources of the Great Lakes. (D. Meredith)
- 1931 Natural History Survey. Mineral Content of Bird Feathers. The identification of goose nesting grounds by trace element analysis of wing feathers. (Harold C. Hanson)
- 1932 Agricultural Economics. Price Analysis. An analysis will be done on the price structures in the agricultural field. (Raymond Leuthold)
- 1933 Economics. Negative Income Tax. A study of various income maintenance plans such as the negative income tax, their effects on incentives, their impact on the economy, their estimated cost. (Husby)
- 1934 T Mechanical Engineering. Effects of Torsional and Axial Vibrations on Frictional Losses in Gear Systems. To investigate the effects of axial and torsional vibration on frictional losses in gear systems. (Mamoun)

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- 1935 Economics. Quadratic Programming Estimators and Specification. This time will be used to continue work on the Monte Carlo experiment for quadratic programming estimators which we have been doing under problem specification number 63044 on the 7094. (T. A. Yancey)
- 1936 Astronomy. Distances of Planetary Nebulae and Galactic Structure. The use of measured extinction will serve to establish position of spiral arms of galaxy. This in turn leads to more precise determination of local space densities of planetary nebulae. (Julius H. Cahn)
- 1938 Electrical Engineering. Research on a Broadband Isotropic Antenna System. This problem involves research aimed at the development of a configuration of antennas which will radiate a signal equally well in all directions. Machine time will be used in the analysis and design of the necessary antennas. (Dyson)
- 1939 Mechanical Engineering. IBR Steam and Water Heating Research. This is a continuing research program on hydronic heating and cooling. The computer is used for data analysis and plotting. (W. S. Harris)
- 1940 Animal Science. Statistical Genetics of Lamb Meat Production. Data processing and statistical analysis for an extensive sheep breeding project to evaluate heritabilities and genetic correlations for many traits related to lamb meat productivity. (H. W. Norton)
- 1941 Civil Engineering. Numerical Analysis of Cable Structures. This program deals with an exact non-linear solution of suspended cable networks, subjected to statically applied loads. The network is treated as comprising discrete cable elements. (Prem Krishna)
- 1942 T Geography. Climatic Fluctuation: A Case Study in Precipitation Analysis. This study will be a detailed analysis of precipitation time series using spectrum and cross-spectrum analyses for various stations in Illinois. The data will also be used in part for the generation of a simulation model of precipitation events and in part for the testing of the model. (John Lewis, Jr.)

1943 Geology. Microprobe and X-ray Diffraction Mineral Analysis. The geochemical evolution of the minerals is being studied in a group of related igneous rocks from New England. The compositional changes in the evolution of the mineral phases are being followed by microprobe analysis of individual mineral crystals. The microprobe output has to be corrected by computer in order to obtain accurate compositions. The structural states and relations of unit cells to composition are being determined by high-precision X-ray diffractometry. Accurate cell parameters are being obtained by a self indexing least squares refinement program. (D. M. Henderson)

1944 T Mechanical Engineering. Tandem Airfoils in a Diffuser. This problem is the study of the flow of air past two airfoils in tandem with the pressure generally increasing in the flow direction. The effects of boundary layers and wakes are included in this two dimensional problem. Numerical methods are to be used in the analysis. (Morgan)

1946 Electrical Engineering. Oxygen-Hydrogen Atmosphere. The diurnal variation of important oxygen and hydrogen constituents in the atmosphere between 60 and 90 km is being studied. (Stowe)

1947 Mechanical Engineering. Thermoregulatory Systems. Mathematical evaluation of various aspects of thermal control of a protective suit for humans. (Chato)

1948 Theoretical and Applied Mechanics. Deflection of Plates. Energy solution, collocation solution, and complex variable solution for deflection of clamped plates of a general type.. (W. J. Worley)

1949 Economics. Optimal Financial Structure and Investment Expenditures. This project will theoretically determine the optimal financial structure for a business firm and empirically find the effect of these results on investment expenditures by firms. In the theoretical part of the work numerical integration is required and will be performed on the 360. Following this the empirical estimation will be performed using techniques which allow a wide variety of lag structures while including appropriate financial variables. (Resek)

1951 Aeronautical and Astronautical Engineering. Structural Dynamics. Contract research in the area of undamped and damped structural dynamic problems. (Zak)

1952 T Electrical Engineering. Minimax Approximation with Rational Functions. The project is concerned with determining poles and zeros of transfer functions such that a specified amplitude response may be realized, in the sense of a minimax approximation. This requires approximation with rational functions, resulting in systems of non-linear simultaneous equations. A computer program for the solution of this approximation problem will be developed. (W. P. Petzold)

1954 Mechanical Engineering. Suspension Boundary Layer Flow. The time requested will be used for short computational problems for turbulent flow of suspensions over parallel plates. (J. J. Stukel)

1955 Animal Science. Lipid Metabolism in the Beef Animal. Detailed study of lipid metabolism in the beef animal to determine: (1) the means by which a beef animal deposits lipid within certain depots in its body during growth and development; (2) the mechanisms of lipid mobilization, transport and utilization; and (3) the influence of physiological status as mediated by hormonal control of items 1 and 2. (John R. Romans)

1956 Electrical Engineering. Full Wave Solutions. To theoretically determine the reflection coefficients for obliquely incident LF and VLF waves reflecting from the D region of the ionosphere, given electron density and collision frequency profiles, magnitude and direction of the earth's local magnetic field, angle of incidence of the waves, frequency of the waves, upper and lower limits for the downward numerical integration, integration interval, and desired accuracy. (Viertel)

1957 T Chemistry and Chemical Engineering. Flow Through Regular Packed Beds. An attempt is made to get some understanding of the flow patterns in a regular packed bed by measuring local properties such as mass transfer coefficients and shear stress. Also by means of an "analog computer" values of the velocity for inviscid flow are obtained. The digital computer must be used to fit a polynomial to the experimental data. (Anastas Karabelas)

1959 Geology. X-ray Analysis. X-ray analysis of mineral structures involves a large amount of data collecting and subsequent processing. Mathematical methods like least-squares analysis and FOURIER synthesis are extensively used. A series of programs in 360/FORTRAN will be kept on disk files together with the collected data. (Necip Guven)

1960 Plant Pathology. Field Corn Disease Research. Project involves evaluation of lines and varieties of field corn as sources of disease resistance and genetic studies of host resistance. Appropriate statistical and genetic, quantitative and qualitative, procedures will be used to analyze results from inheritance and evaluation studies, and to predict performance of disease resistant lines and hybrids. (Hooker)

1961 Computer Science. Tracing Program. The purpose is to adapt TRACK, a FORTRAN program for tracing the behavior of other FORTRAN programs, to the IBM 360 operating system and to investigate the feasibility of a similar code for ALGOL. (Fosdick)

1962 Coordinated Science Laboratory. Cognitive Memory System Simulation. A program will be coded to simulate cognitive memory. (Benjamin Wang)

1964 Materials Research Laboratory. Effect of Acoustical Phonons in Si on Tunneling. The contribution of acoustical phonons to the electron-self energy is calculated. with this function

$$\Sigma(p,E)$$

then the second derivative of the tunneling current (d^2I/dv^2) is calculated for Pb-Si tunnel junctions. (Heinz J. Deuling)

1965 Electrical Engineering. Rocket Data Processing. The Aeronomy Laboratory's Rocket Program includes the analysis of Faraday rotation and differential absorption data from Nike Apache rocket experiments in the D-region of the ionosphere. The processing of these data involves the Sen-Wyller equations of the generalized magnetoionic theory and a representation of the geomagnetic field by spherical harmonic expansions. This work can best (and perhaps only) be done by digital computer. (E. A. Mechtly)

1966 Food Science. Plot Mass Spectral. Normalize and plot mass spectral data from cards. (E. G. Perins)

1967 Industrial Administration. Team Decision Problems. Stochastic linear programming computations of management control problems. For creating input data to the above computations we need to write several programs. Data thus created are computed through the linear programming program available in MPS. (H. Hinomoto)

1968 Architecture. Economics in Building Structures. Faculty research on comparative framing of building frames. (Brightbill)

1969 T Materials Research Laboratory. Curve Fitting. Problem will be to fit curves associated with Mossbauer spectroscopy. (H. G. Drickamer)

1972 T Electrical Engineering. High Voltage Direct Current Transmission. An economic evaluation of a high voltage direct current transmission line. (Stephen R. Lambert)

1973 Agronomy. Consumer and Marketing Service Research. Program development for Consumer and Marketing Service Inspection and marketing problems. (Swanson)

1974 T Theoretical and Applied Mechanics. Domain of Possible Deformation of an Hyperelastic Material of Grade One. There are various interrelationships among the invariants of deformation right Cauchy-Green tensor. This project will use these interrelationships to determine the domain of possible deformation in the invariant space. (T. Moriarty)

- 1975 T Architecture. Low Cost Suburban Chicago Housing. The development of a hierarchial semi-lattice subset structure for a group of elements whose organization is defined by a non-directed graph. (Robert Katz)
- 1977 Mechanical Engineering. Finite-Difference Solution of Parabolic Equations. A study of finite-difference solutions of the diffusion equation and the boundary layer equations. (A. M. Clausing)
- 1978 T Recreation. Analysis of Water Resources Recreation Literature. The IBM 360 Document Processing System will be used to enable this investigator to receive, using key word inputs, those bibliographical notations that are pertinent to his request. This bibliographic retrieval process will be used to classify according to a topical outline model pieces of literature providing insight into concepts and scientific results of research developed in numerous allied disciplines. A "State-of-the-Art" paper will be developed which will deal with and illuminate the most apparent relationships involved in the recreational aspects of water resources use, planning and development. (R. B. Ditton)
- 1979 T Mechanical Engineering. Non-Constant Pressure Mixing. A study of the velocity profiles in the mixing region of two gas streams under the influence of a streamwise pressure gradient. (D. F. Brink)
- 1981 T Theoretical and Applied Mechanics. Scattered Light Photoelasticity. The problem is to develop a method for determining stress distributions by means of scattered light photoelasticity. This project is to improve on experimental procedures and to incorporate a more systematic means of data reduction. (Martin)
- 1984 T Theoretical and Applied Mechanics. Concrete Columns Reinforced with High Strength Steels Subjected to Biaxially Eccentric Loading. A theoretical and experimental analysis of the behavior, ultimate strength and mode of failure of biaxially eccentrically loaded rectangular concrete columns with corner reinforcement of high strength steels. (P. D. Heimdahl)

- 1985 Chemistry and Chemical Engineering. Stability of Falling Film. Compute eigenvalues for stability of laminar liquid film flowing down inclined wall. (Jameson)
- 1986 State Geological Survey. Mineral Matter in Coal. Size analyses of coal and of mineral matter obtained from coal are being done on a "Coulter Counter". Data reduction by computer will assist in determining effects of size of mineral particles in coal on problems of air pollution. (H. Gluskoter)
- 1987 Geography. Soil Toxicity Trends in Southern California. In this investigation, an attempt will be made to evaluate the spatial relationships between soil toxicity patterns, topography (using slope and topographic position parameters) soil texture, soil cation exchange capacity, and geologic fault patterns in Castac Valley California. The spatial nature of soil toxicity patterns will be analyzed by spectrum analysis (in a two-dimensional spatial model rather than a time series model). The relationships between soil toxicity and the other environmental parameters will be studied in a series of cospectrum analyses. (Placido LaValle)
- 1988 T Civil Engineering. Time Dependent Closure of a Spherical Cavity. Analysis of stress-redistribution and creep closure of a spherical cavity in an infinite creep-sensitive material. (Aiyer)
- 1989 T Theoretical and Applied Mechanics. Numerical Analysis of Plane Stress Problems with Creep. Evaluation of flow criteria and constitutive relations for the numerical analysis of plane stress problems with creep using finite element techniques. (T. Pickel)
- 1990 T Nuclear Engineering. Solution of Diffusion-Depletion Equations for Fast Breeder Reactors. Solution of coupled diffusion-depletion equations which describe the breeding characteristics of large fast breeder reactors. (Philbin)

- 1991 T Civil Engineering. Plane Structure-Medium Interaction. A study to evaluate the structure-medium interaction due to a plane elastic stress wave generated from dynamic disturbances. (E. G. Tabujara)
- 1992 T Civil Engineering. Pavement Optimization. A study directed toward the establishment of principles of guidelines that can be used to promote the most effective use of local and stabilized materials in the construction of low traffic highway pavements. (Q. L. Robnett)
- 1993 Civil Engineering. Dispersion in Unsteady Flow. Prior analytical work on dispersion has dealt primarily with steady flow conditions. It is now possible to use numerical simulation for analytical study of dispersion in unsteady flow problems. Specifically, it is planned to use numerical simulation to investigate (1) the influence of flood hydrographs on dispersion in streams and (2) the influence of tidal characteristics on dispersion in estuaries. These are problems of significance in current engineering practice. The planned studies would help to delineate the significance of various physical parameters. (Holley)
- 1994 Civil Engineering. Oxygen Demand and Reaeration. Chemical and biochemical oxygen demand in turbulent water can influence the net rate of oxygen absorption from the atmosphere. The computer will be used to evaluate analytical solutions for absorption and diffusion rates and to perform the statistical analysis of laboratory data. (Holley)
- 1995 Civil Engineering. Reinforced Concrete Arches. The behavior of concrete arches under transverse load from an unloaded stage to collapse is studied using a numerical procedure to evaluate the effects of variation in the following parameters: 1) concrete strength; 2) yielding stress of steel reinforcement; 3) percentage of reinforcement; and 4) ratio of midspan rise to span of the arch. (German Gurfinkel)

1996 T Agricultural Economics. Plant Location Problem. Using a combinatorial approach with the bounded algorithm of linear programming, I would like to find out the minimum-total-cost solution about the processing plant location, number, and size when the plant operation has a characteristic of the "economies of scale." (Hiroshi Tsujii)

1997 Survey Research Laboratory. Test Runs - Tabs. Test runs before analysis of survey results. (M. F. Uchida)

1998 Survey Research Laboratory. PL/1 - Development. Development and conversion of PL/1 for survey purposes. (M. F. Uchida)

2001 Educational Administration. Basic Information Retrieval System (BIRS). The Education Resources Information Clearinghouse (ERIC) on Early Childhood Education is required to establish an internal document retrieval system. This project will develop a number of computer programs (BIRS) which will automate the clerical operations common to most information retrieval systems, e.g., file maintenance and searching. (Carss)

2002 T Nuclear Engineering. Time Studies of Plasma Interactions and Emissions. Plasma interactions and emissions are studied in time as particles are injected radially inwards in cylindrical and spherical geometries, solving simultaneously the equations of poisson, energy conservation, and charge continuity. (Dolan)

2004 T Civil Engineering. Solution of Consolidation Problems Using Finite Differences. Finite difference solution for the time-settlement relationship in a consolidation problem involving a system of contiguous, compressible soil layers with partially draining boundaries. (Fred Gau)

2005 T Chemistry and Chemical Engineering. Stability of Liquid Surface Under Electric Field. Numerical determination of voltage required to initiate instability on liquid surface. (Young Y. Kim)

- 2006 Computer Science. ILLIAC IV. Use of the IBM 360 to work on ILLIAC IV problems. (Hui-Wen Chen)
- 2007 Electrical Engineering. Waves in Plasma. This problem investigates dispersion surface for E.M. waves in plasma. Essentially, this involves solving a fourth order equation. The object is to give a computer graphic display of this dispersion surface. (Y. T. Lo)
- 2009 T Electrical Engineering. Electromagnetic Boundary Value Problems. Change time from 7094 problem specification 6N004 to 360/75. (Imbriale)
- 2010 Chemistry and Chemical Engineering. Microwave Spectroscopy. Calculation of rotational, quadrupole, and related effects in microwave spectroscopy. (Arthur C. Ferguson)
- 2012 Physics. Properties of Many Particle Systems. Consideration of properties (low temperature) of many body systems. (Gordon Baym)
- 2013 Theoretical and Applied Mechanics. Hemodynamics. This is to change 7094 problem specification 70082 to the 360. (M. E. Clark)
- 2014 T Chemistry and Chemical Engineering. Experimental and Theoretical Study of Acid-Base Interactions. Fitting experimental heats of acid-base interactions to a two-parameter equation. (R. S. Drago)
- 2015 Civil Engineering. Recursion Adjustment of Coordinates. From a drawing the approximate coordinates of all the points can be scaled. (In three dimensions, if required) certain constraining conditions can now be stipulated for the points, e.g., collinearity, perpendicularity, etc., and imposed by a stepwise recursion adjustment to obviate the need for large matrix inversions. (L. A. White)
- 2016 T Accountancy. Bayesian Treatment of a Priori Information Using Monte-Carlo. Comparative study of different estimation techniques using Monte-Carlo technique. (Saadia Montasser)

2017 Geography. Morphological Variation of Karst Topography in Jamaica. Spatial variations in karst depression occurrence and form will be analyzed with respect to spatial variations in geologic structure, hydrologic conditions, and lithology within a portion of Western Jamaica. The spatial variations of karst depressions will be examined in a two-dimensional spectral analysis of terrain surface configuration, and the influence of structure, hydrology, and lithology will be examined through a series of cospectrum studies. (La Valle)

2018 Business Administration. Location Models. Mixed integer programming problems in location. (Sovereign)

2019 Physics. Solid State Thermodynamics. Reduction of experimental data and curve fitting related to thermodynamic measurements of superconductors and ferromagnetic transitions. (D. E. Mapother)

2021 Civil Engineering. Gradually Varied Flow. This replaces 7094 problem specification 76032. (Cheng-Lung Chen)

2023 Chemistry and Chemical Engineering. X-ray Structural Studies of Phosphonitriles. Crystal structure studies are being carried out on a number of derivatives of phosphonitrilic halides. The x-ray method is a powerful and unique tool to establish the structures of inorganic molecules. The methods being used are mainly direct methods programs. The computations involve structure factor calculations, formation of Fourier series, and refinement by least squares techniques. (Arrington)

2024 T Electrical Engineering. Electron Multiplier Design. Design of an electron multiplier device employing static electric and magnetic fields with high frequency electric fields to permit operation with microwave bandwidth. (Schaefer)

- 2026 T Civil Engineering. Drag Forces. Aim is the analytical determination of drag forces on bodies moving through non-Newtonian fluids. This is to be done via calculation of the energy dissipation by numerical methods. (Hormoz Pazwash)
- 2027 State Geological Survey. Steady State Ground-Water Flow Model. Finite difference techniques are applied to the solution of a 3D, non-homogeneous, isotropic flow system with the aid of a digital computer. (Paul Heigold)
- 2028 T Civil Engineering. Irregular Slab Analysis. A program entitled "A General Computer Program for the Elastic Analysis of Irregular Slabs" has been written by D. D. Moss which runs on the 7094. This request for computer time is made in order to modify this program so that it can be used on the 360. Once this has been accomplished the program shall be used to obtain data for a thesis concerning the study of slab behavior. (Charles H. Hofmayer)
- 2031 Theoretical and Applied Mechanics. Deflection of Curved Beam. The large and small deflections of a curved beam of variable cross section are calculated by successive summation of the deformations of a finite number of sections, each of which is considered to be circular. The beam is loaded by a force and/or a moment at each end. (J. C. McWhorter)
- 2032 Astronomy. Processing Photographic Data of Gaseous Nebulae. Photographic plates of gaseous nebulae are processed in the microphotomer. The digitized data (plate-transmission and plate-position) are recorded on magnetic tape which serves as input to the computer. The final output will include contour maps (= CalComp plots) of the distributions of the surface brightnesses across each nebula. Firstly, with the original resolution of the plate and, secondly, with a lower resolution. The output will also include the matrices of the surface brightnesses. (Helene Dickel)

2034 Children's Research Center. Production of KWIC Information Retrieval Project. The provision of a research tool by use of the computer to generate a master and KWIC index to 7,000 bibliographic entries considered relevant to research in the area of the motor performance of children.
(M. J. Ellis)

2035 Children's Research Center. Production of KWIC Information Retrieval Project. The provision of a research tool by use of the computer to generate a master and KWIC index to 7,000 bibliographic entries considered relevant to research in the area of the motor performance of children.
(M. J. Ellis)

2036 T Political Science. Post-Independence Electoral Politics in Ceylon. The major calculations will be correlations of data from six Parliamentary elections with delimitation and census statistics, and the correlation of party membership with other relevant characteristics of Members of Parliament. (W. W. Morris)

2038 T Political Science. Coalition Building. A simulation of presidential coalition building process using decision rules which relate to coalition size, ideological distances between delegates and candidates.
(J. Zais)

2039 Veterinary Pathology and Hygiene. Endogenous Development of Laboratory Coccidia. Study of the life cycle including endogenous stages of Eimeria stiedae of rabbits. (Fitzgerald)

2040 T Psychology. Multidimensional Scaling. Multidimensional scaling with the direct solution of coefficients of a general distance function. (Pieszko)

2041 T Home Economics. Effect of Formulation on the Quality of Rice Flour Cake. This study is concerned with the quality of rice flour cake as affected by fat source, flour level, and carboxymethylcellulose gum addition. (Lsiekiss)

2043 Chemistry and Chemical Engineering. Line-Shape Calculations for NMR Adiabatic Fast Passage Experiments. These differential equations will be solved for a variety of experimental conditions for the Adiabatic fast passage. (J. Jonas)

2044 Physics. Analysis of Fissile Element Cross Sections. The work proposed here has as its basic aim the development of a group of computer programs which should become useful for the large scale analysis and evaluation of neutron resonance cross sections at Brookhaven National Laboratory and possibly at other installations or by experimental groups from which the data originate. Specifically, work in the following area is proposed: (1) An extension of the existing programs TANDEM and CODILLI, to provide for the simultaneous fitting of fission, capture, and total cross sections, or of any pair of cross sections; special attention will be devoted to make the codes usable for a range of resolution functions, and to treat, for example, transmission data with more than one sample thickness in an efficient manner. (2) Development of a special program, based directly on the use of complex arithmetic, to determine directly the complex partial fission widths, as discussed in Section III. (3) Study of recent developments concerning the procedures for accelerating convergence in least square or other optimization techniques, and implementation of useful devices in the programs. (4) Fitting of selected experimental data, which are of current interest and where the evaluation could complement other current work at BNL, ORNL, or other installations. (F. T. Adler)

2045 Astronomy. Eclipsing Binary Spectroscopy. The computer will be used to make linearization of microphotometer tracings of astronomical spectra of eclipsing binary stars. The CalComp plotter will be used to make intensity tracings. Line broadening calculations will also be made. (Edward Olson)

2047 T Theoretical and Applied Mechanics. Analytical Analysis of Statically Indeterminate Structures Made of Hollow Box Sections. Analysis of a series of statically indeterminate structures composed of hollow box sections to determine the reactions on the structures at fixed sections and stresses throughout the structures. (F. M. Thomas)

- 2048 T Agricultural Economics. Cattle Supply Study - Argentina.
Multi-period linear programming about the cattle supply in Argentina.
(Jose Kohout)
- 2050 Civil Engineering. Flow in Alluvial Rivers. Numerical analysis
and data processing of resistance to flow in alluvial rivers. (Liou Ying-Chang)
- 2051 Civil Engineering. Watershed Runoff. Numerical analysis and
data processing for investigations on the non-linearity and non-uniqueness of
the unit hydrograph in the study of watershed runoff. (Anderson)
- 2052 Astronomy. Ionization Model of Orion Nebula. The Orion Nebula
is a large mass of gas illuminated by a hot star. A mathematical model has been
developed to predict the ionization structure of the nebula. The computer will
be used to quantitatively evaluate the model parameters. (Julie Lutz)
- 2052 Bureau of Institutional Research. Administrative Research.
The job number will be used for analysis of staff at the university in such
areas as salary and length of service. Usage will also be made for analysis
of student data such as curriculum, age, etc. (Walter Tousey)
- 2054 Astronomy. Studies in Gaseous Nebulae. The computer will be
used for the reduction of nebular spectra and for the evaluation of nebular
parameters from these spectra. (James Kaler)
- 2055 Materials Research Laboratory. Electron Scattering in Metals.
The electrical resistivity and the quadrupole effects in NMR, both arising
from the scattering of conduction electrons in metals, will be calculated by
the pseudo-potential theory. (Y. Fukai)
- 2057 T Agricultural Economics. Monte Carlo Experiments. I am going
to do some Monte Carlo experiments to study the small-sample properties of
various systems of simultaneous equations with particular emphasis on
forecasting and decision-making in an economic context. (Thomas Bell)

- 2058 T Aeronautical and Astronautical Engineering. Transverse Waves in Detonations. An attempt to determine the effect of a boundary layer on transverse waves in detonations. Using an acoustic approximation, a ray tracing technique will be used. (Webb)
- 2059 Civil Engineering. Constraint Processor. This program will be used to check a structure against the building codes. (Khan)
- 2061 Materials Research Laboratory. Research in Transition Metals and Alloys. Low temperature investigations of specific heats and magnetic susceptibilities of transition metal alloys. (P. A. Beck)
- 2062 Civil Engineering. Simulation of Corps of Engineers. Develop integrated series of operators to be used in a selected order to simulate particular decision-making processes on operations inherent in the work performed in Corps of Engineers. (L. R. Shaffer)
- 2063 T Civil Engineering. Competitive Strategy Models. Develop integrated series of competitive strategy models for comparative study of models utilizing data obtained in professional practice. (T. W. Mischeau)
- 2064 T Civil Engineering. Calendar-Day CPM. Extend Calendar-Day CPM algorithm to include treatment of resources. (L. R. Shaffer)
- 2065 T Electrical Engineering. Sound Propagation Between Partially Connected Spaces. Theoretical calculations of sound transmission from one office area to another when the areas are separated by a "partial" partition (one that does not go all the way to the ceiling). (Schomer)
- 2066 Forestry. Soil Moisture Stress. To investigate the effects of controlled soil moisture stress on (1) foliar nutrients, number of growth flushes, diameter growth, and height growth of loblolly pine trees; (2) the specific gravity, tracheid length, and percentage of summerwood, springwood, cellulose, extractives, and lignin of the wood of loblolly pine trees. (A. R. Gilmore)

- 2068 Computer Science. Consulting. Automatic processing of test data for consulting work. (Gear)
- 2069 T Mining, Metallurgy, and Petroleum Engineering. Statistical Model of River Meanders. A spectral analysis of actual river meanders and statistically generated meanders is to be performed. (A. E. Scheidegger)
- 2072 Astronomy. Electronic Velocity Distributions in Stellar Atmospheres. Determination of stellar emission as dependent upon the functional form of the electronic velocity distribution function. (Julius H. Cahn)
- 2075 Psychology. Determination of Number of Factors. Determination of an objective decision rule for the number of factors to be extracted from a given correlation matrix. (L. G. Humphreys)
- 2077 T Theoretical and Applied Mechanics. Creep. Creep of load carrying members made of metals subjected to nonproportionate load changes. (S. Chu)
- 2078 T Electrical Engineering. Faraday Rotation D.A. Digitize two taped analog rocket signals using the 1800 ADC facility. Derive a FORTRAN program to extract Faraday Rotation as a phase shift using the sampling time base of the 1800, with the ADC output as suitable input. (A. G. Sleky)
- 2079 Physics. Optical Constants and Dispersion Relations. This problem is the same as problem specification 1436. (F. C. Brown)
- 2084 T Physics. Evaporation of Nuclear Particles. The thesis project includes numerical integration of a nuclear evaporation formula and analysis of experimental data testing nuclear evaporation theory. (William Switzer)

- 2085 T Theoretical and Applied Mechanics. Wave Propagation. Study of the effect of nonlinear boundary conditions on the propagation of waves in linear systems of finite length. Involves the numerical solution of hyperbolic partial differential equations with nonlinear boundaries. (Richard D. Strunk)
- 2086 Electrical Engineering. New Aspects of Antenna Synthesis. The objective of this problem is to search for a proper reactive reflecting surface, such as corrugated structure, so that the imaging property of the antenna system can be greatly improved. (Y. T. Lo)
- 2087 T Coordinated Science Laboratory. Tunneling Current Calculation. Solution of tunneling equation for metal-insulator-metal junctions. (Steven Depp)
- 2088 Nuclear Engineering. Coupled Core Studies. Preliminary studies of the transient behavior of two coupled critical reactors taking into account negative temperature feed back, using the code WIGLE. (G. Thayer)
- 2089 Agricultural Engineering. Data Analysis for Farm Waste Management Procedures. Data from farm animal waste treatment systems will be analyzed and compared using the 360/75 computer and the CalComp Plotter. (Don D. Jones)
- 2091 T Chemistry and Chemical Engineering. One-Center Hartree-Fock Calculations. The molecular Hartree-Fock equations are expanded in a series of numerical radial functions and spherical harmonics at one nucleus and the resulting 2nd order differential equations are solved numerically for the radial functions and eigenvalues by an iterative method. (R. L. Belford)

2092 State Water Survey. Radar Hail Evaluation. This project will involve analyses of various historical hail data to determine the most meaningful statistical seeding design. Studies of various past and recent surface hail data collected in Illinois to provide basic statistics on hailstorm characteristics. Developing a recording hailgauge that would provide objective measures of hailfall intensity for employment in areas of modification projects. Radar-hail investigations to determine the capability of radars to detect storms producing surface hail in a modification project. (Robert Sinclair)

2094 Civil Engineering. Pavement Testing. Statistical analysis. (E. Barenberg)

2095 Provost's Office. Organizational Study of Departmental Performance. This project is an investigation of organizational factors of university academic departments and how these factors relate to various departmental outputs, such as quality of graduate students and publications of the faculty. (Lanier)

2097 T Physiology and Biophysics. Metabolic Hormonal Research. Routine isotope calculations, statistical analyses, curve fitting and plotting, and enzyme kinetical analyses for biochemical data. (Peter M. Spooner)

2099 Finance. Risk Simulation Model. To simulate a frequency distribution of benefit-cost ratios for a given investment decision. (Le Bloch)

2100 Children's Research Center. Analysis of Children's Play Behavior. The analysis of various physical and social factors as they interact in conditioning the play of preschool children. Locomotor behavior described by the changes in position in the Motor Performance and Play Research Laboratory will lead to emphasis concerning the effect of the physical environment on the activity patterns of the children at play. Analyses of the social structure of the play group will be undertaken to determine the interaction between social physical factors on play. (M. J. Ellis)

2101 T Chemistry and Chemical Engineering. Semi-Empirical Molecular Orbital Calculation. Application of semi-empirical molecular orbital theory to the description of carbonyl complexes. (T. L. Brown)

2102 T Civil Engineering. A Post-Buckling Analysis of Some Selected Structures. The set of nonlinear ordinary differential equations which describe the equilibrium of the structure at some load level are solved by a numerical procedure. The nonlinear equations are linearized analytically and the linear equations solved as a series of initial value problems by a predictor-corrector numerical integration process. Convergence of a sequence of these linearized problems to the solution of the nonlinear equations is sought through the application of Newton's method. (J. F. Harris)

2103 Education. Estudio de Problemas Intercultural. To develop and use natural language analysis programs for use in breaking down and integrating field notes gathered in the course of an examination of problems associated with differences in the cultures of the home and school. (Burnett)

2104 Agricultural Economics. Prepare Matrices for Linear Programming Problems. Formulation of linear programming problems for solution on the 360. (Baker)

2105 Electrical Engineering. Modeling the Plasma in a Discharge Tube. An attempt to model the plasma in a discharge tube on the basis of the external scattered fields. (Mittra-Schaubert)

2107 Bureau of Institutional Research. Administrative Research. Study of characteristics and activities of the University's staff and related variables. (Franklin L. Duff)

9.3 Class Problem Specifications

During the fourth quarter of 1968, 58 problem specifications were submitted to cover all assigned problems on the System/360 in the following courses.

1906	Electrical Engineering 416.
1907	Electrical Engineering 386.
1910	Computer Science 101.
1911	General Engineering 393.
1913	Electrical Engineering 386.
1914	Electrical Engineering 416.
1915	Civil Engineering 220.
1917	Physics 107.
1918	Computer Science 109.
1919	Electrical Engineering 382.
1925	Mechanical Engineering 495.
1927	Electrical Engineering 232.
1928	Electrical Engineering 383.
1930	Civil Engineering 352.
1937	Economics 476.

1945	Agricultural Engineering 299.
1950	Aeronautical and Astronautical Engineering 351.
1953	Computer Science 490.
1958	Aeronautical and Astronautical Engineering 296.
1963	Mathematics 123.
1970	Agricultural Engineering 499.
1971	Agricultural Engineering 287.
1976	Educational Psychology 497.
1980	Architecture 493.
1982	Physics 386.
1983	Mechanical Engineering 293.
1999	Civil Engineering 315.
2000	Civil Engineering 316.
2003	Electrical Engineering 229.
2008	Electrical Engineering 357.
2011	Industrial Engineering 355.
2020	Theoretical and Applied Mechanics 493.
2022	Civil Engineering 262.
2025	Civil Engineering 297.

2029	Music 320.
2030	Theoretical and Applied Mechanics 235.
2033	Mechanical Engineering 343.
2037	Political Science 291.
2042	Electrical Engineering 497.
2046	Theoretical and Applied Mechanics 424.
2049	Industrial Engineering 458.
2056	Urban Planning 376.
2060	General Engineering 221.
2067	Mechanical Engineering 448.
2070	Civil Engineering 374.
2071	Civil Engineering 497.
2073	Mechanical Engineering 448.
2074	Mathematics 490.
2076	Educational Psychology 497.
2080	Civil Engineering 201.
2081	Agricultural Engineering 221.

2082	Computer Science 1800.
2083	Civil Engineering 470.
2090	Accountancy 325.
2093	Architecture 348.
2096	Economics 295.
2098	Finance 294.
2106	Agronomy 440.

10. IBM 7094/1401 SERVICE, USE, AND DEVELOPMENT

(Supported in part by the National Science Foundation under Grant No. NSF-GP-700.)

10.1 Log Summaries

Table I - IBM 1401-II

Summary of Use

October, 1968

Scheduled Engineering	4:15
Unscheduled Engineering	24:47
Maintenance	5:47
7094 Preparation	539:29
List/Reproduce	16:21
Code Check	:45
Tape Dump	:47
1604 Preparation	2:21
Idle	58:36
Total	<u>653:08</u>

Table II - IBM 1401-II

Summary of Machine Errors

October, 1968

1402 Card Reader Punch	6
1403 Printer	1
729V Tape Drives	1
Total	<u>8</u>

Table I - IBM 7094

Summary of Use

October, 1968

Scheduled Engineering		24:26
Unscheduled Engineering		3:54
Maintenance		3:11
Air Conditioning		22:55
Idle		110:06
Miscellaneous (Operator training, tape rewind, system tape mounting, rerun of failing problems)		109:41
Total Use		
Training and Education	7:25	
University Administrative Overhead Use	:41	
System Modification and Improvements	12:37	
System Accounting	8:01	
System Updating	:11	
Customer Use		
In System	303:05	
Special Short Shots	<u>3:00</u>	
Customer Use Total		<u>306:05</u>
	Total Use	<u>335:00</u>
	Total Time	<u>609:13</u>

Table II - IBM 7094

Summary of Errors

October, 1968

Disk File	1
Console	1
Tape Drive	1
7607 Data Channel	<u>1</u>
Total	<u><u>4</u></u>

IBM 7094 TABLE III OCTOBER, 1968

DEPT ¹	NUMBER OF RJNS			NUMBER OF SPECS			IBM 7094			USAGE IN HOURS-MINUTES-SECONDS		
	TANDE ²	RES	TOTAL	TANDE ²	RES	TOTAL	TANDE ²			RESEARCH	REFUND	TOTAL
AAE	0	47	47	0	2	2				1 33 10		1 33 10
ACCY	0	30	30	0	2	2				6 53		6 53
ADV	0	7	7	0	3	3				2 59		2 59
AGE	0	126	126	0	4	4				1 25 17		1 25 17
AGEC	61	41	102	3	4	7	38 47			51 13		1 30 03
AGREXT	0	4	4	0	1	1				19 15		19 15
AGRON	0	2	2	0	1	1				46		46
ANS	0	62	62	0	4	4				1 08 22		1 08 22
ASTR	0	108	108	0	5	5				1 54 12		1 54 12
ASTRMI	0	2	2	0	1	1				9 07		9 07
BINRES	0	29	29	0	1	1				23 09		23 09
CCSCS	0	2	2	0	1	1				1 12		1 12
CE	326	169	495	2	16	18	1 09 03			4 02 37		5 11 40
CHE	0	880	880	0	25	25				28 12 36		28 12 36
CIRCE	0	4	4	0	1	1				1 48		1 48
COMM	0	2	2	0	1	1				54		54
CRC	0	19	19	0	1	1				17 24		17 24
DCS	0	1	1	0	1	1				03		03
DS	1	2	3	1	2	3	07			21		28
ECON	18	30	48	1	3	4	6 14			19 58		26 12
ED	0	77	77	0	10	10				1 26 32		1 26 32
EDPSY	15	0	15	2	0	2	19 04					19 04
EE	0	132	132	0	7	7				3 35 22		3 35 22
ENTOM	0	57	57	0	3	3				49 15		49 15
FIN	0	30	30	0	2	2				48 46		48 46
FT	0	12	12	0	2	2				2 59		2 59
GENE	275	40	315	1	3	4	1 06 28			25 01		1 31 29
GEOL	19	55	74	1	2	3	7 26			1 37 15		1 44 41
GSBA	0	2	2	0	1	1				1 55		1 55
HED	0	2	2	0	1	1				21		21
HLTHSV	0	2	2	0	1	1				20 38		20 38
HONORS	0	1	1	0	1	1				5 27		5 27
HORT	0	2	2	0	1	1				1 33		1 33
ICR	0	134	134	0	2	2				4 16 33		4 16 33
IED	0	86	86	0	1	1				2 33 36		2 33 36

IGPA	0	42	42	0	1	1		2	23	52		2	23	52
ILR	0	7	7	0	1	1			24	18			24	18
INADM	0	3	3	0	1	1			1	08			1	08
IREC	0	14	14	0	3	3		1	22	29		1	22	29
LIBS	0	3	3	0	1	1			10	19			10	19
MATH	0	5	5	0	1	1			19	51			19	51
MATRL	0	819	819	0	17	17		25	43	23		25	43	23
MCBIO	0	47	47	0	3	3			21	38			21	38
ME	26	865	891	1	24	25	14 13	27	19	45		27	33	53
MMPE	0	186	186	0	1	1		2	43	08		2	43	08
MUSIC	0	6	6	0	1	1			20	42			20	42
NHS	0	6	6	0	1	1			11	31			11	31
NUCE	0	136	136	0	6	6		2	53	58		2	53	58
OIR	0	370	370	0	1	1		14	19	22		14	19	22
ORME	0	3	3	0	1	1			45	57			45	57
PEM	0	19	19	0	4	4			36	23			36	23
PHYB	0	65	65	0	3	3			41	19			41	19
PHYCS	3	261	264	1	6	7	25	4	05	50		4	06	15
PHYX	0	1332	1332	0	10	10		123	10	00		123	10	00
POLS	12	44	56	2	3	5	39 35	6	21	17		7	00	52
PROVST	0	6	6	0	1	1			12	32			12	32
PSYCH	166	823	989	3	24	27	2 59 34	17	56	54		20	56	29
REC	0	6	6	0	1	1			2	24			2	24
SCONS	0	38	38	0	1	1			10	44			10	44
SGS	0	51	51	0	2	2		1	19	18		1	19	18
SOC	11	44	55	1	4	5	1 01	2	15	38		2	16	39
SOCW	7	9	16	1	1	2	2 42		12	50			15	32
SPED	0	9	9	0	1	1			11	31			11	31
SRL	0	74	74	0	2	2		4	58	37		4	58	37
SWS	0	218	218	0	15	15		4	18	26		4	18	25
TAM	0	12	12	0	2	2			4	26			4	25
VPP	0	19	19	0	1	1			4	40			4	40
VTED	0	5	5	0	1	1			3	03			3	03
SUBTOTAL	940	7746	8686	20	261	281	7 24 39	303	03	42		310	28	21

DCSSYS ³	0	4 4 6	4 4 6	0	10	10	20	38	23	20	38	23
SSUAD ⁴	0	26	26	0	1	1		41	02		41	02
XDCS ⁵	0	16	16	0	1	1		10	33		10	33
XSS ⁶	0	2 2 8	2 2 8	0	1	1	2	59	38	2	59	38
<hr/>												
SUBTOTAL	0	7 1 6	7 1 6	0	13	13	24	29	36		24	29 36
<hr/>												
TOTALS	940	84 6 2	9402	20	274	294	7	24	39	327	33	18 334 57 57

- 1 See list of departmental codes following
- 2 Training and Education
- 3 System Improvement and Modifications
- 4 University Administrative Overhead Use
- 5 System Updating
- 6 Special Short Shots

Table I - IBM 1401-II

Summary of Use

November, 1968

Scheduled Engineering	4:43
Unscheduled Engineering	23:20
Maintenance	3:46
7094 Preparation	499:14
List/Reproduce	17:36
Code Check	:06
Tape Dump	4:13
1604 Preparation	2:40
Air Conditioning	2:15
Idle	<u>67:55</u>
Total	<u>625:48</u>

Table II - IBM 1401-II

Summary of Machine Errors

November, 1968

1401 Main Frame	1
1402 Card Reader Punch	6
1403 Printer	<u>4</u>
Total	<u>11</u>

Table I - IBM 7094

Summary of Use

November, 1968

Scheduled Engineering	21:59
Unscheduled Engineering	1:10
Maintenance	1:30
Idle	21:41
Miscellaneous (Operator training, tape rewind, system tape mounting, rerun of failing problems)	70:03

Total Use

Training and Education	23:27
University Administrative Overhead Use	:46
System Improvement and Modifications	9:00
System Accounting	8:43
System Updating	:10

Customer Use

In System	248:01
Special Short Shots	<u>:05</u>

Customer Use Total

248:06

Total Use 290:12

Total Time 406:35

Table II - IBM 7094

Summary of Errors

November, 1968

Disk

1

Total

1

IBM 7094 TABLE III NOVEMBER, 1968

DEPT ¹	NUMBER OF RUNS			NUMBER OF SPECS			IBM 7094 USAGE IN HOURS-MINUTES-SECONDS		
	TANDE ²	RES	TOTAL	TANDE ²	RES	TOTAL	TANDE ²	RESEARCH	REFUND TOTAL
AAE	0	42	42	0	2	2		1 21 32	1 21 32
ADV	0	1	1	0	1	1		32	32
AGE	0	43	43	0	2	2		24 06	24 06
AGEC	195	46	241	3	6	9	43 33	1 10 28	1 54 01
AGREXT	0	2	2	0	1	1		18 21	18 21
AGRCN	0	6	6	0	3	3		4 47	4 47
ANS	0	64	64	0	5	5		1 16 32	1 16 32
ARCH	64	0	64	1	0	1	10 04		10 04
ASTR	0	54	54	0	4	4		1 26 30	1 26 30
ASTRML	0	1	1	0	1	1		17 52	17 52
BINRES	0	33	33	0	2	2		1 42 07	1 42 07
CCSCS	0	1	1	0	1	1		54	54
CE	124	99	223	2	14	16	18 46	2 24 38	2 43 24
CHE	0	547	547	0	26	26		13 32 20	13 32 20
CIRCE	0	4	4	0	1	1		12 46	12 46
COMM	0	10	10	0	1	1		3 57	3 57
CRC	0	36	36	0	3	3		50 45	50 45
CS	23	1	24	1	1	2	2 45	03	2 48
ECCN	0	16	16	0	2	2		10 58	10 58
ED	0	109	109	0	11	11		1 47 26	1 47 26
EDPSY	7	15	22	2	1	3	2 08	1 19 26	1 21 34
EE	0	96	96	0	9	9		1 37 50	1 37 50
ENGCS	0	5	5	0	1	1		8 52	8 52
ENTOM	0	52	52	0	2	2		33 10	33 10
FIN	0	5	5	0	2	2		1 48	1 48
FOR	0	3	3	0	1	1		43	43
FT	0	9	9	0	1	1		5 31	5 31
GENE	23	26	49	1	3	4	3 50	22 25	26 15
GECL	51	23	74	1	1	2	25 01	20 24	45 25
GSBA	0	1	1	0	1	1		3 54	3 54
HEC	0	7	7	0	2	2		10 00	10 00
HED	0	6	6	0	1	1		7 30	7 30
HORT	0	2	2	0	1	1		39	39
ICK	0	192	192	0	2	2		7 53 30	7 53 30
IED	0	40	40	0	1	1		2 05 02	2 05 02

IBM 7094 TABLE III NOVEMBER, 1968 -CCNT

DEPT ¹	NUMBER OF RUNS			NUMBER OF SPECS			IBM 7094 USAGE IN HOURS-MINUTES-SECONDS			
	TANDE ²	RES	TOTAL	TANDE ²	RES	TOTAL	TANDE ²	RESEARCH	REFUND	TOTAL
IGPA	0	10	10	0	1	1		1 10 01		1 10 01
ILR	0	65	65	0	3	3		57 03		57 03
INADM	0	13	13	0	1	1		11 38		11 38
IREC	0	19	19	0	3	3		12 28		12 28
LAW	0	1	1	0	1	1		14 09		14 09
LIPS	0	1	1	0	1	1		14		14
MATH	0	18	18	0	1	1		1 36 32		1 36 32
MATRL	0	423	423	0	14	14		12 00 29		12 00 29
MCBIO	0	10	10	0	3	3		4 47		4 47
ME	3	558	561	1	25	26	1 08	23 30 25		23 31 33
MMPE	0	151	151	0	1	1		2 33 18		2 33 18
MUSIC	2	4	6	1	1	2	08	8 02		8 10
NHS	0	7	7	0	2	2		8 31		8 31
NUCE	0	140	140	0	10	10		2 30 38		2 30 38
CIR	0	278	278	0	1	1		9 30 00		9 30 00
CRME	0	7	7	0	1	1		1 09 36		1 09 36
PEM	0	11	11	0	2	2		16 58		16 58
PHYB	0	100	100	0	3	3		1 18 53		1 18 53
PHYCS	22	147	169	1	5	6	3 32	3 31 49		3 35 21
PHYX	0	1191	1191	0	10	10		105 53 38		105 53 38
POLS	128	30	153	3	3	6	17 21 17	1 47 22		19 08 39
PSYCH	230	895	1125	4	18	22	3 44 16	24 44 08		28 28 24
REC	0	8	3	0	1	1		2 56		2 56
SCONS	0	41	41	0	1	1		15 03		15 03
SGS	0	21	21	0	1	1		12 28		12 28
SOC	76	62	138	1	5	6	10 22	4 04 39		4 15 01
SOCW	13	18	31	1	1	2	5 45	55 33		1 01 18
SPED	7	4	11	1	1	2	13 51	54		14 45
SRL	0	54	54	0	2	2		2 45 53		2 45 53
SWS	0	227	227	0	16	16		3 58 15		3 58 15
TAM	0	24	24	0	2	2		12 17		12 17
VPP	0	10	10	0	1	1		3 21		3 21
VTED	0	3	3	0	1	1		21		21
SUBTOTAL	968	6148	7116	24	258	282	23 26 26	247 59 37		271 26 03

IBM 7094 TABLE III NOVEMBER, 1968 -CONT

DEPT ¹	NUMBER OF RUNS			NUMBER OF SPECS			IBM 7094 USAGE IN HOURS-MINUTES-SECONDS			
	TANDE ²	RES	TOTAL	TANDE ²	RES	TOTAL	TANDE ²	RESEARCH	REFUND	TOTAL
DCSSYS ³	0	302	302	0	6	6		17 43 08		17 43 08
SSUAD ⁴	0	30	30	0	1	1		45 54		45 54
XCCS ⁵	0	20	20	0	1	1		10 22		10 22
XSS ⁶	0	8	8	0	1	1		4 40		4 40
<hr/>										
SUBTOTAL	0	360	360	0	9	9		18 44 04		18 44 04
<hr/>										
TOTALS	968	6508	7476	24	267	291	23 26 26	266 43 41		290 10 07

1 See list of departmental codes following

2 Training and Education

3 System Improvement and Modifications

4 University Administrative Overhead Use

5 System Updating

6 Special Short Shots

Table I - IBM 1401-II

Summary of Use

December, 1968

Scheduled Engineering	12:21
Unscheduled Engineering	13:15
Maintenance	2:33
709 ⁴ Preparation	509:34
List/Reproduce	9:55
Code Check	:50
Tape Dump	2:13
160 ⁴ Preparation	:10
Idle	<u>45:14</u>
Total	<u>596:05</u>

Table II - IBM 1401-II

Summary of Machine Errors

December, 1968

1402 Card Reader Punch	2
1403 Printer	1
729V Tape Drives	2
Total	<u>5</u>

Table I - IBM 7094

Summary of Use

December, 1968

Scheduled Engineering	30:11
Unscheduled Engineering	17:40
Air Conditioning	6:40
Maintenance	2:28
Idle	26:41
Miscellaneous (Operator training, tape rewind, system tape mounting, rerun of failing problems)	51:18

Total Use

Training and Education	20:06
University Administrative Overhead Use	10:25
System Improvement and Modifications	9:24
System Accounting	8:27
System Updating	:32

Customer Use Total

215:59

Total Use 264:53

Total Time 399:51

Table II - IBM 7094

Summary of Errors

December, 1968

7631 Disk File Control
Tape Drive

1
1

Total

2

IBM 7094 TABLE III DECEMBER, 1968

DEPT ¹	NUMBER OF RUNS			NUMBER OF SPECS			IBM 7094 USAGE IN HOURS-MINUTES-SECONDS			
	TANDE ²	RES	TOTAL	TANDE ²	RES	TOTAL	TANDE ²	RESEARCH	REFUND	TOTAL
AAE	0	17	17	0	1	1		36 32		36 32
ACCY	0	18	18	0	1	1		17 13		17 13
ADV	0	6	6	0	1	1		19 30		19 30
AGE	0	1	1	0	1	1		14		14
AGEC	349	127	476	3	6	9	1 38 01	2 46 03		4 24 04
AGREXT	0	4	4	0	1	1		2 24		2 24
AGRON	0	11	11	0	2	2		5 31		5 31
ANS	0	42	42	0	4	4		39 34		39 34
ARCH	30	0	30	1	0	1	5 27			5 27
ASTR	0	78	78	0	4	4		1 05 45		1 05 45
ASTRMI	0	5	5	0	1	1		19 48		19 48
AVI	0	2	2	0	1	1		46		46
BINRES	0	23	23	0	1	1		52 33		52 33
CCSCS	0	3	3	0	1	1		4 08		4 08
CE	133	115	248	3	11	14	21 27	5 17 36		5 39 03
CHE	0	441	441	0	24	24		14 24 09		14 24 09
CIRCE	0	5	5	0	1	1		23 31		23 31
COMM	0	21	21	0	1	1		28 51		28 51
CRC	0	18	18	0	3	3		25 25		25 25
DCS	0	4	4	0	2	2		7 29		7 29
DGS	0	16	16	0	1	1		30 10		30 10
DS	5	5	10	1	2	3	57	1 36		2 33
ECON	3	5	8	1	2	3	8 52	9 03		17 55
ED	0	75	75	0	9	9		1 06 39		1 06 39
EDPSY	229	6	235	3	1	4	1 31 43	6 14		1 37 57
EE	0	63	63	0	6	6		39 27		39 27
ENGCSST	0	1	1	0	1	1		18		18
ENTOM	0	4	4	0	2	2		2 55		2 55
FIN	0	9	9	0	1	1		7 33		7 33
FOR	0	9	9	0	1	1		8 06		8 06
FT	0	7	7	0	1	1		2 24		2 24
GENE	37	39	76	1	3	4	24 07	26 19		50 26
GEOG	0	59	59	0	2	2		41 23		41 23
GEOL	34	26	60	1	1	2	33 18	1 03 54		1 37 12
GSBA	0	1	1	0	1	1		5 49		5 49

IBM 7094 TABLE III DECEMBER, 1968 -CONT

DEPT ¹	NUMBER OF RUNS			NUMBER OF SPECS			IBM 7094 TANDE ²	USAGE IN HOURS-MINUTES-SECONDS		
	TANDE ²	RES	TOTAL	TANDE ²	RES	TOTAL		RESEARCH	REFUND	TOTAL
HEC	0	8	8	0	2	2		37	00	37 00
FED	0	25	25	0	1	1		23	24	23 24
HONORS	0	1	1	0	1	1			14	14
ICR	0	197	197	0	2	2		6	37 11	6 37 11
IED	0	39	39	0	1	1		6	04 51	6 04 51
IGPA	0	1	1	0	1	1			10	10
ILR	0	41	41	0	3	3		32	19	32 19
INADM	0	12	12	0	1	1		15	25	15 25
IREC	0	23	23	0	3	3		1	28 07	1 28 07
LIBS	0	3	3	0	1	1		6	18	6 18
MATH	0	4	4	0	1	1		11	45	11 45
MATRL	0	242	242	0	15	15		8	13 49	8 13 49
MCBIO	0	5	5	0	2	2		2	20	2 20
ME	56	273	329	1	8	9	22 30	10	17 39	10 40 09
MMPE	0	68	68	0	1	1		1	48 46	1 48 46
MUSIC	7	4	11	1	1	2	4 42	5	20	10 02
NHS	0	63	63	0	3	3		30	56	30 56
NUCE	0	145	145	0	7	7		2	00 22	2 00 22
DIR	0	161	161	0	1	1		4	34 37	4 34 37
GRME	0	3	3	0	1	1		13	08	13 08
PEM	0	24	24	0	5	5		33	09	33 09
PHYB	0	51	51	0	3	3		2	08 41	2 08 41
PHYCS	0	131	131	0	4	4		5	29 36	5 29 36
PHYX	0	1082	1082	0	10	10		81	54 25	81 54 25
POLS	99	26	125	4	2	6	8 14 08	1	55 33	10 09 41
PSYCH	319	906	1225	4	21	25	6 09 16	30	38 03	36 47 19
REC	0	28	28	0	2	2		1	13 04	1 13 04
SCONS	0	20	20	0	1	1		6	03	6 03
SGS	0	21	21	0	2	2		49	36	49 36
SOC	37	101	138	1	9	10	13 51	3	33 12	3 47 03
SOCW	1	10	11	1	1	2	2 06	59	06	1 01 12
SPCH	0	2	2	0	1	1			14	14
SPED	3	24	27	1	2	3	15 43	20	13	35 56
SRL	0	26	26	0	2	2		1	40 37	1 40 37
SWS	0	264	264	0	15	15		6	11 42	6 11 42
TAM	0	41	41	0	3	3		21	05	21 05

IBM 7094 TABLE III DECEMBER, 1968 -CONT

DEPT ¹	NUMBER OF RUNS			NUMBER OF SPECS			IBM 7094 TANDE ²	USAGE IN HOURS-MINUTES-SECONDS		
	TANDE ²	RES	TOTAL	TANDE ²	RES	TOTAL		RESEARCH	REFUND	TOTAL
VPP	0	17	17	0	1	1		7	30	7 30
VTED	0	3	3	0	1	1		2	13	2 13
ZOOL	0	33	33	0	2	2		21	31	21 31
<hr/>										
SUBTOTAL	1342	5394	6736	27	244	271	20 06 08	215	58 06	236 04 14
DCSSYS ³	0	461	461	0	7	7		17	50 29	17 50 29
SSUAD ⁴	0		84		2	2		10	24 46	10 24 46
XDCS ⁵	0	28	28	0	1	1		31	37	31 37
XSS ⁶	0	2	2	0	1	1				
<hr/>										
SUBTOTAL	0	575	575	0	11	11		28	46 52	28 46 52
<hr/>										
TOTALS	1342	5969	7311	27	255	282	20 06 08	244	44 58	264 51 06

1 See list of departmental codes following

2 Training and Education

3 System Improvement and Modifications

4 University Administrative Overhead Use

5 System Updating

6 Special Short Shots

7094 TABLE III 4TH QT 1968

DEPT ¹	NUMBER OF RUNS			NUMBER OF SPECS			7094 USAGE IN HOURS-MINUTES		
	T AND E ²	RES	TOTAL	T AND E ²	RES	TOTAL	T AND E ²	RES	TOTAL
AAE	0	106	106	0	5	5	0.0	3 31.2	3 31.2
ACCY	0	48	48	0	3	3	0.0	24.1	24.1
ADV	0	14	14	0	5	5	0.0	23.0	23.0
AGE	0	170	170	0	7	7	0.0	1 49.6	1 49.6
AGEC	605	214	819	9	16	25	3 0.4	4 47.8	7 48.2
AGREX	0	10	10	0	3	3	0.0	49.0	49.0
AGRON	0	19	19	0	6	6	0.0	11.0	11.0
ANS	0	168	168	0	13	13	0.0	3 4.5	3 4.5
ARCH	94	0	94	2	0	2	15.5	0.0	15.5
ASTR	0	240	240	0	13	13	0.0	4 26.5	4 26.5
ASTRM	0	8	8	0	3	3	0.0	46.7	46.7
AVI	0	2	2	0	1	1	0.0	0.7	0.7
BINRE	0	85	85	0	4	4	0.0	2 57.8	2 57.8
CESCS	0	6	6	0	3	3	0.0	6.2	6.2
CE	583	383	966	7	41	48	1 49.3	21 49.2	23 34.4
CHE	0	1868	1868	0	75	75	0.0	36 9.5	36 0.5
CIRCE	0	13	13	0	3	3	0.0	38.0	38.0
COMM	0	33	33	0	3	3	0.0	33.7	33.7
CRC	0	73	73	0	7	7	0.0	1 33.5	1 33.5
DCS	0	5	5	0	3	3	0.0	1.5	1.5
DGS	0	16	16	0	1	1	0.0	30.1	30.1
DS	29	0	29	3	6	8	1.8	2.0	0.8
BCON	21	51	72	2	7	9	15.1	40.0	55.1
BD	0	261	261	0	30	30	0.0	4 20.8	4 20.8
EDPSY	251	21	272	7	2	9	1 52.9	1 29.6	3 18.6
EE	0	291	291	0	22	22	0.0	5 52.7	5 52.7
ENGCS	0	6	6	0	2	2	0.0	9.1	9.1
ENTOM	0	113	113	0	7	7	0.0	1 25.0	1 25.0
FIN	0	44	44	0	5	5	0.0	58.1	58.1
FOR	0	12	12	0	2	2	0.0	8.8	8.8
FT	0	28	28	0	4	4	0.0	10.9	10.9
GENE	335	105	440	3	9	12	1 34.4	1 13.8	2 48.2
GEOG	0	59	59	0	2	2	0.0	41.3	41.3
GEOL	104	104	208	3	4	7	1 9.7	3 1.5	4 7.3

7094 TABLE LII 4TH QT 1968- CONT

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DEPT ¹	NUMBER OF RUNS			NUMBER OF SPECS			7094 USAGE IN HOURS-MINUTES		
	T AND E ²	RES	TOTAL	T AND E ²	RES	TOTAL	T AND E ²	RES	TOTAL
GSBA	C	4	4	0	3	3	0.0	11.6	11.6
HEC	C	15	15	0	4	4	0.0	47.0	47.0
HED	C	33	33	0	3	3	0.0	31.2	31.2
HLTHS	C	2	2	0	1	1	0.0	20.6	20.6
HONOR	C	2	2	0	2	2	0.0	5.6	5.6
HORT	C	4	4	0	2	2	0.0	2.2	2.2
ICR	C	523	523	0	6	6	0.0	18 47.2	18 47.2
IED	C	165	165	0	3	3	0.0	10 43.4	10 43.4
IGPA	C	53	53	0	3	3	0.0	3 34.0	3 34.0
ILR	C	113	113	0	7	7	0.0	1 53.6	1 53.6
INADM	C	28	28	0	3	3	0.0	28.1	28.1
IREC	C	56	56	0	9	9	0.0	3 3.1	3 3.1
LAW	C	1	1	0	1	1	0.0	14.1	14.1
LIBS	C	7	7	0	3	3	0.0	16.8	16.8
MATH	C	27	27	0	3	3	0.0	2 8.1	2 8.1
MATRL	C	1484	1484	0	46	46	0.0	45 58.0	45 58.0
MCBIO	C	62	62	0	8	8	0.0	28.7	28.7
ME	85	1696	1781	3	57	60	37.8	61 8.2	61 46.0
MMPE	C	405	405	0	3	3	0.0	7 5.2	7 5.2
MUSIC	9	14	23	2	3	5	4.9	34.0	38.9
NHS	C	76	76	0	6	6	0.0	50.9	50.9
NUCE	C	421	421	0	23	23	0.0	7 25.1	7 25.1
OIR	C	809	809	0	3	3	0.0	28 23.9	28 23.9
ORME	C	13	13	0	3	3	0.0	2 8.6	2 8.6
PEM	C	54	54	0	11	11	0.0	1 26.5	1 26.5
PHYB	C	216	216	0	9	9	0.0	4 8.9	4 8.9
PHYCS	25	539	564	2	15	17	3.9	13 7.3	13 11.3
PHYX	C	3605	3605	0	30	30	0.0	310 58.2	310 58.2
POLS	239	100	339	9	8	17	26 15.0	10 4.2	36 19.3
PROVS	C	6	6	0	1	1	0.0	12.5	12.5
PSYCH	715	2624	3339	11	63	74	12 53.1	73 19.5	86 12.7
REC	C	42	42	0	4	4	0.0	1 18.4	1 18.4
SCONS	C	99	99	0	3	3	0.0	31.8	31.8
SGS	C	93	93	0	5	5	0.0	2 21.4	2 21.4
SOC	124	207	331	3	18	21	25.2	9 53.5	10 18.8
SOCW	21	37	58	3	3	6	10.5	2 7.4	2 18.0

7094 TABLE III 4TH QT 1969- CONT

DEPT ¹	NUMBER OF RUNS			NUMBER OF SPECS			7094 USAGE IN HOURS-MINUTES			
	T AND E ²	RES	TOTAL	T AND E ²	RES	TOTAL	T AND E ²	RES	TOTAL	
SPCH	0	2	2	0	1	1	0.0	0.2	0.2	
SPED	10	37	47	2	4	6	29.5	32.6	1 2.2	
SRL	0	154	154	0	6	6	0.0	9 25.1	9 25.1	
SWS	0	709	709	0	46	46	0.0	14 28.7	14 28.7	
TAM	0	77	77	0	7	7	0.0	37.8	37.8	
VPP	0	46	46	0	3	3	0.0	15.5	15.5	
VTED	0	11	11	0	3	3	0.0	5.6	5.6	
ZOOL	0	33	33	0	2	2	0.0	21.5	21.5	
Subtotal	3250	19288	22538	71	763	834	50 57.7	767 6.8	818 4.6	
DCSSYS ³	0	1209	1209	0	23	23	0.0	56 11.9	56 11.9	
SSUAD ⁴	0	140	140	0	4	4	0.0	11 51.7	11 51.7	
XDCS ⁵	0	64	64	0	3	3	0.0	52.5	52.5	
XSS ⁶	0	238	238	0	3	3	0.0	3 4.3	3 4.3	
Total	3250	20939	24189	71	796	867	50 57.7	839 7.2	890 5.0	

1 See list of departmental codes following.

2 Training and Education

3 System Improvement and Modifications

4 University Administrative Overhead Use

5 System Updating

6 Special Short Shots

10.2 Research Problem Specifications

During the fourth quarter of 1968, 49 problem specifications were submitted to the Department for computation on the 7094. The following brief descriptions of these problems have been prepared for inclusion in this report by those submitting them. T indicates a calculation associated with a thesis.

3290-80002 T Political Science. Illinois Criminal Courts. Analyze the similarities and differences in responses to, and adaptations to, Miranda by several types of criminal court systems in Illinois. (Neubauer)

3291-80003 Chemical and Metallurgical Engineering, University of Michigan. Thermodynamic Properties of Refrigerants. Compute tables of thermodynamic properties of "Freon-502". (Philip Goldblatt)

3292-80005 T Physical Education for Men and Graduate PE. Relationship Between Two Groups or Types of Measures. The relationship between two groups or types of measures, therefore, three different analyses: (1) a correlation matrix to determine the individual relationships between items; (2) canonical correlation; and (3) factor analysis to determine the orthogonal factors from the test variables. (Denise Allard)

3293-80006 T Political Science. Labor Voting Behavior. Secondary analysis of the SRC data (especially 1964) to delineate the labor voting behavior. (Ra)

3294-80008 Psychology. Organizational Incentive Plan. It is necessary to perform a factor analysis of employee performance data to determine which variables explain most of the performance variance. Cutting scores will be established to coincide with company standards of performance. Changes in performance and employee attitudes will be monitored and analyzed. (Andres Inn)

LIST OF DEPARTMENT CODES

If your department or office does not appear on this list, please write its full name in the department field on the Problem Specification Form even though it will require more than 6 characters.

ACCY	Accountancy	HONORS	Honors Program
ADMREC	Admissions and Records	HORT	Horticulture
ADV	Advertising	ILLDMH	Illinois Dept. of Mental Health
AAE	Aeronautical and Astronautical Eng.	INADM	Industrial Administration
AGEC	Agricultural Economics	IE	Industrial Engineering
AGE	Agricultural Engineering	IREC	Institute for Research on Exc. Children
AGREXT	Agricultural Extension	ICR	Institute of Communications Research
AGRON	Agronomy	IGPA	Institute of Govt. and Public Affairs
ANS	Animal Science	ILR	Institute of Labor and Ind. Relations
ANTH	Anthropology	LIBS	Library Science
ARCH	Architecture	LING	Linguistics
ASTR	Astronomy	MKTG	Marketing
BIOPH	Biophysics	MATRL	Materials Research Laboratory
BOT	Botany	MATH	Mathematics
BCMPL	Bureau of Community Planning	ME	Mechanical Engineering
BECBSR	Bureau of Economic Business Research	MCBIO	Microbiology
BEDRES	Bureau of Educational Research	MMPE	Mining, Metallurgy, and Petroleum Eng.
BINRES	Bureau of Institutional Research	MUSIC	Music
BED	Business Education	NHS	Natural History Survey
CZR	Center for Zoonoses Research	NUCE	Nuclear Engineering
CERE	Ceramic Engineering	OAC	Office of Agricultural Communication
CPUBS	Champaign Public Schools	DNW	Office of the Dean of Women
CHE	Chemistry and Chemical Engineering	OIR	Office of Instructional Resources
CRC	Children's Research Center	PEM	PE for Men and Graduate PE
CP	City Planning	PEW	PE for Women
CE	Civil Engineering	PHYPLA	Physical Plant
COMM	Communications	PHYCS	Physics
CURLAB	Curriculum Laboratory	PHYB	Physics Betatron Laboratory
DS	Dairy Science	PHYX	Physics Project X
DCS	Department of Computer Science	PHYSL	Physiology and Biophysics
DGS	Division of General Studies	PLPA	Plant Pathology
DUE	Division of University Extension	POLS	Political Science
DOW	Division of Waterways	PROVST	Provost's Office
ECON	Economics	PSYCH	Psychology
ED	Education	REC	Recreation
EDPSY	Educational Psychology	SHCBRC	Small Homes Council
EDADM	Educational Admin. and Supervision	SOCW	Social Work
EDTEST	Educational Testing	SOC	Sociology
EE	Electrical Engineering	SCONS	Soil Conservation Service
ENGADM	Engineering Administration	SPED	Special Education
ENGCST	Engineering College and Station	PSDEC	Special Education, Decatur Pub. Schools
ENGH	Engineering Honors Program	SPCH	Speech and Theatre
ENGLSH	English	SGS	State Geological Survey
ENTOM	Entomology	SWS	State Water Survey
EDC	Extension Division Counseling	SCS	Student Counseling Service
FIN	Finance	SRL	Survey Research Laboratory
FT	Food Science	TAM	Theoretical and Applied Mechanics
FOR	Forestry	USGS	U.S. Geological Service
GENE	General Engineering	UNIHI	University High School
GEOG	Geography	UCCTE	Urbana-Champaign Coun. on Teacher Ed.
GEOL	Geology	VMS	Veterinary Medical Science
GER	German	VMA	Veterinary Medicine Administration
GSA	Graduate School of Business Admin.	VPH	Veterinary Pathology and Hygiene
HED	Health Education	VPP	Veterinary Physiology and Pharmacology
HLTHSV	Health Service	VTED	Vocational and Technical Education
HEC	Home Economics	WPGU	WPGU Radio Station
		ZOOL	Zoology

Chicago Circle

CCCHE	Chemistry
CCDME	Materials Engineering
CCENEN	Energy Engineering
CCPHCS	Physics
CCSOC	Sociology
CCSCS	Student Counseling Service

Medical Center

ORME	Office of Research in Medical Ed.
OT	Occupational Therapy

I.I.I. State University

ISEDAD	Department of Education Administration
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3295-80010 Sociology. Small Claims Court. This is a study of the small claims court using a sample of 500 past users of the small claims court of Champaign, Illinois. It seeks to answer questions such as: who uses the court, for what, and how did they learn of this procedure. (Kronus)

3296-80012 T Sociology. Chicago Policewomen Study. Study of policewomen in Chicago area - exploratory research into attitudinal and behavioral variables. (Leslie Pfister)

3297-80013 Education. Junior College Student Study. A sample of 200 junior college students responded to twenty pairs of bipolar adjectives for each of seven criterion words on a semantic differential instrument. The D^2 statistics and factor analytic methods will be used to analyze these responses. The factor analyses will be used to ascertain the connotative framework used by this sample of students and by subgroups of the sample. The D^2 statistic will be used to gauge any clustering of the criterion words and the differences which may occur as this same sample responds to the instrument at a future date. (William Wellner)

3298-80014 T Physical Education for Men and Graduate PE. The Speed Factor in the Illinois Agility Run. The purpose of this problem is to determine the amount of variance in the Illinois Agility Run that can be accounted for by the speed factor. The statistical procedure will be correlation of dash time and Illinois Agility Run time. (Paula L. Schutt)

3299-80015 T Education. The Academic Performance of Culturally Disadvantaged Adolescents. Teacher and student academic expectations were experimentally manipulated with a population of culturally disadvantaged adolescents. It is hypothesized that the parameters related to academic success will be a function of the experimentally induced expectation levels. The experimental design is a three-way multi-variate analysis of variance with approximately 15 dependent measures. (T. H. Anderson)

3300-80016 Graduate School of Business Administration. Purchasing Behavior Predicted by Need for Achievement. The relationship between levels of need for achievement and present and desired inventory of goods and services. (David M. Gardner)

- 3301-80018 Psychology. Multivariate Study of Form Perception.
Multivariate analysis of data from a set of experiments on form perception.
SSUPAC programs for factor analysis, multiple discriminant analysis,
canonical correlation, and distribution analysis will be used. In addition,
FORTRAN II programs for nonmetric multidimensional scaling will be employed.
(Larry G. Richards)
- 3302-80019 T Education. Transfer and Inhibition in Free Recall of Verbal
Material. Lists of words which either could or could not be easily organized
in recall were studied to criterion by college students. Interpolated lists
of the same character were presented for four trials before recall of
original learning. Effects of transfer and inhibition were studied.
(Graeme Watts)
- 3303-80022 Civil Engineering. STRESS. Structural analysis. (S. J. Fenves)
- 3304-80023 Economics. Secondary Wage Changes. To determine the amount
and pattern of wage emulation over the business cycle between manufacturing
industries. (Wallack)
- 3305-80024 Psychology. Distribution of Fears in College Students.
This problem will involve frequency counts and factor analysis. The data
represent reports of one of seven levels of fear with respect to 51 stimuli
or situations. We will want to know the fear-level pattern for each of
approximately 2500 subjects, the number of times each item was ranked at
each level, and the ways in which items tended to cluster together in terms
of their ability to elicit fear reports. (D. A. Bernstein)
- 3306-80025 Geography. Evaluation of Geography 101. Analysis of student
reactions to Geography 101 course content and instructional methods. Antici-
pate use of SSUPAX programs--frequency count, missing data correlations,
principal axis factor analysis with varimax rotation. (Janice Monk)

3307-80027 T Psychology. Sequential Effects in Absolute Judgment. Data has been collected suggesting that accuracy of size judgments is related to the order in which the stimuli are seen. A mathematical model stemming from multiple discriminant analysis is to be applied to these data providing a useful description of the judgmental process and a measure of the degree to which sequential effects are present. (Friden)

3308-80028 T Educational Psychology. Cognitive Systems in Judgment of Teaching Performance. Four separate principal components analyses will be performed on minor product matrices formed from input matrices of order $N \times 26$, two $N \times 210$, and $N \times 84$; $N = 100$. Output includes characteristic roots and vectors and $N \times r$ and $n \times r$ matrices of loadings on principal components ($n = 26, 210, 84$). Loadings of subjects on principal components from first three analyses will be dependent variables multivariate analysis of variance and predictors in canonical correlation analysis with loadings from fourth analysis as criteria. (Rumery)

3309-80029 T Home Economics. Inhibition of Infant Distress. Distressed infants usually become quiet when rocked or taken in a car for a ride. This effect could be due to motion itself or some environmental-social factor related or associated with motion. The present study concerns the effect of various speeds of motion and presence or absence of mother for infants in four age groups from 3 to 25 weeks of age. While various correlated of infant responsiveness to motion will be investigated, the primary design corresponds to an age by sex by treatments, repeated measures ANOVA of difference scores (for pre- and post tests). This analysis may be supplemented by a treatment by levels ANOVA or an ANCOV depending upon distribution of scores for pretest. SSUPAC is the intended program for analysis (Van Den Daele)

3310-80030 Institute of Labor and Industrial Relations. Determinants of Rule Performance. Analyses of the relationships between the variables associated with a member's psychological role and his role performance within an organization. Analysis requires SSUPAC. (George B. Graen)

3311-80031 Law. Analysis of Automobile Insurance. Frequency tabulations using Survey Research Laboratory 1968 Omnibus Survey data on attitudes toward auto insurance. (J. O'Connell)

3312-80032 Geography. SMSA Gravity Model. An attempt to measure and predict, through regression analysis and associated techniques, the existant relationships between population densities and the movement of goods among and between the S.M.S.A.'s in the United States. (Roepke)

3313-8N001 Graduate School of Business Administration. Economics of Advertising. Economics of advertising - several related regression studies. (Julian L. Simon)

3314-8N002 Home Economics. A Longitudinal Study of Vocal Development. The basic problem in this study is a longitudinal project involving the later effects of group nursery school music training. Related problems include vocal acceleration, multi-sensory performance practice, and the effect of vocal range on singing performance. (Robert B. Smith)

3315-8N003 T Physical Education for Men and Graduate PE. The Long-Term Effects of an Exercise Program on Selected Physiological and Psychological Measures in Middle-Aged Men. The purpose of this study is to determine the long-time value of exercise programs on selected physiological and psychological parameters in non-athletic, middle-aged men engaged in sedentary occupations. (Jette)

3316-8N004 Special Education. Acquisition of a Complex Assembly Task by Retardates. To determine the effects of certain learning variables on retardate performance in a sheltered workshop. (Marc W. Gold)

3317-8N005 Psychology. Follow-up Evaluation of Volunteer Project Effects. Evaluation of outcome results for various sub-groups of patients and students who participated in a volunteer state hospital project. Investigation of the relationship between patient, volunteer, attendance, and activity variables. (Julian Rappaport)

3318-8N006 Survey Research Laboratory. Non-Charge Development Runs. Development of programs for future survey to be run. (M. F. Uchida)

3319-8N007 Children's Research Center. Social Factors in Children's Play. To determine the effects of competition, failure, and knowledge of results, on aspiration level and motor performance. Basic statistics needed for analysis of multiple factorial designs, e.g., analysis of variance, chi squares, and correlations. (M. J. Ellis)

3320-8N009 T Zoology. Behavioral Changes Due to Cross-Fostering. An analysis of variance will be run comparing normal mice with those raised by another species. (David Quadagno)

3321-8N013 Psychology. Individual Differences in Multiple Cue Learning. A search for clusters of individuals in a multiple cue learning task and the relation of these clusters to psychological measurements of these individuals. (Schenck)

3322-8N014 Agricultural Economics. Husband-Wife Response Discrepancy. Data from 300 married couples in Brasilia, Brazil, are used to compare discrepancy between husband's response and wife's response to identical questions. Response discrepancy will then be related to personal characteristics of the respondent. The study has mainly methodological objectives. (J. C. Van Es)

3323-8N015 Education. Thai Universities. The research concerns the sociology of universities and students in Thailand. Social mobility mediated by the universities is examined for several of its aspects, including: rural-urban migration, ethnic assimilation, and class mobility. The research studies the campus culture which emerges among the students and the impact it has on the attitudes of the students. Research is directed also to the investigation of organizational change occurring in the universities in response to technological and other sources of modernization existing in the larger society. (William E. Maxwell)

3324-8N016 T Education. Attitudes Toward Science. The study will use the semantic differential technique to determine how the meanings of concepts change during a course in college physical science. An attempt will also be made to determine whether various sub-groups within the main group have different semantic structural frameworks. (John O. Wernegreen)

3325-8D001 Psychology. Imitation and Comprehension of Adult Sentences by Young Children. This is a study in the area of developmental psycholinguistics. The study examines young children's, age 3 to 5, ability to imitate and comprehend sentences of various types. (Gramling)

3326-8D004 Psychology. Doctor of Psychology Program Evaluation. Factor analysis of clinical trainee competence ratings, and additional problems relating to evaluation of the Doctor of Psychology program. (Dr. D. Peterson)

3327-8D005 T Finance. Option Premiums. Transformation program on option premiums. (Silber)

3328-8D006 Sociology. Attitude Formation Research Based on WISOB. This research involves the calculation of the relative amounts of influence over the attitudes of an individual exercised by significant others, self-reflexive acts and related cognitive structures. (Woelfel)

3329-8D007 Education. Student Opinionaire Development. A study of opinions of students on various subjects is to be analyzed in an attempt to develop a Student Opinionaire form. (Thomas)

3330-8D008 Physical Education for Men and Graduate PE. Individual and Group Performance on a Muscular Power Task. Individuals will be measured on their rope pulling power. These same individuals will then pull the rope in groups of 2's, 4's, and 8's. The fatigue and strength factors will be controlled. The potential productivity of the group (the sum of what the individuals did alone) will then be compared to the actual productivity of the various groups to determine the extent of the coordination and/or motivation losses in the initial learning and later performance on this additive task. (D. Landers)

3331-8D009 Advertising. Source and Content of Communication About Advertising and That Effect on Student Attitudes About Communication. 2 x 2 factorial design which investigates the effect of the source and content of communications about advertising on student attitudes about advertising. (Wiggins)

3332-8D010 Provost's Office. Organizational Study of Departmental Performance. This project is an investigation of organizational factors of university academic departments and how these factors relate to various departmental outputs, such as quality of graduate students and publications of the faculty. (Lanier)

3333-8D012 T Special Education. The Acquisition of a Complex Assembly Task by Retardates. Use of SSUPAC programs for ANOVA to determine effectiveness of techniques to train trainable retardates to do complex assembly work. (Marc W. Gold)

3334-8D013 Speech and Theatre. Variables Related to Belief Structure. An attempt will be made to extract variables related to belief structure through statistical analysis. (R. A. Clark)

3335-8D014 T Psychology. Effects of Hypnotic Suggestion on Pain Perception. An attempt to assess the roles of the variables of hypnotic induction and analgesic suggestion in pain relief using two autonomic indices of pain perception (heart rate and finger pulse volume) and subjective report. (Evans)

3336-8D015 Aviation. Analysis of Optimized Training Program. Analysis of scores obtained from pilots' performance in airline simulators and in aircraft to determine the effectiveness of simulators in the transition of airline captains to new aircraft. (Gandelman)

3337-8D016 T Advertising. Retail Advertising and Store Image. Research designed to determine if, in fact, there is a positive relationship between images perceived through advertising (specifically newspaper advertisements) and the consumer image of the retail outlet which put the ad in the newspaper. (Tate)

3338-8D019 T Education. Cognitive and Perceptual Skills of Conduct Problem Children. Forty-seven children rated as conduct problems by their classroom teachers were given an extensive battery of perceptual and cognitive tasks to determine how they differ on the performance of these tasks from the normal population. (Lloyd S. Wright)

10.3 Class Problem Specifications

During the fourth quarter of 1968, 19 problem specifications were submitted to cover all assigned problems on the 7094 in the following courses.

J955-80001	Educational Psychology 390.
J956-80004	Geology 479.
J957-80007	Music 304.
J958-80009	Psychology 332.
J959-80011	General Engineering 103.
J960-80017	Political Science 326.
J961-80020	Special Education 449.
J962-80021	Sociology 185.
J963-80026	Dairy Science 205.
J964-8N008	Music 320.
J965-8N010	Political Science 326.
J966-8N011	Political Science 291.
J967-8N012	Aeronautical and Astronautical Engineering 241.
J968-8N017	Educational Psychology 497.

J969-8D002 Mechanical Engineering 293.

J970-8D003 Civil Engineering 297.

J971-8D011 Economics 295.

J972-8D017 Political Science 345.

J973-8D018 Sociology 385.

11. GENERAL DEPARTMENT INFORMATION

11.1 Personnel

The number of people associated with the Department in various capacities is given in the following table:

	<u>Full-time</u>	<u>Part-time</u>	<u>Full-time Equivalent</u>
Faculty	23	2	24.30
Visiting Faculty	2	0	2.00
Research Associates	4	0	4.00
Graduate Research Assistants	13	110	70.46
Graduate Teaching Assistants	0	8	3.00
Professional Personnel	29	3	31.17
Administrative and Clerical	27	0	27.00
Nonacademic Personnel (Monthly)	63	3	64.75
Nonacademic Personnel (Hourly)		119	36.02
<u>TOTAL</u>	<u>161</u>	<u>245</u>	<u>262.70</u>

The Department Advisory Committee consists of Professor J. R. Pasta, Head of the Department; Professor J. N. Snyder, Associate Head of the Department; Professors K. W. Dickman, M. Faiman, L. D. Fosdick, H. G. Friedman, C. W. Gear, D. B. Gillies, D. J. Kuck, B. H. McCormick, S. Muroga, T. A. Murrell, J. Nievergelt, R. S. Northcote, J. R. Phillips, W. J. Poppelbaum, S. R. Ray, J. E. Robertson, P. E. Saylor, and D. L. Slotnick.

11.2 Bibliography

During the fourth quarter, the following publications were issued by the Laboratory:

File Numbers

- (1) Dill, C., Ellis, C. A., Gear, C. W. and Ratliff, K., "The Automatic Integration Package for Ordinary Differential Equations," File No. 779, November, 1968
- (2) Flowerdew, S., "Automatic Karyotyping: A Statement of the Problem and Summary of Image Processing Procedures," File No. 780, November 6, 1968
- (3) Gear, C. W., "Generalized Simulation and Modeling," File No. 785, December 30, 1968
- (4) Katoh, L., "Task Directive Language for the Illiac III Computer," File No. 782, December, 1968
- (5) Krabbe, S. P., "Specifications for Termi-Point Wiring of Section 6 (Taxicrinic Processing) of the Illiac III," File No. 550-118, October 29, 1968
- (6) Krabbe, S. P., "Specifications for a 9" False Floor for DCL 223 that Overlaps the Existing False Floor in DCL 280," File No. 550-120, November 5, 1968
- (7) Krabbe, S. P., "Specifications for Wire Wrap of Section 13 (Exchange Net)," File No. 550-119, November 6, 1968
- (8) Krabbe, S. P., "Specifications for Wire Wrap of Section 14," File No. 550-121, November 5, 1968
- (9) McCarthy, T. E., "Solving a Set of Coupled Systems of Ordinary Differential Equation on Illiac IV," File No. 778, November 5, 1968
- (10) Rudsinski, L. E., "A Tranquil Version of an Idealized Particle-In-Cell Code for a Plasma," File No. 781, November 25, 1968
- (11) Rudsinski, L. E., "Tranquil Code for the Modified Successive Overrelaxation (MSOR) Method for Solving Laplace's Difference Equation," File No. 784, December 24, 1968

- (12) Wallman, L. H., "Camera Specifications," File No. 550-122, December 5, 1968
- (13) Winje, G. L., "'Massless' Particle Trace and the Numerical Solution of the Eulerian Hydrodynamic Equations on Illiac IV," File No. 777, October 22, 1968

Report Numbers

- (1) Flowerdew, S. J., "LEFT: A Language for Editing and Formatting Text," Report No. 291, October 30, 1968
- (2) "Illiac IV Progress Report - July -- September 1968," Report No. 294
- (3) Koo, P. L. and Atkins, D. E., "Arithmetic Unit of Illiac III Simulation and Logical Design -- Part II," Report No. 290, October 28, 1968
- (4) Muroga, S. and Ibaraki, T., "Logic Design of an Optimum Network by Interlinear Programming Part II," Report No. 289, October, 1968

Thesis

- (1) Liu, T., "A Code for Zero-One Integer Linear Programming by Implicit Enumeration," (A Programming Manual for ILLIP), Report No. 302, December 15, 1968

11.3 Colloquia

"Logical Design with One NOT - Element, or How to Say 'NO' Once and Really Mean It," by David Huffman, University of California, Santa Cruz, California, October 21, 1968

"Boolean Analyzer and Its Application in Design Automation," by Antonin Svoboda, University of California, Los Angeles, California, November 4, 1968

"Do Most Machines Have a Series-Parallel Decomposition?," by David Muller, University of Illinois, Urbana, Illinois, November 18, 1968

"Galerkin Methods for Parabolic Equations," by Jim Douglas, Jr., University of Chicago, Chicago, Illinois, November 25, 1968

11.4 Shops' Production

Fabrication Facility Annual Report by Contracts is as follows:

	1018	1469	300	360/7094	4144
WORK REQUESTS COMPLETED					
Machine Shop	88	63	50	9	9
Electronic Shop	132	109	7	0	1
Chemical Shop	41	112	31	5	1
Layout Shop	81	105	6	0	2
TOTAL	342	389	94	14	13

Fabrication Facility Printed Wiring Board Annual Report is as follows:

	1018	1469P	1834
Printed Boards Wired	856	427	37
Printed Boards Converted	536	0	0
Printed Boards Repaired	32	0	0
Transistors Wired	9207	9236	318
Diodes Wired	47697	9639	837
Integrated Circuits Wired	34	2470	69

(F. Serio)

11.5 Drafting

During the fourth quarter, a total of 344 drawings were processed by both drafting sections:

	<u>General</u>	<u>Pattern Recognition</u>
Large Drawings	62	72
Medium Drawings	27	60
Small Drawings	37	19
Layouts	17	0
Report Drawings	33	0
Changes	1	8
Miscellaneous	8	0
TOTAL	<u>185</u>	<u>159</u>

(M. Goebel and J. Otten)