LA-3930-MS



LOS ALAMOS SCIENTIFIC LABORATORY
of the
University of California
LOS ALAMOS • NEW MEXICO

# Semiannual
# Atomic Energy Commission
# Computer Information Meeting
# May 20-21, 1968


UNITED STATES
ATOMIC ENERGY COMMISSION
CONTRACT W-7405-ENG. 36

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LOS ALAMOS SCIENTIFIC LABORATORY
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Report distributed: May 17, 1968

# Semiannual
# Atomic Energy Commission
# Computer Information Meeting
# May 20-21, 1968

AEC COMPUTER INFORMATION MEETING
LASL
PROGRAM
MONDAY MAY 20, 1968

SESSION I

CHAIRMAN: CHESTER S. KAZEK, JR.

| | |
|---|---|
| 8:00-9:00 | Registration - Los Alamos Inn. |
| 9:15-9:30 | Transportation to Meeting. |
| 9:30-9:45 | Welcoming Address - N. E. Bradbury, LASL Director. |
| 9:45-10:25 | History of Computing - William J. Worlton, LASL. |
| 10:25-10:45 | "LASL's CCF" - P. E. Harper, LASL. |
| 10:45-11:00 | Coffee Break |
| 11:00-11:35 | "Convergence of Difference Approximations for the Transport Equation"- N. Madsen, Univ. of Maryland |
| 11:35-12:30 | "Visual I/O Facilities for Illiac III" - B. McCormick, Univ. of Illinois. |
| 12:30-1:45 | Lunch. |

SESSION II

CHAIRMAN: ROGER B. LAZARUS

| | |
|---|---|
| 1:45-2:20 | "2 Dimensional Numerical Simulation of High Temperature Plasmas" - R. L. Morse, LASL. |
| 2:20-2:50 | "Monte-Carlo Calculations of Ground State of a Boson Fluid" - M. H. Kalos, NYU. |
| 2:50-3:30 | "Large Scale Use of Computers in Weapons Development" - T. N. Godfrey, LASL. |
| 3:30-3:45 | Coffee Break. |
| 3:45-4:20 | "Gravitational N-Body Calculation" - R. H. Miller, Univ. of Chicago. |
| 4:20-5:15 | "Some Syntax Directed Compiler Techniques" - M. Goldstein, NYU. |
| 5:15 | Transportation to Los Alamos Inn. |
| 5:55 | Transportation to Cocktail Party. |
| 7:15 | Transportation to Los Alamos Inn. |

TUESDAY MAY 21, 1968

SESSION III

CHAIRMAN: THOMAS L. JORDAN, JR.

| | |
|---|---|
| 8:00-9:00 | Security Badge Issuance - Los Alamos Inn |
| 9:00-9:15 | Transportation to Meeting. |
| 9:15-9:50 | "An Analysis of High Energy Physics Experiments Using Vidicon Spark Chambers with the CDC 6600" - H. A. Thiessen, LASL. |
| 9:50-10:15 | "Color Development for the SC 4020" - C. J. Fisk, Sandia. |
| 10:15-10:30 | Coffee Break |
| 10:30-11:10 | "2-Dimensional Lagrangian Hydrodynamics with Rezoning" - P. Browne, LASL. |
| 11:10-11:45 | "EXCEL-Automatic Printed Circuit Card Layout" - C. J. Fisk, Sandia. |
| 11:45-12:15 | "Hydrodynamics of Chemically Reacted Flow" - C. Mader, LASL. |
| 12:15-1:45 | LUNCH. |
| 1:45 | Tour of MANIAC and CCF. |

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# SUMMARY OF RECENT RESEARCH

AEC CONTRACT AT-(40-1)-2430

DEPARTMENT OF ELECTRICAL ENGINEERING

DUKE UNIVERSITY

Co-principal Investigators

John L. Artley and Herbert Hacker, Jr.

April 19, 1968

The following short summaries describe our activities in the several topical areas covered by contract No. AT-(40-1)-2430 since April, 1967.

## A. Magnetic Domain Switching of Superconducting Circuitry.

### 1.) The Ferromagnetic Cryotron (G. Buckley under J. L. Artley).

A Ferromagnetic Cryotron configuration, which has been described in ORO-2430-28 and in Applied Physics Letters 9 (1966), has been tested at 3.3°K. The device consists of a superconducting lead drive and a superconducting tin gate deposited on top of a Permalloy thin film. The switching of the gate circuit or "sense line" indicates that the domain wall within the magnetic film collapses on removal of the drive field, i.e. the tin gate is restored to its superconducting phase. Thus, the principle of reverse switching, which has been observed in our laboratory for Permalloy films at room temperature, has now been established at cryogentic temperatures.

An important question that remains to be considered, and is of prime concern in present studies, is how fast can this switching be achieved. Fast pulsing techniques are currently being developed for measuring the switching speed of a Ferromagnetic Cryotron at temperatures in the range 2.9° to 3.4°K. This information is basic to further development of the cryotron for device applications.

B. Development of Optimum Materials for Thin-Film Devices.

1.) A Method of Producing Thin Nickel Foils (G. Rechten under J. L. Artley).

In proposal AT-(40-1)-2430 a method of producing continuous thin nickel foil films was outlined. Thin nickel films formed by vacuum deposition are continuously removed from the rim of a rotating cylindrical glass substrate while the system is under continuous vacuum. The process requires that the cylindrical substrate have a very smooth surface; hence, a layer of SiO is deposited on its surface prior to the nickel film. Masking techniques normally used in the production of thin films do not yield edges sufficiently smooth for continuous stripping; hence, two thin wires (40 ga) are wrapped around the substrate to insure very smooth and straight film edges. At present, this method can be used to produce films 8000Å thick and up to 12 cm in length at a rate of up to 2 mm per minute. The limits of the process are being determined and the films are being examined by electron microscopy. A complete report on the process is anticipated before August, 1968.

2.) Dielectric Thin Films (J. Halford under H. Hacker).

Preliminary investigations of the dielectric and insulating properties of 1000Å, 2000Å and 3000Å $Bi_2O_3$ dielectric films have been completed and a complete report is in preparation. Bismuth trioxide films were evaporated from a refractory platinum boat and found to be microcrystalline with an average grain size of 100Å. Dielectric film surfaces were found to be extremely smooth and the films exhibited excellent adhesion to the gold underlayers. Two types of Au-$Bi_2O_3$ capacitors (area = .62cm$^2$) were fabricated Type I films have dielectric constants ranging from 34.5 to 38.0 with capacitance per unit area equal to 344nF/cm$^2$ (2.21 μF/in$^2$) for a

thickness of 1000Å. Dissipation factors range from .009 to .04 at 1000 Hz with dc resistivity equal to $10^{11}$ ohm-cm and dielectric strength equal to $10^4$v/cm. Type II dielectric films have dielectric constants ranging from 90.0 to 98.8 with capacitance per unit area equal to 477nF/cm$^2$ (3.08 μF/in$^2$) for 1000Å films. Dissipation factors range from .04 to .25 at 1000 Hz with dc resistivity equal to $10^{11}$ Ω-cm and dielectric strength equal to $10^4$v/cm.

3.) Strain Effects in Thins Films (B. McDowell under T. C. Pilkington).

X-ray diffraction techniques have been reported in ORO-2430-38 for determining the best linear approximation to the strain distribution in thin films. It was found that freshly deposited gold films do not have linear strain distributions, but these distributions become linear after several days of aging. In order to examine the nonlinear strain characteristics, the accuracy of our x-ray diffractometer facility was increased. A solid-state circuit has been incorporated so that the output of the GE XRD-5 x-ray unit is fed directly onto IBM cards. Thus, the accuracy of the x-ray peaks has been increased by determining more points on the peaks. A residual stress device has been installed to determine the average variation of the displacement of atoms from the relaxed bulk lattice spacings.

These improvements in the x-ray diffraction diffractometer system result in sufficient data to study nonlinear strains. Having tried several methods of fitting the x-ray data, a computer program has been written to find the best piece-wise linear fit to the nonlinear distributions. The nonlinear distributions can be approximated as accurately as the data permits since the number of linear pieces is arbitrary. This program has been successfully used to solve several problems with known solutions and it has improved

the analysis of some gold thin films data. The piecewise linearization technique is presently being studied and extended.

4.) Thin Films Filters (J. Hartwell under J. L. Artley).

For several months in the late summer and early fall of 1967 attention was given to the design of a thin film transmission line for use as a filter. An equivalent circuit representation for the device was formulated and its electrical characteristics expressed in terms of the basic properties of the film material, its spatial dimensions, and the magnitude of an applied dc magnetic field intensity. Present techniques would permit the fabrication of such a device using Permalloy as the thin film material, although the conduction losses would severely limit its performance. An impedance on the order of 10 ohms and a "Q" of about 10 at a resonant frequency of about $10^9$ Hz would be expected for a resonably dimensioned device constructed of Permalloy. Acceptable performance as a low pass filter should be attained with such a configuration. More sophisticated filters could perhaps be achieved by employing a material with smaller magnetic losses. Research presently underway in this laboratory should determine the suitability of rare earth thin films for this application.

C. Rare Earth Thin Films

1.) Properties of Rare Earth Films (D. Miller under H. Hacker).

Work is in progress to determine the physical characteristics of selected rare earth films which influence their spin wave spectra independently of the material properties. Surface topology vs deposition temperature and age of gadolinium films have been recorded and studied by surface replication and electron microscopy. A suitable technique for preparing transmission specimens

for electron diffraction studies is still being sought. X-ray diffraction studies are to be employed to determine the strain distributions and crystallite orientations of the films.

2.) High Field Capability (R. Gupta under H. Hacker).

A recent grant from Duke Endowment funds has made it possible for our laboratory to acquire a superconducting magnet facility capable of 55 KG operation. This magnet will be incorporated into a spin-wave spectrometer and a high field vibrating sample magnetometer. This instrument will make it possible for us to investigate additional properties of rare earth films in spite of their unusually high magnetic anisotropy. Most of the components are now available and construction is in progress on a K-band (24 Kmc/sec) spin wave spectrometer.

D. Exploratory Research

1.) Spin Wave Studies (J. Hartwell under J. L. Artley).

Since the late fall of 1967 a theoretical investigation of the loss mechanisms at work in ferromagnetic thin film resonance experiments has been pursued. Exchange-enhanced eddy current damping has been considered in detail, and its influence on thin film spin wave spectra is thought to be understood.

Several forces that couple the electro-magnetic and accoustic fields have also been considered in a naive attempt to relate spin wave losses and mechanical anelasticity. Further work in this area is anticipated.

The present research is centered on the dispersive effects of inhomogeneous dc fields. Scattering to long wavelength states and other two magnon interactions are enhanced by the inhomogeneties which arise from thin

film surface topology. It is felt that dispersion due to the observed bumpy surface structure is sufficient to account for the linewidths measured in spin wave experiments. The present research aims at giving a quantitative description of these processes.

2.) Electron Beam-Thin Film Interaction Processes (J. L. Artley and H. Hacker).

Some preliminary thought and study has been devoted to a quantum mechanical description of the interaction process that takes place when an electron (or stream of electrons) is impinged on a thin film of magnetized material. A model of the electron's motion in terms of a wave packet including its spin coordinate is contemplated. In passing through a region of the film with a given direction of magnetization, an interaction of the electron spin and the internal field of the films takes place. Our first aim is to describe the interaction process to determine if information storage and retrieval is possible. If so, the small size of the beam and the ease of "scanning" the film may offer improved memory devices.

AMES LABORATORY OF AEC
IOWA STATE UNIVERSITY
AMES, IOWA

# Summary of Computer Activities for the AEC Computer Information Meeting at Los Alamos Laboratory May 20-21, 1968

## Control Facilities

This report covers the period since the last meeting in November at Brookhaven Laboratory. Since that time a DATEX 4-axis neutron diffractometer has been added to the previously reported experiment facilities available in the real time control system located at the reactor. A parameter study in real time control of the continuous isotope separator is in progress preparatory to including this device in the system.

A research program in adaptive and self-organizing logic systems is being carried out under the direction of Dr. R. M. Stewart. A logical system with adaptive properties is potentially possible in terms of a majority logic implementations. Majority logic devices exist which behave in a Boolean conjunctive or disjunctive sense depending upon the state of a control input. The majority formulations to the present have involved a net odd integer weighing of the inputs so that the output is Boolean in nature. Other devices can be formulated which are majority logic devices but which have a three state output. The three state output capability of these devices means that non integer weighing of majority inputs can be used effectively, and the output correctly represents the logical state of the input.

Another area of research is concerned with the concept of adaptive control theory as applied to digital computer process control.

An interface which accepts a wide range of analog inputs has been designed, built and appended to the Research Reactor Computer System. This interface accepts eight channels of analog data and, under computer control, a specific channel may be converted to digital form and supplied to the computer. The interface is currently being used to monitor the isotope separator experiment. Data from the experiment is being analyzed

to refine a mathematical model of the isotope separator. This model will serve as the basis for a sampled-data adaptive-control system for the isotope separator.

## Programming Languages

A text editing language was implemented for use on the teletype interfaced to the real time computer system at the Ames Laboratory Research Reactor. Study of the applications of the language to the area of real time control of experiments preceded the work on the modification of the language to allow the users to manipulate internal information from their teletypes in a real time environment.

A detailed study was made on the state of the art of concept learning. Some of the applications of concept learners were studied with particular emphasis placed on the role of concept learners in computer learning.

## Mathematics Research

### Calculations of Eigenvalues of Matrices

A new algorithm for finding eigenvectors of a matrix without loss of accuracy has previously been reported. The convergence of the algorithm has been established but the rate of convergence was rather slow. Recently acceleration schemes have been developed which give striking improvements in the rate of convergence. In two instances in which 500 and 18,000 iterations were previously required for satisfactory results, the acceleration scheme has reduced these to 18 and 72 iterations respectively to obtain the same degree of accuracy.

### Special Functions

From any analytic function f of one complex variable, an analogous function F of several complex variables can be constructed by an averaging process. A basic theorem about the analytic continuation of F has been proved by using an integral representation which is a generalization of Cauchy's integral formula. It has been shown that various cases of F are related to axially symmetric potentials, repeated integrals, fractional integrals, mean values, and divided differences.

Integral transforms have analogues in several variables which can be constructed by the averaging process mentioned above. Two theorems have been proved about the analogues of Laplaces and Stieltjes transforms.

The properties of inhomogeneous mean values and generalized integral transforms are currently being studied in an effort to understand why the higher transcendental functions that occur most commonly in practice are associated with a special type of weight function in the averaging function.

Selective Dissemination of Information

The Ames Selective Dissemination of Information (SDI) system is currently scanning an average of 6500 articles per week for seventy-five individual scientists within the Ames Laboratory in an average time of 26 minutes of computer time on an IBM Model 65. Each individual receives notices of articles which may be of interest to him. The SDI system automatically generates a personalized KWOC index based on all articles which were of interest to him during the past quarter. The generation of this KWOC index requires approximately 1 minute of computer time per year per individual with a typical number of 60 to 70 items per quarter per individual. Samples of these KWOC indices are now in the hands of the individual scientists and we expect to be getting the user reactions in the near future.

Research is being done in the area of automatic profile enriching. Current indications show that it may be possible to increase the percentage of desired references significantly by enriching the individual profile by increasing the number of entries in the profile by using words in titles not already in the profile and utilizing these with positive or negative weights depending upon the user's response to the documents.

Investigation is going forward to study the effect of ordering the documents by calculation of weights associated with each article and disseminating only the top n based on a variable cut-off weight. Preliminary investigations show that documents of interest tend to migrate to the top of the list and give a high order of precision to the process.

This implies that the user may have to examine only a small number of titles and that a high percentage of them will be of interest to him.

Management Operating Systems

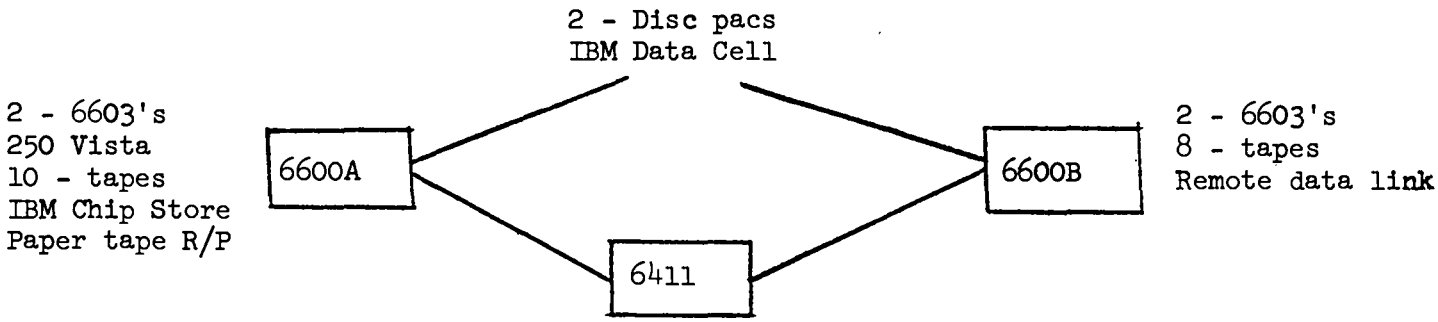
For the past several months the Management Operating Systems group have been designing and implementing a new computer oriented system. This system is designed to be compatible with current AEC requirements as well as the needs of the Ames Laboratory. The accounting, personnel and budget programming is complete and being run currently. Current developmental work includes a follow-up system for purchasing, maintenance records systems for engineering services and a comprehensive commitment report for budget purposes. The overall objective of MOS is to provide the Laboratory's top management with a strong data base and a retrieval system that will permit an accurate appraisal of alternatives in decision processes, and also call attention to as many alternatives as possible.

Lawrence Radiation Laboratory, Berkeley
Mathematics & Computing Department

Report for A.E.C. Computer Information Meeting
May 20, 21, 1968

## Equipment

No changes in equipment have taken place since the second CDC 6600 was installed last July. The basic 6600 configuration is:




## Operations

Our computing machines have been operating around the clock with a high level of reliability. Down time due to hardware fault run on the order of 3% for 6600B and 1 1/2% for 6600A (i.e., around 21 hours and 10 hours per month respectively). Preventive maintenance time has been reduced to 4 hours per week, per machine with no noticeable ill effects. Extra maintenance time is allotted on occasion for installation of a time consumming hardware modification.

The operating system in use at LRL Berkeley on the 6600's includes memory and functional unit diagnostics which are run automatically every 30 minutes. These diagnostic routines have been over 85% effective in detecting marginal hardware faults that develop in the memory and functional units.

A few job profile statistics might be interesting.

| # of input cards/job | % of jobs |
|---|---|
| less than 150 | 25 |
| 150 - 600 | 30 |
| 600 - 2000 | 35 |
| more than 2000 | 10 |

| # pages of printout/job | % of jobs |
|---|---|
| less than 50 | 65 |
| 50 - 200 | 20 |
| 200 - 500 | 10 |
| 500 - 1500 | 5 |
| more than 1500 | 1/2 |

| # of cards punched/job | % jobs |
|---|---|
| less than 150 | 60 |
| 150 - 1000 | 33 |
| 1000 - 2000 | 6 |
| more than 2000 | 1/2 |

| # tapes/job | % jobs |
|---|---|
| 0 | 23 |
| 1 | 35 |
| 2 | 25 |
| 3 | 8 |
| 4 or more | 8 |

Our users are distributed as follows:

Bubble Chamber Physics - 57%
Spark Chamber Physics - 19%
Chemistry - 10%
Miscellaneous (Bio-Med, Theo. Physics, Magnet Design, Engineering Support, Administrative Work) 14%

Systems Programming

An operating system for the CDC 6600 based on the SCOPE 3 system was tried and subsequently abandoned as unacceptable to meet the computing requirements of the laboratory. Some of the SCOPE facilities were made

available under the LRL Berkeley version of the Chippewa Operating System (BKY). Included were the Fortran 2.3 Compiler, Fortran Extended Compiler, COMPAS Assembler, and the SCOPE UPDATE system. In addition a new operator console display driver was written which provided improved displays.

The IBM photo-digital chip storage device was installed at the laboratory. Preliminary testing is under way and the formal acceptance test period will follow.

Data Link to the 6600

Some time ago a design was finalized for providing a remote data link to the CDC 6600. The motivation for the link was prompted by the need for monitoring experiments and providing the experimentor with information which could be valuable to him while the experiment is in progress.

One of the ground rules was to provide "nearly" on-line processing by the 6600 to facilitate control of experiments without significantly degrading the total 6600 performance.

The initial design provides for a PDP-5 computer, used as a data collection device at the experimental site, an interface mechanism between the PDP-5 and the CDC 6600 and a signal light at the 6600 console. When the experimentor wants to have a sample of his data analyzed by a program in the 6600 the following sequence of events takes place. He pushes a button which lights a light at the 6600. The 6600 operator causes a program to be loaded into the 6600, this program then makes contact with the PDP-5, and data is transmitted from a disc on the PDP-5 to a disc on the 6600, the data is analyzed by the 6600 program and some results are passed back to the PDP-5. It is expected that this might take place about once an hour and the time spent per transaction on the 6600 would be of the order of 2-5 minutes.

At present the hardware interface and software (on the 6600 side) are being debugged. The hope is that this facility will be operational by mid May.

A similar facility will be provided for a remote PDP-9.

Applications

COBWEB

The COBWEB Project, a computer-controlled bubble chamber film measuring system, continues expanding. Presently connected to the IBM 7044 system are three Franckensteins, a measuring microscope, and a scan table. A number of improvements have been made in the programming area dealing with Physics data checks and system operations. Current efforts relating to the COBWEB program include decreasing its memory requirements, improving segmentation, replacement of IBM's library subroutines and interrupt system, and to provide the facility for the

Physicists to more easily interact with the system in the areas of experiment dependent parameters and specialized physics computations.

Software design work has started on a teletype multiplexor which will communicate with ten scan tables. A small disc file is being considered as a tool to enable the COBWEB system to expand functionally without sacrificing speed. Particular areas of the program are being modified in order to effectively utilize this disc file.

Magnet Design

The general purpose, two dimensional, magnetostatic program LINDA is presently being revised to include the calculation of magnetic fields possesing axial symmetry.

The design of a beta-ray spectrometer has been proposed by this laboratory and extensive computational work is being done in designing the coils.

The design of an electrostatic spectrometer is also being proposed, utilizing a novel technique. The feasibility of such a spectrometer is being investigated and various parameters are being calculated.

The optimization of electron focussing devices such as spectrometers has been investigated by a joint effort with the University of Uppsala, Sweden. The results of this investigation are being published.

Orbit Studies

Various programs for the calculation of orbits in an electric or magnetic field have been prepared and are being used extensively by the 184" cyclotron and Nuclear Chemistry Groups.

A CRT version of the program Transport is being prepared which will include on-line interactions using the CDC 250 consoles.

Bio-Medical Research

A PDP8 computer with disc, CRT and magnetic tape has been programmed for use with NMR spectrometers. Programs which store on disc, average and display data were written and are being tested. Programs have been written for the CDC 6600 to carry out Fourier transforms and spectral decomposition of NMR data. PDP8 programs which process 2 channel counter data input via paper tape, have been written and are in routine use.

Radiation dosage calculations were improved. Program KALNAES was completed and the calculations carried out by program DOSMAP were generalized. A program SPRAY was written to compute beam profiles at varying distances from a collimator. Programs BRSEC and TVSECS were written to compute and display the contribution of secondary particles to the energy

spectrum of a particle beam at a chosen depth in a target.

IRK, GASP, FINDR, DIFEQS and other previously coded programs were used to process large amounts of human tracer kinetics data. Computed parameters were compared with clinical findings in order to establish the diagnostic value of these programs.

Donner Pavillion data on pituitary irradiation of diabetics has been coded and placed on a master data tape for use with programs TIPS and MEDPIC. Analysis of this data has started. A boolean filter section was added to the MEDPIC program to permit more general selection criteria to be applied to the medical records.

A program was written to process data from a wire spark chamber used as a medical Gamma-ray camera.

Math & Computing Research

Approximately five man-years of effort is currently being devoted to these projects during FY 1968. It is planned that the effort will continue at approximately the same level through FY 1969, and it is anticipated that the level of effort will increase to approximately seven man-years in FY 1970.

Work was completed on a paper entitled, "Transient Diffusion in a Composite Slab" (UCRL-17607), where the solution of the diffusion equation for two slabs of different materials of finite thickness in contact at a plane interface was obtained numerically using a truncated eigenfunction series technique. The paper will appear later in the International Journal of Heat and Mass Transfer. Supplementary tables required for the solution were also prepared in the report, "Table of the Solutions of a $\cdot\tan(\pi x) = -b.\tan(a\pi x)$" (UCRL-17608).

The approximate periodic, steady-state temperature of a rotating nuclear target system was found by solving the equations for a one-dimensional model of the system by a method similar to the one above.

Work has begun on formulating a non-linear block successive over-relaxation method to solve two-dimensional elliptic, quasi-linear partial differential equations. Preliminary results for the magnetostatic-field equation have indicated the method to be a promising one.

Mathematical analysis shows that stable control of stochastic proliferation of stem-cells may be based on the probability distribution governing their differentiation and on a desired or optimal size of the stem-cell population. Such control has a simple biological interpretation that includes the assumption of stem-cell avidity for a mediating substance.

A study of information in biological systems resulted in the conclusion that transmitted genetic information cannot include an explicit description of an organism, but may include data with instructions defining how physical law is to operate on the data. A parallel with stored-program computers was suggested, as well as the connection between the development of an organism and the internal modification of instructions.

Design specifications for an inexpensive, small-scale, general-purpose interactive time-sharing system were formulated and implementation was begun. Hardware to be delivered in FY 68 includes a PDP-8I Computer with hardware multiply/divide and 8K of memory, a 500 K-word disk, and one console (teletype-plus 5" storage scope). In FY 1969, another PDP-8I, disk, and four consoles will be added; one of the design criteria is sufficient modularity to facilitate the addition of this, and possibly other, hardware. Somewhat analogously, the basic structure of the software is sufficiently modular to provide simultaneous (time-shared) support of several different applications. At present, only one application, a modified Culler-Fried System, is in the final design state.

The hardware has been selected with extreme reliability in mind. An attempt is being made to provide software which is equally reliable by providing individual users with a powerful common language (which is interpreted by the system), instead of direct access to the computer.

The programming language BLIMP (Bit and LIst Manipulating Processor), user-designed data structures such as text, list-structures, numerica data, and, in particular, sub-words or fields, was designed and implemented. This language is a variant of $L^6$. It has been used for writing a compiler, assembly language translator, and an inventory report generator. BLIMP programs are compatible with FORTRAN routines on the subroutine level, thereby providing access to the resources of FORTRAN without the burdening overhead of an embedded algebraic translator.

A study was made of the numerical solution of the Laplace equation in a two-dimensional, simply-connected, bounded domain subject to boundary conditions of the first, second, or third king. A program was developed which obtains the solution by approximating the given boundary values in the least-squares sense with a linear combination of harmonic polynomials.

For a computation which consists of a simple algebraic transformation on two variables, iterated many thousands of times, a method was developed for analyzing the propagation of errors, including perturbations of the initial values of the variables, as well as round-off errors which occur during the iteration.

The first phase in this development was the programming of a set of multiple-precision floating-point interval arithmetic routines.

When these multiple-precision routines were applied to the iteration, it was found that the interval width did not provide a suitably close error estimate. The second phase was initiated which consisted of the implementation and testing of a method of error propagation analysis based on the matrix representation of an affine transformation (that is, a linear transformation combined with a translation).

A study has been made of methods of numerical differentiation by the use of spline functions. The report "Approximate Differentiation by Cubic Spline Fitting" (UCRL-17659) was written to describe the process in more detail. The report "Numerical Applications of Cubic Spline Functions" (UCRL-17742) discusses higher order differentiation, numerical integration, and interpolation by means of the cubic spline fit. An article also entitled "Numerical Application of Cubic Spline Functions", combining and condensing the material of the two reports was published in the December, 1967, issue of the Logistics Review.

PUBLICATIONS

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Harold Hanerfeld, BISE -- A two Vertex Kinematic Program, UCRL-17473, March 28, 1967.

Gerald M. Litton, Program BRAGG - A FORTRAN IV Program for Calculating Gragg Curves and Flux Distributions, UCRL-17391; Feb. 24, 1967.

Gerald M. Litton, Penetration of High-Energy Heavy Ions, With the Inclusion of Coulomb, Nuclear, and Other Stochastic Processes, UCRL-17392, (Ph.D. Thesis), August, 1967.

Ronald Zane and Deanna A. Wilber, PUZZLE: A Program for Computer-Aided Design of Printed-Circuit Artwork, Hawaii International Conf. on System Sciences, Honolulu, Hawaii, Jan., 1968.

Jonathan D. Young, Approximate Differentiation by Cubic Spline Fitting, UCRL, 17659, June 12, 1967.

Jonathan D. Young, Numerical Applications of Cubic Spline Functions, The Logistics Review, v. 3, no. 14, 1967.

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Grove C. Nooney, Age Distributions in Stochastically Dividing Populations, UCRL-17356 (Revised), January, 1968; submitted to J. of Theoretical Biology.

William D. Hogan, Bibliographical Note on Controlled Clinical Trials, UCRL-17698, January, 1968; submitted to J. of the American Medical Assoc.

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LAWRENCE RADIATION LABORATORY - LIVERMORE

SUMMARY OF COMPUTER ACTIVITIES

AEC COMPUTER INFORMATION MEETING

LOS ALAMOS SCIENTIFIC LABORATORY

MAY 20-21, 1968

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## STATUS OF EQUIPMENT

Since the November 1967 meeting at Brookhaven, a fourth CDC 6600 computer has been installed. The system is similar in configuration to the first three and is now operating at a high effective use rate along with the others. The first of two CDC 7600's is scheduled for delivery in the first quarter of F. Y. 1969.

The Librascope Disk File and the IBM Photo-digital Store are being integrated into our OCTOPUS equipment configuration. Practical usage should occur at any time now.

The SDS Sigma 7 and Sigma 2 computers slated for graphics work were delivered in January and the equipment complement is now complete. The graphics terminals being built by Information International Incorporated are on schedule and should be delivered by the end of F. Y. 1968.

The OCTOPUS equipment is moving along quite well, with 2 - PDP-6's now controlling the 4 - 6600's along with the Mass Storage Devices.

Bids have been received for a series of remote TV console display devices to be used in connection with the OCTOPUS system. An evaluation has been made, and procurement action is pending a final decision.

## PROGRAMMING

The new 6600 time-sharing system called FROST has proven to be considerably better than the older program. The programming for the PDP-6 portion of OCTOPUS is being used for periods which are increasing daily. Good progress is being made on the diagnostic program which will be an integral part of the final OCTOPUS system.

The time-sharing graphic programming is proceeding quite well and is coded and in the check-out stages. Final check-out can only be completed when the graphic terminals arrive.

LRLTRAN, a modified and updated version of FORTRAN 63, has been implemented in itself. This is generally referred to as a FORTRANED-FORTRAN. It is now working and in constant use. A similar effort is being made to write PL/1 in PL/1. In addition, COBOL is being written in LRLTRAN and a conversational LRLTRAN is being developed for use on the OCTOPUS time-sharing system particularly oriented to the teletype station.

Our numerically controlled machine tool group is implementing APT IV on the 6600. In the near future, we intend to have a conversational APT and a graphical APT.

April 24, 1968.

Computer Activity Report

Los Alamos Scientific Laboratory

May 1, 1968

## Central Computer Facility

The Central Computer Facility (CCF) now operates under the newly formed Computer Science and Services Division. Division Leader Roger Lazarus, Alternate Division Leader Tom Jordan, Assistant Division Leaders Paul Harper and William Spack, Nicholas C. Metropolis Advisor. C-1 CCF Operations Support - Don Smith, group leader, William Hudgins, alternate. C-2 CCF Systems Support - Charles Folkner, group leader. C-3 CCF Plant and Hardware Support - Chester Kazek, Jr., group leader. C-4 Scientific Applications Services - Roger Lazarus, acting group leader. C-5 Statistical Services and Management Applications - Keith Zeigler, group leader, Roger Moore, alternate. C-6 Numerical Methods and Consultation - Tom Jordan, acting group leader. C-7 Computer Science Research - Mark Wells, group leader, William Spack, alternate & CADP office with Edward Voorhees and Jack Worlton comprise this new division. The following computing systems are operated in the CCF building:

1) Two IBM Model 7094-I
2) One IBM Model 7030 (Stretch)
3) Three CDC Model 6600
4) Two IBM Model 1401
5) One GE Model 225

In addition, the CCF contains an off-line Stromberg-Carlson Model 4020, a CDC Model D280 (film recorder and graphics terminal) on-line to one of the 6600 systems, and a CDC Model 3691 (paper tape reader and punch) on-line to another 6600 system. The three 6600's will be coupled through a 500K ECS (scheduled to arrive in May, 1968) and now share 22-607 tape drives and three 6638 disk files.

The following items of additional hardware are being obtained with procurement status as indicated:

1) A fourth 6600 with 128K memory on rental basis with option to buy. Washington approval has been obtained and negotiations with CDC have begun.

2) 128 channel multiplexor (project MUX) to interface directly with one of the 6600's in the CCF. The multiplexor is being built by Group P-1 in LASL's Physics Division and is expected to be completed in June, 1968. Designed for great flexibility, the multiplexor will allow terminals from TTY's to small computers with a maximum transfer rate of 2400 bits/sec. The software is being done by LASL.

3) A CDC 200 User Terminal to be placed in the new physics building is scheduled to arrive in November, 1968. This terminal will consist of an entry/display station (a CRT display and keyboard), a card reader, and a printer. This will interface with one of the 6600 systems using the IMPORT/EXPORT remote batch software.

The CCF operation is on a 24-hour, 7-days a week basis and involves about 75 employees in Group C-1. The operation of the major computers is split between three independent stations with the I/Ø gear for the 6600's organized to operate as a single station. This decentralized operation has proved to be quite satisfactory. The software used is in all cases the manufacturers' with many local modifications and extensions. The first phase of the MUX software, which is being developed by Group C-2, is expected to be completed in June, 1968.

The three 6600's are operating to general satisfaction and running at about 90% of capacity with an average efficiency of about 90%. If one excludes scheduled maintenance the average efficiency figure goes to 98%. Oriented toward processing short jobs during prime shift and long production jobs during the late shifts and weekends, the three 6600's are currently processing approximately 1000 jobs per day. The other three systems together process about 300 jobs per day.

MANIAC Facility

Since last reported, MANIAC II memory has grown to 80K with installation of the second half of the Fabritek memory and incorporation of the old 16K core memory. A full-word (48 bit) instruction format is now used. Recent improvements include installation of a 240 character/second punch and a new 1500 lines/minutes printer. Software experiments are currently underway concerning use of the 16K memory (and the disk) in a "resident" I-O and service system.

AEC COMPUTING AND APPLIED MATHEMATICS CENTER
Courant Institute of Mathematical Sciences
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New York, New York 10012

# AEC COMPUTER INFORMATION MEETING
Los Alamos, New Mexico
May 20-21, 1968

## I. Computer Operations and Activities

### A. New Features Added to the Operating System

During the past six months, 14 editions of the system tape were released; these editions contained new features as well as improvements and corrections to the operating system. The new features include:

Null files, MTR release equipment function, DSD* and typeins, control point ID restrictions, trapping of program stop instruction, a new XJD program, new EXIT, CXIT and FIN control cards, CDC 3637A and 863 drum incorporated, new utility routines READ CM and READ CP and toggle central processor (to facilitate testing).

The routine XJD warrants some further commentary. The system was modified to allow a program to request that an exchange jump be executed to a smaller program within its field length. This is primarily for use by the SHARER time-sharing system, but may be used by any program. The requesting program provides an exchange jump package and indicates a time limit for the subprogram to which the exchange jump is made. MTR checks the field length for validity and relocates the reference address of the exchange jump package. MTR executes the jump instruction and then monitors RA+1 of the subprogram. If an error occurs in the subprogram or its RA+1 becomes non-zero, MTR exchange jumps back to the main program.

### B. Improvements and Corrections to the Operating System

Chippewa compiler releases were maintained. Version 63 of RUNJUN was made the nominal compiler.

It exhibits greatly improved object code efficiency particularly in DO-loop processing. Other improvements include improvements to:

OUTPTC, NUMBER (plot package numerical output), DMP, REL, 1BJ, 1FT, 1RT, 1SJ and other routines.

C. Projects Currently Being Developed

1) SNOBOL4. We have been experimenting with and working on various versions of the "SNOBOL4" system supplied by Stockton Gaines of IDA. We have succeeded in integrating "SNOBOL4" into our current SCOPE 3.1 system and have reported various errors to IDA.

2) CDC 6676. We have been concerned with testing our CDC 6676 teletype multiplexer. A test program was written which has revealed some difficulties in using the multiplexer in the manner which we were exploring.

3) SCOPE 3.1. We are planning to switch over to the SCOPE 3.1 operating system as our standard production system sometime in the Fall of 1968. For this reason an increasing amount of attention has been given to SCOPE 3.1. We are currently running the SCOPE 3.1 system for about one hour each day. (After learning of Berkeley's problems, we are reviewing the SCOPE problem.)

D. Programming Research Activities

1) SHARER - Time Sharing System.

Debugging of the time sharing system seems to be nearly at an end. The system is currently running on a regular production basis. No fatal errors have been encountered for several weeks. Several of the utility routines still have problems, but these are minor and local.

2) Remote Batch Processing.

Communication has been successfully established with four remote terminals:

(a) IBM 1130 in Troy, New York, for R.P.I.

(b) Univac DCT 2000 in Weston, Illinois, for National Accelerator Lab.

(c) Univac DCT 2000 in Texas for Southwest Center for Advanced Studies.

(d) CDC 3100 in Idaho Falls for Phillips Atomic Energy Division.

In each case, job input has been received from the terminals, processed in the CDC-6600 and output has been returned to the terminals. The interfaces of each of these terminals has been matched by subroutines running on our DDP-116 computer as was initially intended. The present scheme can only handle one terminal at a time. A next step already in progress is to provide service simultaneously to several terminals.

3) Syntax Directed Compiling

(a) Syntax-directed Fortran statement checker has been completed and is being put into the time sharing system. This work is described in a report NYO-1480-85.

(b) A Fortran syntax directed compiler is being developed called PFØRTRAN. Several strategies have been investigated including control macros and automatic syntax analysis.

4) Algebraic Manipulation

Symb66, the algebraic manipulator, has been extended and revised. A report has been written and will be issued as NYO-1480-88. The package of routines to do tedious algebra is now being put into the time-sharing system.

5) Sharer - SCOPE 3.1 Version.

Sharer is being converted to run under SCOPE 3.1. Coding to implement XJD and the 6676 multiplexor drivers has been written and appears to be working. Coding to modify LOD and LDR to accept a dummy RA and FL has been written and is in good shape. Sharer 2 has been modified to compile under Fortran 2.3, to use the overlay feature rather than the chain feature, and to use LOD and LDR instead of CLL and CLS. The extended CIO calling sequence will also be accepted.

6) Lisp 66 - Scope 3.1 Version

A number of modifications have been made to LISP66 to enable it to run under Scope 3.1. It has been rewritten in Compass, and basic subroutines have been replaced by macros. This, together with some streamlining of the interpreter, has given a five-fold increase in execution speed, making it comparable with Texas LISP. Certain other improvements in tightening up the code in the area of I/O, storage allocation, and the evaluation of arguments could yield a further two-fold or three-fold increase in speed.

## II. Applied Mathematics and Mechanics

### A. Fluid Mechanics

1) In one space and two space variables stability was proved when the analogous mesh refinement is performed along a coordinate line along which the data is generated by interpolation. Calculations indicate that this technique is an efficient method for improving accuracy in regions of special interest while preventing new inaccuracies of the interface.

2) A class of efficient methods was found for solution of the Navier-Stokes equations. Applications were made to problems of finite amplitude instability and wave number selection in thermal convection.

3) A class of geophysical dynamos which can be studied numerically was started in connection with the problem of the origin of the earth's magnetic field and motion in the earth's core.

4) A paper on the results obtained concerning the solution of the flow in the transonic region occurring in the two-dimensional detached shock problem was accepted for publication in the CPAM. Further application of the method to smooth airfoil flow and to models from plasma physics are being pursued.

5) The method of complex characteristics is used to compute the flow past an axially symmetric blunt body behind an analytic bow shock wave in supersonic flow. From the theory we know that locally we can expect a solution when the shock is non-characteristic. Our problem is to compute flows at low Mach numbers and to study the effect of the shape of the shock on the flow.

6) Numerical solutions to the time-dependent equations of hydrodynamics have been obtained for a system undergoing period motion with finite amplitude.

7) The determination of finite difference solutions to two distinct classical free boundary problems, Riabouchinsky flow and the vena contracta model, are being studied for both plane and axially symmetric geometries.

B. Numerical Analysis.

1) A new characterization of the standard relaxation method for solving elliptic problems was found and applied to fluid flow problems. Work also was begun on the problem of the influence of round-off error on the stability of nonlinear hyperbolic difference equations.

2) A study of the solutions to a two-point boundary value problem for a set of ordinary differential equations has been started.

3) Work continued on IMPROVE, a small fluid dynamics code for the numerical solution of a cylindrically symmetric implosion problem with initial conditions.

4) Convergence of a variable metric minimization method in which the metric is changed by a matrix of rank one at each iteration was proven for a wider class of functions than quadratics.

5) A general theory for stable difference approximations was developed for the initial-boundary value problem for a hyperbolic system with constant coefficients in the quarter space $x \geq 0$, $t \geq 0$.

6) Work was continued on alternating direction methods.

C. Other Applications.

1) Stresses have been obtained in cantilever plates subjected to surface pressures and shear forces along the edges.

2) Additional numerical results have been obtained for the buckling of spherical shells subjected to uniform external pressure.

3) A study of wave diffusion was started using methods previously developed for wave propagation in solids and for longitudinal impact of a Maxwell visoelastic rod.

4) A computational study to obtain numerical evidence of the existence of periodic solutions was made of Duffing's equation which describes the motion of vibrating systems.

5) Monte Carlo solution of the many-body Schrodinger equation was applied to test systems of (a) three particles with gaussian interaction, and (b) one-dimensional bosons with periodic potentials. Using a stationary energy principle greatly decreased computation time for the former. For the latter, with a band of frequencies, significant but surprisingly small deviations from Bogoliubov theory were found.

6) The methods used for the above problems have been adapted to treat an interacting Bose fluid with Lennard-Jones potentials. It was concluded that periodic boundary conditions are more reliable for infinite-body simulation than an equivalent-fluid boundary potential.

III. List of Publications

NYO-1480-80 High Order Accurate Difference Methods in Hydrodynamics, by S. Z. Burstein, Academic Press (Nonlinear Partial Differential Equations), 1967.

NYO-1480-81 Melting Transition of Lennard-Jones Molecules, by V. Nardi and J. K. Percus, Physical Review, 8/5/67.

NYO-1480-82 The Numerical Solution of the Navier Stokes Equations for an Incompressible Fluid, by A. J. Chorin, Nov. 1967.

NYO-1480-84 Upper Bounds for Errors of Expectations in the Few-Body Problem, by S. Aranoff and J. K. Percus, Physical Review, Oct. 20, 1967.

NYO-1480-86 SHARER, A Time Sharing System for the CDC 6600 by M. C. Harrison, J. T. Schwartz, Comm. ACM, Oct. 1967.

NYO-1480-89 Lower Bounds to the Many-Body Problem Using Density Matrices, by L. J. Kijewski and J. K. Percus, Physical Review, Dec. 5, 1967.

NYO-1480-90 Difference Methods for the Inviscid and Viscous Equations of a Compressible Gas, E. L. Rubin, S. Z. Burstein, Jour. Computational Physics, Nov. 1967.

NYO-1480-91 A Detached Shock Calculation by Second-Order Finite Differences, by A. Lapidus, Jour. Comp. Physics, Nov. 1967

Accepted for Publication:

Stability Theory for Difference Approximations of Mixed Initial Boundary Value Problems, by Heinz-Otto Kreiss, Math. of Comp.

Comments on a Paper by J. Hellums and K. Aziz, by Alexandre Chorin, Physics of Fluids

PROGRESS REPORT

Engineering Research Laboratory - CIMS

## 1. I/O PERIPHERAL EQUIPMENT

During this reporting period the Engineering Research Laboratory has continued it's research into computer systems and added two pieces of peripheral equipment to the inventory - a Motorola 200 line per minute printer and a Soroban Engineering 1000 card per minute reader. Interfaces using Honeywell S-Pac logic were assembled and a number of programs were written to integrate the printer and reader into the existing system. The interface units for the Potter Line Printer and the two 201 data sets have been rebuilt on a modular basis.

Another interface was designed and built to enable the DDP-516 computers' I/O to operate on the same voltage levels as the DDP-116 computer. This work will enable the Laboratory to have available two racks of interface equipment to which a DDP-516, or DDP-116 or both can be connected via the I/O bus of either computer.

Time has been spent in software experimentation with the display unit on the 516. A program displaying memory in real time was written and has proven to be a very useful tool in debugging other software.

In November a course on the theory and maintenance of the Cal-Comp 565 Plotting System was attended. The information and techniques obtained from this course are proving quite valuable in keeping the system owned by the Computer Center operating with almost no down time.

## 2. REMOTE ACCESS

The following remote terminals have been successfully made operational as I/O devices of our CDC-6600 computer:

1. IBM-1130, at Rensselaer Polytechnic Institute, Troy, New York.
2. DCT-2000, at National Accelerator Laboratory, Weston, Illinois.
3. DCT-2000, at Southwest Center for Advanced Studies, Dallas, Texas.
4. CDC-3100, at Phillips Petroleum, Idaho Falls, Idaho.

The Soroban Card Reader, Potter Printer, 201 data set and DDP-516 have been integrated into a system to be used as an experimental remote. Through the use of such a system efficient data transfers can be developed to utilized the speed of the data communications networks. Experience gained by the system should provide specifications for future systems.

A Western Union GSA teletype terminal and computer data set for our 116/6600 ''Sharer'' System has been delivered and connected. This system will permit users of the GSA Advanced Record System (ARS) network to interact in a real time mode with our 6600.

## 3. 516 - 6600 INTERFACE

Construction of the DDP-516/CDC 6600 interface has been completed and debugging begun. The interface will permit computer communications under conditions of A) program control by the Peripheral Processor of the 6600 and B) either program control by the 516 or via the Direct Memory Access feature of the 516. In the latter mode communication can proceed at speeds up to 6 mega bits/sec.

The interface employs both standard integrated circuit logic boards purchased from Honeywell and special boards designed and constructed at the Engineering Research Laboratory. The standard boards used are the U-Pac 5 mc family, as contrasted with the S-Pac series employed on the existing DDP-116/CDC 6600 interface. The use of integrated rather than discrete circuitry results in a much higher packaging density and consequently a smaller and neater interface. Our experience has been that the decrease in size makes debugging a longer and more laborious task than with the more amply spaced discrete circuitry. One objectionable feature of the U-Pac line is the marked asymmetry in positive (0 --> + 6 volt, slow) and negative ( + 6 --> volt, fast) risetime. This necessitated special design on the level changers used to A) terminate 100 ns pulses from an open-circuited collector over 15 feet of twisted-pair cable and B) drive the pulse amplifiers required to present the 6600 with a transformer coupled input. The final design utilized the stored charge in a back-biased zener diode operating below the zener voltage to maintain the constant input impedance required for proper termination of these signals.

Our experience with remote users connected to the DDP-116 via 201 data sets (over voicegrade telephone lines) has indicated the need for bulk storage at the 516 in order to lower the rate at which the 6600 will be required to service this machine. Therefore an investigation has been undertaken into the relative characteristics of inexpensive disk and drum systems suitable for use with the 516.

## 4. GRAPHICS I/O

With the object of expanding computer input and output methods, we have made a study of graphic input devices and have concluded that the acquisition of a Rho-Theta transducer and a Track Ball would enhace our man-machine interaction.

The Rho-Theta transducer is an analog device consisting of a ball-point pen linked to two potentiometers with electrical outputs proportional to the polar coordinates of a point that can be used to input information from a drawing. The device is of medium resolution, 0.040 inches over a sector of 100 degrees by 10 inches, costs under $1200.00 excluding A/D converters.

The Track Ball is a cursor positioning device on a CRT screen. Biaxial rotation of the ball is resolved by shaft encoders and the analog or digital output is used for positioning a cursor on a computer-generated display. Resolution is one pulse per 0.03 inches with 350 pulses per rotation, and the cost under $1800.00 including the count logic.

A prototype device to permit viewing of three-dimensional pictures generated by a computer on a CRT screen has been constructed. The device consists of a vertical plate with two viewing apertures. One aperture is shut and the other is opened alternately by a rotating disc. Two images which vary slightly in perspective are triggered alternately on a CRT screen. Successive views of one image with the left eye and the other image with the right eye will appear as one image with the dimension of depth. Testing of this device is still required.

OAK RIDGE NATIONAL LABORATORY

Report of Activities

A. E. C. Computer Information Meeting

Los Alamos Scientific Laboratory

May 20 and 21, 1968

## Computer Operations

The ORNL Computing Center continues to operate an IBM 360/75 and Control Data 1604-A on a batch mode basis. Both computer systems are essentially saturated, the 360/75 operating around the clock, seven days a week and the 1604-A around the clock, six to seven days a week. Figure 1 shows the work load on both computer systems as measured by the number of jobs submitted, while Figures 2 and 3 show the productive hours and downtime experienced by the 360/75 and 1604-A respectively.

No changes in computing equipment have been made since the last Information Meeting and complete descriptions of the computer configurations have been made in earlier site reports. Some comments on operating experience during the last six months, however, seem to be in order.

The CDC 1604-A and 160-A computers completed their fifth year of service in February, 1968, and continue to give good, reliable performance. During the report period, all seventeen magnetic tape drives (CDC 606's, fourteen of which are serial number 50 or less) underwent an "overhauling" program which resulted in noticeable improvement in tape performance.

Because of the turnaround time (two to three hours for jobs running 5 minutes or less) on these computers, they are utilized heavily by those users who have short running production codes or who are making debugging runs on new programs.

The IBM 360/75 completed its second year of operation in March 1968 and appears to have settled down to a reliable level of performance. The alarming increase in down time reported at the last meeting has been reversed by revised preventive maintenance policies on the part of IBM. The current PM schedule calls for 8 hours of maintenance every Saturday and 2 hours every Wednesday (if needed). The ORNL machine is serial number 3 and, as one of the earliest 75's, was the object of much pioneering effort in the area of engineering changes. This also contributed to the down time mentioned in the last report. IBM has, however, altered their policy in this matter (at our request) so that, as far as possible, no engineering changes are made to this system that have not been first installed and checked elsewhere. These two changes in procedure have apparently been successful in reducing down time and in acheiving the IBM goal of making the machine available to ORNL for 600 hours per month or better.

The 360/75 is currently being operated with Version 13 of the Operating System and the FORTRAN Compiler from Version 14, with input/output under the control of the HASP (Houston Automatic Spooling Priority) System. The HASP system provides better control over the computer operations and receives more extensive IBM programming support than was received with the SPOOL system. At the present time, the HASP system operates three printers, two card punches and two card readers overlapped with problem

program computation. The system also allows priority job scheduling and extensive operator communication with HASP via the console typewriter.

Version 14 of the Operating System included the re-written version of Fortran IV, Level H. While this version of Fortran does correct a set of known problems with the earlier compiler, a new set of problems, some of them not as well known as the earlier set, have been discovered in the newest version of the compiler. As a result, some programs which used to run routinely, are now failing, and it has been necessary in those instances to give the programmer access to the Version 13 compiler.

All the equipment reported upon at the last meeting has been checked out and accepted with the exception of the data cell. This device is attached to the 360/75 via a selector subchannel on the multiplexor channel. In that configuration, with the level of programming support available, the Data Cell has proved unusable for the application planned for it, i.e., the loading and executing of load modules from the data cell. The problem appears unique to data cells attached to Model 75's on something other than a selector channel, but this is not entirely clear. In view of this, ORNL has proposed to the AEC that the Data Cell be returned to IBM and that other large capacity storage devices, e.g., a 2314 Direct Access Facility, be considered.

During the report period, remote hook-up between the 360/75 and a SEL 840A computer located at the Isochronous Cyclotron Facility was completed. Software for both computers was checked out and the link has been used successfully for remote job submission, with the option of printing job output at the ORNL Computing Center or back at the ORIC computer. Routine use of this capability has not yet begun.

Three new plotting systems were added to the Computing Center in January 1968. All three are made by California Computer Products (Calcomp) and are off-line, tape-driven systems. One is a 765 "Zip Mode" Plotter (11" maximum ordinate), the second is a 763 "Zip Mode" Plotter (29 1/2" maximum ordinate), and the third is an 835 Electronic Digital Plotter (CRT Plotter). The two pen-and-ink plotters have been in productive use for some time while the CRT plotter will go into production in early May.

Future plans of the ORNL Computing Center have to do primarily with alleviating the saturated condition on both computer systems as well as making possible solutions of a class of problems as yet unattempted. Evaluation of the situation indicates the need for the largest, fastest computer deliverable within the year, with an absolute minimum of reprogramming effort. With this in mind, a proposal has been made to the AEC for the acquisition of an IBM System/360, Model 91K Computer System to be delivered in January 1969.

## Systems Programming

Extensive changes were made to the ORNL FORTRAN Compiler described in the last report, including the incorporation of features of FORTRAN IV that had not been included in the language. Known errors in the compiler were also corrected.

A new compiler has been designed for ORNL FORTRAN using a different approach from the original version. The compilation process has been divided into three parts; syntax scanning, program optimization and generation of object code.

The syntax scanner inputs the source program, scans it for syntactical errors and produces an internal representation which can be processed efficiently. This internal representation can be considered as a basic language.

The program optimizer takes the internal representation of the source program and processes it to eliminate program inefficiencies. The object in this phase is to produce a code, using the internal representation, that will have the same effect as the original program, but whose execution time will be reduced as much as possible.

The third phase of the compiler will produce object code from the optimized internal representation.

It is worth noting that the internal representation is a language in itself and that the second and third phases of the compiler act on that language. This implies that languages other than ORNL FORTRAN can be processed by phases two and three provided the source program can be converted into the internal representation.

Other activities of system programming personnel include system generation of new versions of the IBM-supplied OS/360 (Operating System), writing of routines for system maintenance, alteration of some of the library routines to make error messages more definitive, and support of the following computer languages on the 360/75: FORTRAN/360 (ORNL FORTRAN), FORTRAN IV H-Level, FORTRAN IV G-Level, COBOL F-Level and Assembly Language F-Level.

## Applications Programming

In the last report, there was described the development of a simple programming language to facilitate the use of data analysis routines. The language is called ORDEAL (Oak Ridge Data Evaluation and Analysis Language) and has now been released for use by interested personnel at ORNL. A manual has been written which gives a general description of the language and a catalog of available procedures for the 360/75. With time and knowledge gained from experience, the catalogs should be extended.

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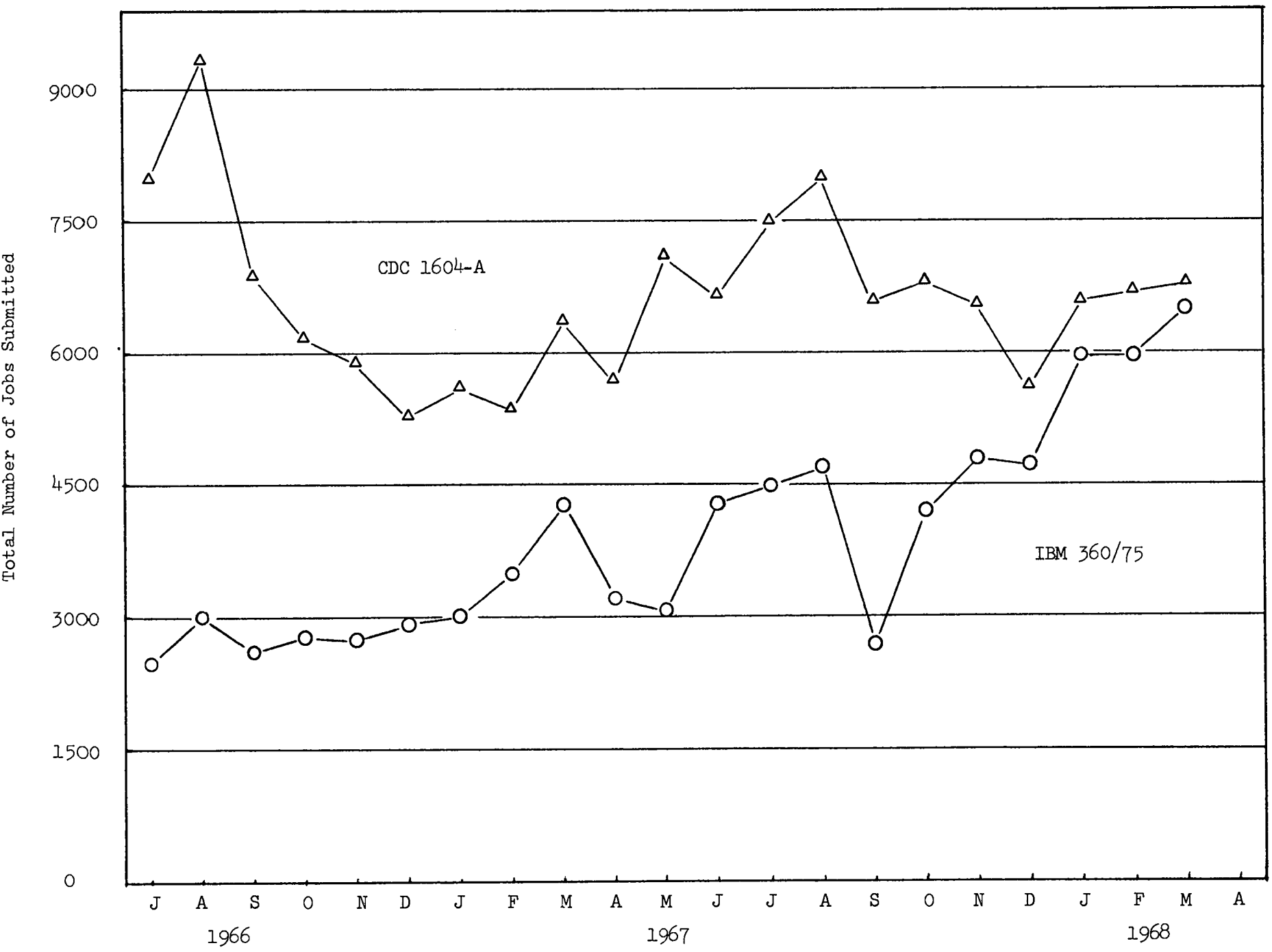
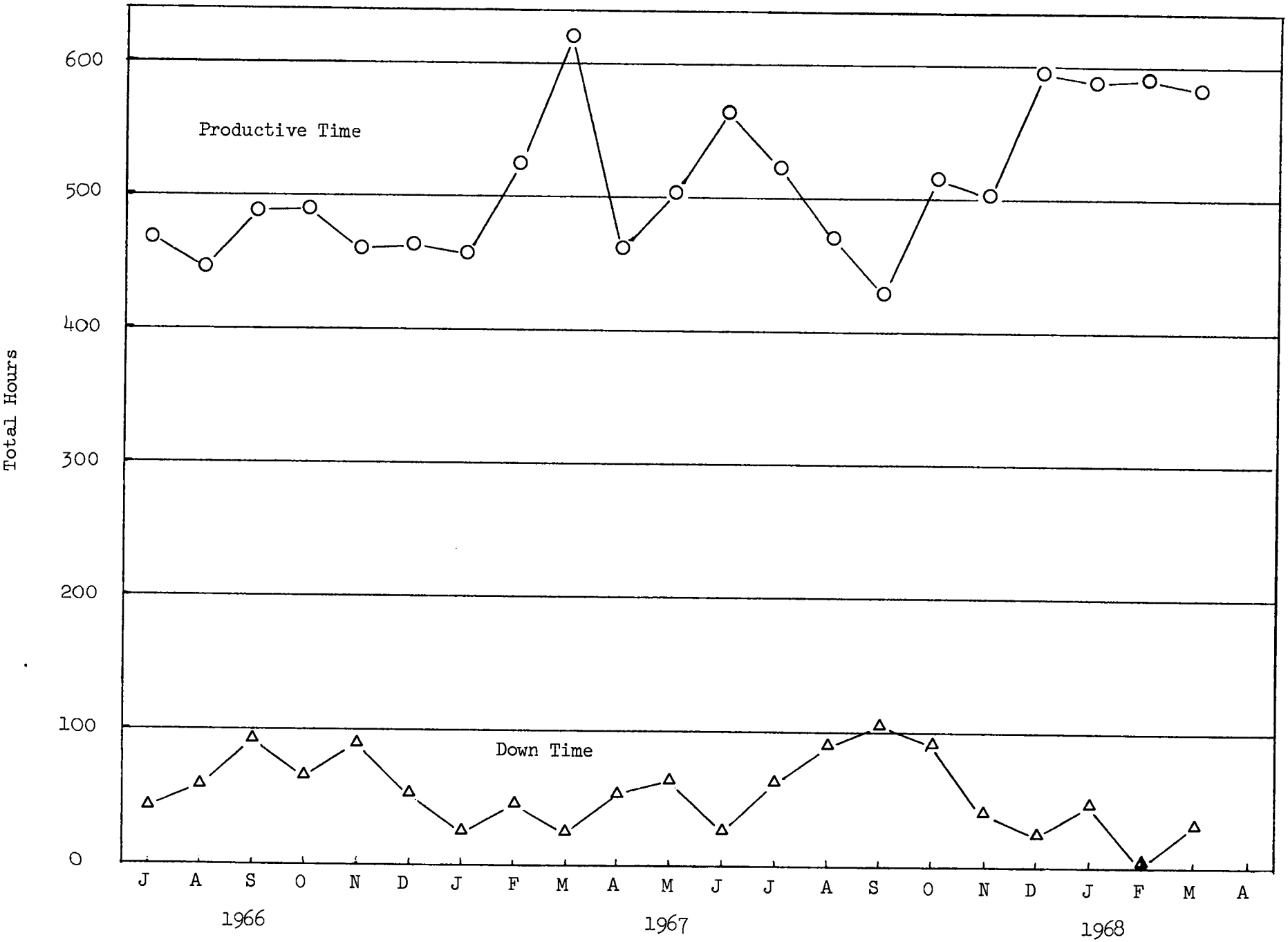
4/29/68



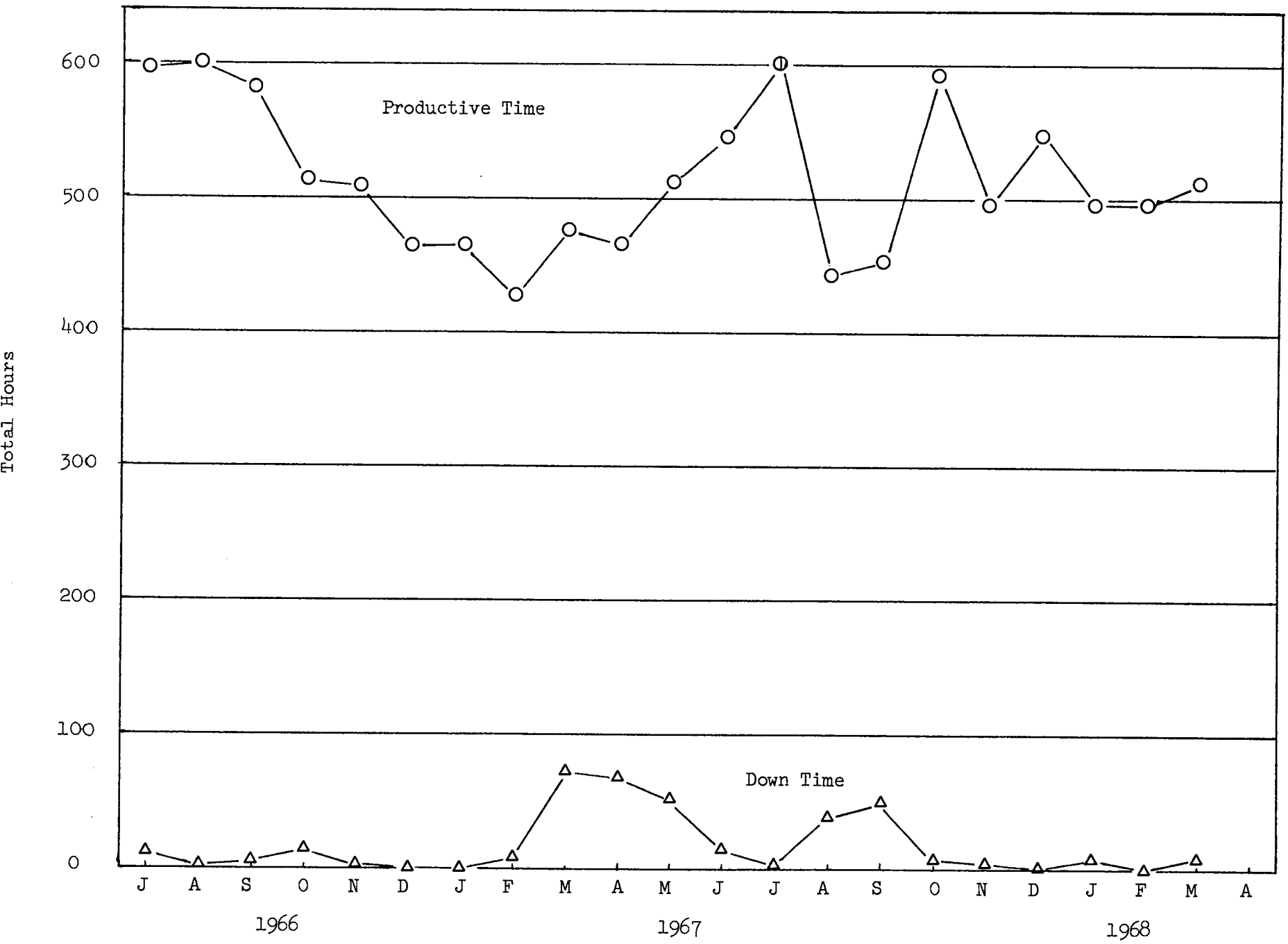

Work Load on the IBM 360/75 and CDC 1604-A

Figure 1




IBM 360/75 Productive Time and Down Time

Figure 2




CDC 1604-A Productive Time and Down Time

Figure 3

INSTITUTE FOR COMPUTER RESEARCH

THE UNIVERSITY OF CHICAGO

Chicago, Illinois 60637

Summary of Activities for the AEC Computer Information Meeting
May 20-21, 1968

# Part I. Current Status of the Multi-Computer Project

## Introduction

By the end of the previous report period, the project to design and build a multi-computer had reached the point where detailed logical design work was well advanced. During the current report period it has been possible to work on other aspects of the project. We have successfully tested a simulated system, trying out variations on several ideas, and we are approaching the final design of the new computer.

## Simulation

A simulator has been written to simulate the current revision of the new multi-computer on Maniac III. An assembly language has been defined, an assembler written, and a number of test programs have been written and run on the simulated system.

The present design scheme will be modified on the basis of our experience with the simulated system. The simulator and assembler will then be updated so that testing can continue while construction is going on.

The Maniac III computer lent itself well to the role of a simulation device, enabling us to test several novel ideas without making a drastic prior commitment to hardware.

Engineering

The design of some typical instructions and important hardware routines has been outlined in order to determine desirable control functions and data paths within the interface computer.

A testing program which runs on the PDP-8 computer has been written in anticipation of a need for rapid testing of numbers of identical printed circuit boards. This program is readily adaptable for use with a variety of different printed circuit boards, including commercially available types, and can check the operation of all circuits on a 150-pin board in a few minutes. An error listing can be produced and the operation of any selected circuit can be monitored on an oscilloscope.

The scratch-pad memory register boards are complete and will be tested using the PDP-8 program. The most suitable organization of the driving and data-transmission circuits for this unit has not yet been determined.

Operating System

Work is progressing on the operating system. The first version of general specifications for the system is nearing completion. A sketch of a possible scheme for implementing this version of the operating system is

at a similar stage of development. Included in this preliminary design is a plan for an assembler, a Basic Fortran compiler, a debugger, and an UNCLLL compiler.

Part II. Research Activities During the Report Period

Research activities within the Institute for Computer Research since the last progress report are described in detail in ICR Quarterly Reports Nos. 14, 15, and 16. The Table of Contents of each Quarterly Report is given below and on the following pages. Copies of these reports are available as long as they last.

Quarterly Report No. 14
August 1, 1967

Section I

A. Maniac III Engineering Activity

B. The Man-Machine Project (C.C.J. Roothaan)

C. An Investigation of a Graph Simulator Computer (J. Bounin & C. Robinson)

Section II

A. A Bench Mark Calculation for Retrieval by Confluence of Binary Attributes in a Random-Access Computer (G.K. Manacher)

Section III

A. Numerical Stability in N-Body Integrations (R.H. Miller)

Quarterly Report No. 15
November 1, 1967

Section I

A. Project Support Activity

B. The Man-Machine Project (C.C.J. Roothaan)

C. A User's View of Capabilities (R. Fabry)

Section II

A. On Simplified Implementations of the EOL Language (L. Lukaszewicz)

B. Symmetrical Stacks in EOL (L. Lukaszewicz)

C. The UNCLLL Plex-Processing Language: Preliminary Design Description II, and Tentative Programmer's Manual (R. Dewar and G. Manacher)

Section III

A. Signal-to-Noise Ratio in Fringe Visibility Measurements with a Michelson Stellar Interferometer (R. Miller)

B. A Scheme for Studying Astronomical "Seeing" (R. Miller)

Quarterly Report No. 16
February 1, 1968

Section I

A. Project Support Activity

B. The Man-Machine Project (C.C.J. Roothaan)

C. PDP-8 I/O Devices (J. Bounin)

D. Phase Counter and Interface to the PDP-8 for an Interferometer (J. Bounin & L. Herzenberg)

Section II

A. The Linguistic Information Analysis and Retrieval System (S. Herbst)

Section III

A. Essential Features of Purposive Movements (P.H. Greene)

B. Cybernetic Problems of Sensorimotor Structure: Introductory Remarks and Survey of a Study (P.H. Greene)

C. Seeking Mathematical Models for Skilled Actions (P.H. Greene)

D. An Aspect of Robot Control and Nervous Control of Skilled Movements: Coordination of Two Effectors and Transfer of Adaptation. (P.H. Greene)

DEPARTMENT OF COMPUTER SCIENCE
GRADUATE COLLEGE
UNIVERSITY OF ILLINOIS

# PROGRESS REPORT

for

Atomic Energy Commission
Computer Information Meeting
Los Alamos Scientific Laboratories
Los Alamos, New Mexico

May 20 and 21, 1968

JNS:bt
May 1, 1968

C O N T E N T S

Hardware Systems Research

Report on the activities of Atomic Energy Commission 1469-Poppelbaum

Fall, 1967 to Spring, 1968.

The PARAMATRIX system received an addition in the form of a flying spot scanner which allows the display - after translation, rotation, and magnification - of a quantized version (32 x 32 matrix) of the pattern on an input slide. The overall system positions the spot of the scanner within less than one microsecond under the control of the PARAMATRIX computer and asks the question "Is the transform of a given output point on the slide or not?" Very satisfactory results have been obtained with the augmented system.

The TRICOLOR CARTOGRAPH project has started working on a limited scale and is expected to be fully operational by the end of the summer. It is effectively possible to draw complicated outlines - even with multiple connectivity - and to color the "inside" of the zones by indicating interior points with a light pen. Besides the primary colors, any combination thereof is acceptable. One of the principle insights gained from the project is the efficient use of a multiple track video disc as a storage medium.

The BANDWIDTH COMPRESSION SCHEME in which the intersection times of a drawing with scanning lines are stored and then transmitted at equal time intervals, is well along the way and the reconstitution of lines from register information has been successfully demonstrated. The bandwidth compression scheme for graphical information has been supplemented with the VISTA project in which the scan rate of a gray scale television system is determined by the rate of change of information content in successive frames. A variable integration time display is used in order to give a steady output.

The On-Line Fourier Transform project, OLFT, has now entered the first stages of experimentation. In particular, the Pockels Effect Chamber has been received from the Westinghouse Space Electronic. Division and has passed its acceptance tests. Considerable problems will have to be solved, especially in the area of definition, contrast, and keystoning of the charge distribution on the KDP serving as a transfer memory when illuminated by polarized light. The choice of adaptive conjugate filters produced by the system itself has not yet been clarified: both calcium bromide cells and purely electronic means are being considered.

Software Systems Research

Report on Activities of AEC 1469-Gear, Fall 1967 to Spring 1968

The Computer Aided Programming System has been implemented on the ILLIAC II-DEC 338 system and is now operational. It makes it possible for flowcharts to be drawn on the DEC 338 and executed directly within the ILLIAC II. An improved version of the ILLIAC II program is being developed for the IBM 360 and we will shortly be ready to begin the software interface between the DEC 338 and the 360.

The PDP-7 to which the DEC 338 is connected has been interfaced to the IBM 360 and has been checked out in a hardware sense. It is now possible to communicate between a program running in a partition of the Model 50 and the PDP-7. This connection will be used for the interactive compiling and editing software being developed as well as for the remote graphics developments.

A low-cost remote graphic terminal is in a design and construction phase. Part of the display logic and D to A converters have been constructed and are interfaced to a scope. A 4K 16 bit memory has been received for the terminal and has been coupled to some logic for the purpose of checking it and preparing to interface it to the terminal. It has been temporarily connected to the display logic to generate fixed patterns on the scope.

The automatic integration of stiff ordinary differential equations has been improved to a point that the automatic interval control and integral control work effectively for all cases considered. It has been used to solve some problems arising in radiation studies at the Chemistry Department of Argonne National Laboratory. The input compiler now handles the symbolic input of the equations. The symbolic differentiation section is being debugged as is the interface between it and the integration package.

Computer Graphics Conference

NSF Grant No. GJ-2

C. W. Gear

A successful conference entitled "Emerging Concepts in Computer Graphics" was held on the campus of the University of Illinois at Urbana on November 6, 7 and 8, 1967. There were 258 enrollees to listen to papers presented by 19 speakers of whom 6 were from the University of Illinois. The proceedings from this conference will be published by the W. A. Benjamin Publishing Company, and probably will be available in late April.

A proposal to hold a second conference in the similar area sometime in spring 1969 is now under consideration.

NUMERICAL METHODS, COMPUTER ARITHMETIC, AND ARTIFICIAL LANGUAGES

Report on activities under NSF Grant No. GP-4636.

Research in theorem proving resulted in the masters thesis, "Some New Results on Resolution in Automated Theorem Proving" by L. J. Henschen, and programming is under way to implement the new algorithms.

For the use of finite field models in polynomial manipulation, a set of theorems establishing the validity of the models was proved. One subclass of models can be used to check addition and multiplication of polynomials, and provides a fast test of divisibility -- if the models don't divide, neither do the original polynomials.

The Avizienis symmetric base 2 signed digit adder was studied stochastically to determine the ultimate probability distribution of combinations of digits, and the results were used to devise an optimum algorithm for partial normalization ($\frac{1}{4}$ to 1 in magnitude) of numbers in this representation.

EOL-3 was code-checked and added to the PORTHOS system, and has been used, for instance, by honors section introductory programming students to write simple compilers. EOL-4 is being planned.

ILLIAC III
Report of Activities of 1018

by

B. H. McCormick

## 1. Description of Computer System

Three basic manuals of the Illiac III Computer System have recently been issued. These are:

1) B. H. McCormick, R. M. Lansford (Editors) , ILLIAC III PROGRAMMING MANUAL, March 12, 1968.

2) L. A. Dunn, et. al. , SCANNER-MONITOR-VIDEO PROGRAMMING MANUAL, March 28, 1968.

3) John C. Schwebel, IBAL MANUAL: The Illiac III Basic Assembler Language, March 8, 1968.

These manuals are now available for general distribution. However, we will provide update material only to those individuals who explicitly request this service in writing.

### 2.1 Illiac III Simulation

The Illiac III computer is being simulated on the IBM 360 at two levels. Most important at this stage is a signal level simulation of the various hardware sub-assemblies. This level of simulation is necessary to insure the integrity of the logical design and for later engineering use in troubleshooting the hardware.

For use in software development, this level of simulation has proved inefficient: the excessive detail at this level makes the simulator unnecessarily slow for the software development. Accordingly the various simulation modules are being designed such that they can be replaced on a one-by-one basis as the need arises for a less detailed simulated module - adequate for software simulation - thus increasing the efficiency of the simulator.

Of more general interest the simulator of the Pattern Articulation Unit provides a useful tool for the simulation of parallel image processing algorithms. This portion of the simulator can be considered a successor to the earlier PAX interpreter developed here at Illinois and now widely used.

## 2.2 Operating System

### 2.2.1 Image Processing Package ($IP^2$)

An Image Processing Package is being designed to give the user intermediate level control over the extensive image processing facilities of Illiac III. In addition the user will be given assistance in using extremely flexible, but also complex, image-processing I/O devices of Illiac III.

At this stage the primary emphasis is upon the documentation of the language specifications. It is anticipated that a preliminary report will be available during the second quarter 1968.

### 2.2.2 Telecommunication Processing Package ($TP^2$)

A manual describing the low speed terminal net of Illiac III is in progress. This manual will in format resemble the S-M-V Manual recently issued, but will describe the low speed terminal devices of Illiac III (ASR 33 teletypes, Selectric typewriters, Linc magnetic tape units, etc.); the low speed buffers that provide data concentration and the system programming aspects most directly associated with the multiplex operation of the low speed terminal devices.

### 2.2.3 Data Segmentation

Specification of the Data Pool organization of the Illiac III operating system has centered upon two problems:

1) Development of an efficient mechanism for inter-segment linkage, given the constraints of multi-programming and multi-processing.

2) Development of an efficient algorithm for base register and pointer register allocation for a 2-level addressing scheme used in Illiac III.

Solutions to both problems are at hand, and neither appear to be optimal yet. At present considerable attention is being given to specifying the IBAL - Operating System interface. As the computer can execute micro-instructions without software intervention —the so-called "imprimitive instructions" of Illiac III— uniform segmentation procedures have to be set up if the assembler is to exploit this capability.

The PL/1 translator, like the IBAL translator, produces both data segments and procedures segments. A declaration pass for the PL/1 translator has been designed to generate tables closely parallelling those generated by the IBAL translator. Accordingly as it is anticipated that the PL/1 translator for Illiac III will bypass in this way appreciable intermediate translation into the IBAL language.

### 2.2.4 Task Supervision

The detailed working paper is being drafted by L. Katoh and R. M. Lansford to examine the problem of task supervision for traffic control in the multi-programmed, multi-processor system. Particular attention has been attached to those portions of the system, the so-called "firmware" which must be fast and provide adequate interrupt servicing. Attention is being given to the design of a minimal "firmware" system which can be expanded with conventional software in our evolutionary manner at a later date.

## 2.3 Translators

### 2.3.1 IBAL Assembler

Work on the implementation of the IBAL translator during this spring has centered on the data set declaration facilities.

The following features of the data set facilities in IBAL distinguish it from PL/1:

1) All nodes do not require alphanumeric names.
2) Subscripts, besides providing references within arrays, may also be used to reference any node in the structure.
3) Conditional notes, evaluated at execution time, are allowed.
4) A node may be declared as a vector to speed up its accessing of its subnodes.

The first edition of the IBAL manual was completed and printed this quarter (See Section 1).

### 2.3.2 FORTRAN IV Productions

Floyd productions for the syntax of FORTRAN IV are now essentially complete. Error recovery routines are being devised but have not been completed yet.

### 2.3.3 PL/1 Translator

Internal documents now exist of a declaration pass used to extract all information from all declarations (implicit or explicit) in a PL/1 program to be translated. In particular some 400 Floyd productions have been generated.

Our success in specifying the declaration pass has encouraged us to consider seriously construction of a PL/1 translator for Illiac III. This translator would provide full data declaration capabilities of the language, but would initially implement only that restricted subset of the PL/1 statements taught in our introductory Computer Science 101 course.

## 2.4 Experimental Recognition Procedures

### 2.4.1 Graph Transformation Grammars for Image Processing

We strongly believe that image processing will find its natural mathematical expression in graph transformation grammars. In particular

path-type grammars for the description of images, as developed by Narasimham, Ledley, Breeding and more recently and elegantly by Allen Shaw (Stanford) leave many conceptional gaps. In particular the natural language relations of an object being within another object, touching an object, to the left of, etc. can be formulated only by very artificially and awkwardly within the path-type grammars.

To this end John C. Schwebel and B. H. McCormick are investigating a class of graph transformation grammars which would appear to be the minimal mathematical structures which allow these natural language concepts to be expressed in a natural and elegant way. In particular this mathematical model has suggested a mode of human experimentation - an image processing game - by which it may be possible to systematically extract many of the image processing algorithms used by the human observer.

James Fornango has also implemented a variant of the ASP (Associative Storing Processor) language for the IBM 360/50. This language can be considered a first approximation to class of the graph transformations discussed above.

### 2.4.2 Recognition and Reformatting of Text

The LEFT (Language for Editing and Reformatting Text) has been developed such that the typographical description of a document can be accurately described in a LEFT description. The LEFT language accordingly is used in two contexts:

1) Given an input document, typographical recognition is performed on the document to convert it into an equivalent LEFT description.

2) Given the LEFT description of a document, machine language can be generated to control the photocomposition of the output document.

Previous languages for typographical description do not allow one to retain the description of a sentence, paragraph, page or picture as analog information (i.e. as a stored video signal). This deficiency has been corrected; text recognition can be controlled to any required depth and resolution of detail necessary.

Secondly the description of text to categorize such entities as heading, footnote, illustration, etc. seemingly requires not just the character string description of the text, but also the typographical formats as standardized by the printer's style manual. Accordingly we view text recognition as first mapping the document into an equivalent LEFT description and then processing this string by means of Floyd productions in the now-standard procedure. That is, text recognition is conceived as proceeding from the full text description - including typographical information.

A report on the LEFT language is now ready for printing.

### 2.4.3 Classification Procedures

We use the term classification procedures to refer to algorithms used in work which has been variously termed classification, mathematical/numerical taxonomy, cluster analysis, pattern separation, measurement testing, and even data analysis.

Classification procedures are an integral part of many levels of pattern recognition. For example we may envision a taxonomic scheme which transforms the picture into an abstract graph having symmetric relations between graphic elements, and then employs clustering techniques to transform the graph into a hierarchy of syntactically important constituents. A literature search has been done in the computer science, mathematics, electrical engineering, biology and psychology. Interdisciplinary communication in this area appears very poor. A bibliography has been prepared and will be issued shortly. We solicit those who have similar interests to review this bibliography such that revised documents can be issued later.

## 3. Design/Fabrication of the Computer

### 3.1 Central System

#### 3.1.1 Taxicrinic Processors

The first version of volume one of the TP manual should be ready by next quarter. The second volume of the TP manual containing the control sequencing, has been written as a first rough draft but will not be finalized until late summer.

Physical hardware is currently being readied for the rewiring of those sections of the mainframe which were destroyed in the fire last year. These sections are described in volume one of the TP manual.

#### 3.1.2 Fast Core Storage Modules

Final acceptance tests were run on our first fast (700 nano-second cycle time) core memory February 1968. Since its arrival, the core has completed several eight hour, offline, error-free test runs. A simulator is under construction to extend the class of text which can be performed. The second core module again will be delivered in mid-May giving us a total of 65,000 words of fast storage.

#### 3.1.3 Arithmetic Units

The detailed logic drawings of all registers, data transfer paths and major functional blocks of the AU structure, distinguished from control, are now largely complete. Wiring tables for this logic will be completed shortly. Although detailed logic drawings of the AU control has not yet been done, control sequences have been specified in the arithmetic unit simulator.

Based upon research undertaken in the developments of the division algorithm, a paper has been prepared during the last quarter for submission to the IEEE Transactions on Electronic Computers. It is entitled "Higher Radix SRT Division in the Calculation" by D. E. Atkins.

### 3.1.5 Exchange Net

Pin card and rack numbers have been assigned to half of the drawings of the exchange net and the other half should be available within this quarter.

## 3.2 I/O System: Channel Interface Units

Logical design of the channel interface unit is almost done. Card arrangements have yet not been started. A preliminary form of the manual describing the channel interface unit has been written and should be issued within the next quarter.

## 3.3 Peripheral System

### 3.3.1 Scanner-Monitor-Video Controller

Control flowcharts for all modes of operation have been drawn that reflect the specifications of the recently published S-M-V Programming Manual. Work is presently being done on the integrating of the different modes and simplifying the flow wherever possible. Registers and gates, but not control, of the S-M-V controller have been wired - but do not reflect the most recent design changes. This module on the other hand will be used for interim testing while the new digital logic is being constructed.

### 3.3.2 Scanners/Monitors Center

Prototype new Litton cathode tubes have been installed in the scanner and will be shortly installed in the monitors. Definition and signal/noise ratios in the scanner have been greatly improved.

### 3.3.3 Video Communication Net

An extensive and flexible Video Communication Net is being developed for Illiac III. The net couples to the I/O channels of Illiac III to the scanner-monitor-video controllers. The network permits transmission of video over coaxial cables to remote consoles. Video signals

are transmitted either fast scan 1536 line, 15 fields per second or "slow scan 1536 line, 1.25 fields per second".

Twelve (6 "fast", 6 "slow") monitors have been ordered from Ampex as well as three dual-rate high resolution cameras. These items are due to arrive February 1969, in time to be installed in six remote consoles to be built.

### 3.3.4 Videograph Printer

Delivery was taken this past quarter of a Videograph Printer giving 8-1/2 x 11 inch printout of text, graphs and pictures at 0.8 seconds per page from facsimile input. A character generator under the same contract will be delivered next quarter from A. B. Dick.

### 3.3.5 Low Speed Terminal Network

A preliminary design of the low speed buffers for this system have been completed. This data concentration system provides 256 bytes bins for the five monitor Selectric typewriters, five monitor magnetic tape modules, ten ASR 33 teletype sets and associated analog instruments of the Illiac III computer system.

## 3.4 Power Distribution

The design of this system is now complete and fabrication, assembly and wiring has been initiated. The first draft of the power distribution manual should be completed by mid-summer.

BHM:djs
4/22/68

# ILLIAC IV

## Report On Activities

D. L. Slotnick

Burroughs has executed its subcontract with Texas Instruments. The terms mirror precisely the terms in the contract between the University of Illinois and Burroughs.

The PE design is complete. However, implementation will be delayed by several months due to noise problems that have emerged with the 64 pin packages. It is hoped that the 64 pin packages (possibly expanded to 84 pins to permit providing a separate voltage supply to each gate group) will prove acceptable for the PE. It may be necessary to retreat to conventional IC's (14 or 16 pin dual inline packages) in the CU and PE memory. These considerations impact schedule and performance and have made it impossible to complete our rescheduling efforts during this quarter. It appears certain now, however, that during the next calendar quarter, successful progress can be made to predict accurately the impact on cost, schedule, and specifications.

The overall system design is now complete with the exception of the IOC. This report contains descriptions of configuration control, interrupt control, and the degree of synchronism between quadrants. The diagnostic programming effort has been initiated during this quarter, and it is expected that a preliminary detailed schedule of this task will be available at the end of the first quarter of 1969.

Work on the translator writer system and source language system continue on schedule. A unified approach to many problems in partial differential equations has been initiated and is outlined in this report. It is felt that this is a particularly important application effort and future progress reports will contain summaries of progress as the work develops. In this effort, the help of many people in the community interested in large mesh calculations is being enlisted to achieve a useful definition of this system of programs.

## Service Facilities

## Report on Activities (Fiscal Year, 1967-68)

H. G. Friedman, M. Foster

The Service Area of the Department of Computer Science is responsible for providing the main interface with members of the University of Illinois' computer-using community. The area provides those services necessary to allow usage of the Department's facilities with a minimum of waste and a maximum of learning and efficiency. Duties of the members in the area can be roughly divided into those that maintain a continuing service to the user on equipment and machines presently available to the user, and those that develop services for the future. Thus, the fiscal year 1967-68 saw advancement in expanding services offered to users of the IBM 7094-1401 complex and in initiating usage of the IBM 360/50-75 complex.

As of July 1, 1967, the Department of Computer Science offered computing services on the IBM 7094-1401 complex. In August, 1967, the stand alone 360/50 became available. The 360/50-75 complex became available on January 2, 1968. The Department Consulting and Keypunch areas were freely available to users of both computers. Time-sharing on ILLIAC II, with the 12 consoles dispersed on the Urbana campus, has been retained until such time as time-sharing becomes available on the 360/50-75.

Software improvement:

During the fiscal year the PORTHOS system on the 7094 became stable. One major exception to this was the implementation of FORTRAN IV within PORTHOS.

The major software effort was on the IBM 360/50-75.

PØRTHØS library routines were recoded for the 360 library;
PLØRTS, a time sharing system, is being coded;
Accounting routines were imbedded in OS/360;
A new monthly accounting report program was designed and coded;
Continual updating of OS/360 and ASP was performed.

Keypunching Service:

By July 1, 1967, Service Keypunching was an established and successful service offered to users of DCS facilities. Due to the increased usage of this service it was necessary to expand the service. Additional keypunch operators were hired and an evening shift was added to the day shift.

Consulting Service:

In addition to providing answers to any questions involving the 7094, ILLIAC II timesharing, and the IBM 360/50-75, the Consulting area continually published documentation for the users in an attempt to simplify the information needed by users and to expand the lines of communication with the user. Service programming offered on the 7094 and the 360 for campus users increased the ability of various faculty members to utilize DCS service. This service also enabled many 7094 users to make a smooth transition to the 360/50-75. Additional consultants were hired to aid in service programming. Consultants and programmers were available to provide educational talks on the use of the computer. The consultant area offered a short programming course in FORTRAN IV, JCL, and PL/I to over 150 faculty members. Training of consultants in all phases of the Service Area was intensified.

Personnel:

Service area personnel increased in all subdivisions of the area during the year.

Thirty persons supply 420 man hrs/week for the consulting area - a 17.5 percent increase in hours for the year.

Fifteen persons work 600 man hrs/week in the keypunch area - a 15 percent increase in hours for the year.

Thirty-eight persons supply 1080 man hrs/week in the operating area - a 15 percent increase in hours for the year.

Fifteen programmers devote 490 man hrs/week for development and maintenance of software - a 26.5 percent increase in hours for the year.

Miscellaneous:

By February of 1968, 46 percent of jobs previously run on the 7094 were being processed on the 360 complex in approximately 50 percent less time than would have been needed on the 7094.

Approximately 230,000 jobs were processed under the PORTHOS system. This required approximately 6500 hours of computer time. The highest number of jobs per month processed (24,450) occurred in July 1967, when 4,417 class jobs and 20,033 research jobs were run. From August 1, 1967 on, approximately 130,000 jobs were processed on the IBM 360/50-75. This required approximately 3200 hours of computer time. The highest number of jobs per month processed (17,000) occurred in May, 1968, when 13,000 class jobs and 4,000 research jobs were run. The combined totals for both computer complexes are approximately 360,000 jobs processed (5 percent increase), requiring an approximate total of 9700 hours (60 percent increase).

Work continued on the ILLINET complex. Work was initiated in preparation for the July, 1968 arrival of the IBM 1800. ILLINET became a physical reality with the installation of the IBM 360/30 in April, 1968.

PROGRESS REPORT

"Studies of the Numerical Solution of Elliptic and Parabolic Boundary Value Problems"

Bruce Kellogg (acting principal investigator)

Institute for Fluid Dynamics and Applied Mathematics

University of Maryland

College Park, Maryland

AEC-AT(40-1)3443/2

Research was continued on analyzing the discretization error in finite difference solutions to partial differential equations, especially in the following areas.

1. A study was made of difference approximations for uniformly elliptic equations of the form

$$\sum_{j,k=1}^{N} \frac{\partial}{\partial x_j} \left(a_{jk} \frac{\partial u}{\partial x_k}\right) = F \quad \text{in} \quad R$$

$$u = f \quad \text{on} \quad \partial R$$

in an N-dimensional domain $R$ with a smooth boundary $B$. The difference approximations studied are not of positive type, but the discretization error was bounded in a discrete $L^2$ norm, the bounds depending only on the domain $R$, the data $F$ and $f$, and the mesh spacing. (Work done by J. Bramble, B. Kellogg and V. Thomée.)

2. A study was made of difference approximations for the one group neutron transport equation in x-y geometry. The discretization error was studied for various difference schemes, especially the central difference scheme and the diamond difference scheme. (Work done by N. Madsen.)

3. A study was made of the spectrum of various operators related with the one group neutron transport equation in x-y geometry, with the aim of understanding the convergence properties of some iterative methods for solving this equation. (Work done by B. Kellogg.)