

Digital Computer Laboratory  
Massachusetts Institute of Technology  
Cambridge 39, Massachusetts

SUBJECT: BIWEEKLY REPORT, APRIL 4, 1954

To: Jay W. Forrester

From: Scientific and Engineering Computation Group

1. MATHEMATICS, CODING AND APPLICATIONS

1.1 Introduction

During the period covered by this report 261 coded programs were run on the time allocated to the Scientific and Engineering Computation (S&EC) Group. These programs represent part of the work that has been carried on in 32 of the problems that have been accepted by the S&EC Group. Progress on 14 of these problems is given below in terms of programming hours, minutes of computer time, and progress reports as submitted by the programmers in question.

A study of the transient effects in distillation is being carried out by four graduate students in the Chemical Engineering Department. Progress on this study is described under problem #167.

A report is given below under problem #173 of the activities of the students enrolled in Professor Adams' course 6.537.

Coordination and testing of the revised S&EC utility programs continued during this biweekly period. Progress on this work is summarized under problem #100. It is hoped to have most of these programs in routine use during the next biweekly period.

1.2 Programs and Computer Operation

The following summary is included as a guide for interpreting the abbreviations used below. A more detailed description of the terms involved can be found in M-2497.

- a. The upper case letter following the problem number has the following significance:
  - A implies the problem is NOT for academic credit, is UNsponsored.
  - B implies the problem is for academic credit, is UNsponsored.
  - C implies the problem is NOT for academic credit, IS sponsored.
  - D implies the problem is for academic credit, IS sponsored.

The absence of a letter indicates that it is an internal S&EC problem.

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- b. DIC denotes the Division of Industrial Cooperation.  
DCL denotes the Digital Computer Laboratory.  
CMMC denotes the Committee on Machine Methods of Computation.  
DDL denotes the Division of Defense Laboratories.

100. Comprehensive System of Service Routines, developed by the S&EC Group at the Digital Computer Laboratory for the input conversion of suitably prepared punched paper tapes. When so requested, these routines automatically provide a program with suitable programmed arithmetic, cycle-counting, and output facilities.

:DCL Staff: Arden, 62 hours; Best, 44 hours; Combelic, 59 hours; Demurjian, 10.75 hours; Denman, 76 hours; Frankovich, 53 hours; Helwig, 70 hours; Kopley, 16 hours; Porter, 8 hours; Siegel, 38 hours; WWI, 1734 minutes

The following S&EC utility programs have been recorded on magnetic tape unit 0:

1. CS I
2. CS II
3. The automatic post-mortem program.

These programs appear to be substantially correct and will be used immediately in a semi-routine fashion for testing purposes. Their routine use will presumably become established during the next biweekly period.

The new input program will be recorded on Group 11 as soon as possible.

A memorandum describing the S&EC system of utility tapes is being written.

Staff

The automatic post-mortem program is working satisfactorily at present. The first post-mortem request causes the post-mortem program to be read from magnetic tape unit 0 and recorded on the buffer drum in groups 6 and 7. On all subsequent requests the program on the buffer drum is sum-checked. If the program checks correctly the post-mortem request is performed. If the program on the buffer drum does not check, it is recorded from magnetic tape unit 0 again, and the request performed. Post-mortem requests can be punched on Flexowriter tape in a form to be specified in a forthcoming memorandum.

Arden

A sufficient number of errors have been removed from the CS II conversion scheme so that successful conversions are being obtained. Work on the two remaining features of the new scheme, i.e., drum addressing facilities and automatic conversion post-mortems, is beginning now.

Frankovich

The utility programs for recording and re-recording programs on magnetic tape unit 0 are being combined with a generalized optimizing program in order that the programs which are recorded on unit 0 may occupy as little tape as possible. This combined program will read almost any tape that the input program will read, record or re-record it on unit 0, and /or punch out an optimized tape on either the direct punch or the delayed punch. Some progress has been made in trouble shooting the program.

Best

- 101 C. Optical Properties of Thin Metal Films on transparent backings are determined and printed out automatically by this program; the input data consist of the observed reflection and transmission coefficients, the index of the backing, the wavelength, and the sample thickness. The program calculates by means of an iterative procedure and prints out the index of refraction and the absorption coefficient of the film, the rate of variation of these constants with reflection and transmission, and the film's conductivity and dielectric constant.
- :for Professor L. Harris, Chemistry Department, Dr. A.L.Loeb  
 :by Dr. A.L.Loeb (DIC), 15 hours; Richmond, 35 hours  
 :DCL: WWI, 73 minutes

In the previous biweekly period an approximate equation for optical constants in the infrared had been coded, and its validity tested. This program was extended to allow improvement over the approximate results by iteration. All of Woltersdorff's data were run in this way, and the results obtained are extremely good.

A large set of data on almost transparent films measured in our laboratory was run. The machine stopped on some of these; investigation showed inconsistencies in the measurements. Most results were very satisfactory.

- 106 C. MIT Seismic Project is concerned with the development of methods for locating deep reflections from underground strata in seismic prospecting. The basic method is one of prediction by means of an optimum linear operator.
- :for Professor P.M.Hurley, Geology and Geophysics; Professor G. Wadsworth, Mathematics Department  
 :by E.A.Robinson (Res. Assoc.); Briscoe, 36 hours; Simpson, 15 hours; Walsh, 20 hours  
 :DCL: WWI, 305 minutes

During the past two weeks problem 106 has been chiefly concerned with obtaining a variety of travelling amplitude spectra to use in its study of the statistical behavior of seismic traces. Records chosen for this study ranged from ones with high signal-to-noise to very low signal-to-noise.

- 108 C. An Interpretive Program is being developed that will accept algebraic equations, differential equations, etc. expressed on Flexowriter punched paper tape in ordinary mathematical notation (within certain limits imposed by the Flexowriter) as input and automatically provide the desired solution.  
 :for Dr. J.H.Laning, Jr., Instrumentation Laboratory  
 :by Dr. J.H.Laning, Jr.(DIC), 2 hours; Zierler, 50 hours; Block, 5 hours; Battin, 1 hour  
 :DCL: WWI, 109 minutes

A great deal of work was done during this past period in order to get this interpretive program into a final form. The problem tape may now be placed in the photoelectric tape reader instead of the mechanical tape reader. The numerous tapes that were necessary to run this problem have been combined into one master tape 108-60-30, and some additions have been made to the automatic post-mortem routine.

- 113 D. A Stress Analysis of an L-shaped Homogeneous Planar Structure is being made for the case of a concentrated static load. This structure is approximated by a framework on bars which will deform in the same manner as the prototype. This framework is then analyzed using the principles of virtual work and Southwell relaxation techniques. Boundary conditions have been specified for the edge of the framework so that the deformations of the model will conform to the actual deformations of the structure.  
 :for Professor J.S.Archer, Department of Civil and Sanitary Eng.  
 :by S. Sydney (Res. Assist.CMMC), 20 hours  
 :DCL: WWI, 120 minutes

Production runs are being made on the coarse lattice program. The results are being compared with the experimental work done on this problem. Several more parameters will be analyzed with the coarse grid program.

- 119 C. Spherical Wave Propagation produced by the sudden release of a spherical distribution of compressed air in the atmosphere is being studied by numerical means. This involves replacing a set of non-linear hyperbolic partial differential equations in 2 independent and 2 dependent variables by a set of difference equations written along characteristics. An iterative procedure is used to solve these equations.  
 :for Professor C. C. Lin, Mathematics Department  
 :by A. Ralston.(CMMC), 10 hours  
 :DCL: WWI, 43 minutes

A production run with the new numerical process has been obtained. It will now be necessary to do some hand computation in order to carry the computation through the shock which is forming.

- 132 C. Subroutines for the Numerically Controlled Milling Machine are being revised and tested. The set of subroutines facilitates programming of the computations involved in the preparation of numerical data used to control the milling machine. The subroutines involve routine numerical and logical operations.
- :for J.O.McDonough, Servo Laboratory, DIC No. 6873  
 :by J.H.Runyon (Res. Assist. E.E.), 35 hours  
 :DCL: WWI, 36 minutes

Preparation of milling machine tapes for the conical surfaces was completed. Three different degrees of approximation and two methods of cut spacing were used.

Library type subroutines for facilitating interpolation and for inverting the roles of independent and dependent variables by a simple iterative process are being tested. A program for preparing tapes for airfoil templates is being written.

- 143 D. The Vibrational Frequency Spectrum of a Copper Crystal is to be determined by solving a  $3 \times 3$  secular determinant, each term of which consists of a finite Fourier Series of 12 terms. This equation must be solved for 24,495 different values of the wave-propagation vector.
- :for Professors B.E.Warren and J.C.Slater, Physics Department  
 :by E.H.Jacobsen (Res. Assist.), 65 hours  
 :DCL: WWI, 320 minutes

The elastic spectrum of copper has been finally run in corrected form. The results will be employed in the calculation of the behavior of the specific heat and zero-point energy. As a check, this program will be run again using the specific constants by Leighton (Rev. Mod. Phys., Jan 1948, p.165) where the exact answer is already known in advance from other methods. Also the effect of varying the size of the atomic constants will be studied later.

The frequency spectrum of F.C.C. copper has been successfully run for 3417 wave vectors uniformly spread throughout the first Brillouin zone of momentum space.

Future work will be that of noting the effect on the spectrum due to small changes in the atomic constants from the X-ray data.

- 147 C. Energy Bands in Crystals are being studied by finding solutions of the corresponding second order linear differential equation satisfying boundary conditions at the origin. The solutions are found approximately by using the Gauss-Jackson formula for forward integration. The solutions and their first derivatives are to be combined in a sum, the weighting factors being functions of an independent parameter.
- :for Professor J.C.Slater, Physics Department, DIC No. 6853  
 :by Dr. D.J.Howarth (DIC), 40 hours  
 :DCL: WWI, 527 minutes

During the preceding weeks, a considerable amount of production work has been carried out, involving the calculation of the radial wave functions required in the evaluation of the matrix elements referred to in a previous report. The final routine to set up these matrix elements and solve the resulting secular equation in various degrees of approximation has been assembled and is at present being tested.

A routine to solve secular equations involving non-diagonal overlap matrices has been written up in production form; over 30 such equations, of various orders up to  $14 \times 14$ , have been solved for Dr. R. McWeeny of the Solid State and Molecular Theory Group.

- 161 C. Response of Mass-Plastic Spring System to Transient Loading:  
 a 2nd order non-linear difference equation representing the response of building foundations to transient shock loads is being studied in order to develop criteria for the design of blast resistant foundations. The footing is represented by a concentrated mass, and the soil by a variable mass and an elastic-plastic spring. A Runge-Kutta fourth order integration procedure will be used.  
 :for Professor R. V. Whitman, Asst. Prof. of Soil Mechanics  
 :by S. Sydney (Res. Asst. CMMC), 25 hours  
 :DCL: WWI, 102 minutes

The program has been tested and checked and is operating satisfactorily. In the past biweekly period three sets of production runs were made.

- 166 D. Construction and Testing of a Delta Wing Flutter Model is being effected by replacing the actual wing by a structurally equivalent lattice network. An iterative procedure involving the evaluation of a matrix equation has been evolved for determining the bending and torsional stiffnesses of the component members of the network.  
 :for M.M. Chen (DIC)  
 :by S. Gravitz (Res. Ass. Aero. Eng.), 50 hours  
 :DCL Staff: Porter, 5 hours; WWI, 29 minutes

The subroutine for matrix multiplication with the premultiplier a matrix of unknowns too large to fit entirely into high speed storage has been completed and satisfactorily tested.

A subroutine for storing the transpose of a matrix of unknowns has been completed and is in the process of being tested.

Work has begun on the process of integrating the necessary component subroutines into a coordinated program. This program will yield error corrections to estimates of bending and torsional stiffnesses of the component members of a lattice network simulating a delta wing and will iterate automatically until the corrections become negligible. A program which stores the first stiffness estimates and the given matrix of influence coefficients and uses the first estimates to form first trial matrices has been completed. Tests are being carried out to evaluate the success of this initial integration of several routines. This program is characterized by a relatively

large number of "START AT's", made necessary by the limitations of high speed storage; the preliminary results are stored on the magnetic drum as soon as they are obtained in order to make room for the next sequence of operations in high speed storage.

Future efforts will be directed toward the completion of the entire program and its eventual use.

167 D. Transient Effects In Distillation are being calculated by solving sets of simultaneous non-linear ordinary differential equations using numerical integration methods. Several of the most important types are being explored and results of specific cases will be correlated.  
 :for Professor E.R.Gilliland, Chemical Engineering Department  
 :by J.F.O'Donnell(Res. Assist. CMMC), 80 hours; Myers, 40 hours;  
 Polk, 40 hours; Smith, 40 hours  
 :DCL Staff: Kopley, .5 hour; WWI, 113 minutes

Three different problems are being studied. first, all for binary mixtures. These are: 1. take-off in batch distillation; 2. tuneup in batch distillation; 3. transients in continuous distillation. Results will be obtained giving product composition as a function of time for each of these cases.

A program has been written and tested for the case of take-off in batch distillation. The fourth-order Runge-Kutta routine from the S&EC Library of Subroutines was used as an integration method. One error, due to an erroneous arithmetic sign in the description of the subroutine, was detected and corrected.

Results have been obtained for several increment sizes.

Next, results will be obtained using a second-order Runge-Kutta method, to see if this will give satisfactory results.

Programs are also being written to do calculations of the other two types of transient effects listed above. These will be tested shortly.

172 B. Overlap Integrals of Molecular and Crystal Physics. Two-center overlap integrals are to be evaluated between various Slater atomic orbitals, which are of the form: (power of r) x (exp -ar) x (spherical harmonic). By use of prolate spheroidal coordinates, formulas in terms of simple functions can be derived for these integrals but are unsatisfactory because they are of formidable complexity and have false singularities. The integrals are evaluated by recasting the expressions in terms of spherical Bessel functions of imaginary argument, which can be generated by a high-speed computer.  
 :for Professor J.C.Slater, Physics Department  
 :by F. J. Corbató( Res. Asst, CMMC), 20 hours  
 :DCL: WWI, 38 minutes

The main subroutine has been typed but has not yet been converted correctly by CS II. Revised versions of the square root and exponential subroutines giving buffer-arithmetic accuracy have been written but also await CS II conversion before testing can proceed.

At the present time, several useful auxiliary routines are being written.

173. MIT Course 6.537 Spring Term 1954. Twelve students have enrolled in the Electrical Engineering course 6.537, entitled Digital Computer Applications Practice, being given by Professor C.W.Adams. The purpose of the course is to study the advanced preparation of coded programs for automatic, electronic digital computers, in particular, for Whirlwind I. This study will include techniques for handling storage and terminal equipment, detecting errors and mistakes in program, the control of scale factors, and the use of subroutines. Each student will program, prepare on punched tape, and execute on Whirlwind, one problem of his own choosing, making use of the CS II computer.

:DCL Staff: Combelic, 5 hours; Kopley, 1 hour, WWI, 31 minutes

Problem #173-108 is concerned with the solution of a matrix equation by the Crout Method and is being done as a partial fulfillment of the requirements of course 6.537. A test matrix has been tried in the program and has not as yet given correct results. Further study of the program will be carried out before the problem is again tried on the computer.

P.F.Marino

### 1.3 Operating Statistics

#### 1.31 Computer Time

The following indicates the distribution of WWI time allocated to the S&EC Group.

Programs	59 hours, 14 minutes
Conversion	16 hours, 22 minutes
Magnetic Drum Test	26 minutes
Magnetic Tape Test	19 minutes
Scope Calibration	33 minutes
Demonstrations (#131)	<u>0 minutes</u>
Total Time Used	76 hours, 54 minutes
Total Time Assigned	86 hours, 51 minutes
Usable Time, Percentage	88.4%
Number of Programs	261



1.32 Program Time Distribution

The following table attempts to show how the WWI time expended on S&EC programs was distributed with respect to machine runs that gave meaningful results (productive computer time) and runs that gave unsatisfactory results (lost computer time). Productive computer time is subdivided to indicate the time involved in actual computations as contrasted with the time expended getting information out of WWI. Computer time lost is subdivided to show the portion of time lost due to errors in the programmer's formulation of his problem (logical errors); due to errors in the programmer's use of the WWI code, CS Conventions, etc. (technical errors); due to tape preparation errors; due to errors by the S&EC computer operators in running the program; due to malfunctioning of terminal equipment; and finally, due to miscellaneous causes.

These times are determined as percentages of the time listed above in section 1.31 for programs. The times used in computing these figures are extracted from the biweekly report forms submitted by the various programmers who have used S&EC allocated WWI time.

1. Productive Computer Time	
. Computation	70.6%
Output	9.4%
2. Computer Time Lost Due to Programmer's Errors	
Technical	18.3%
Logical	.7%
3. Computer Time Lost Due to Other Difficulties	
Tape Preparation	.5%
Operators' Errors	.2%
Terminal Equipment Malfunction	0%
Miscellaneous	.3%

1.33 Tape Preparation

An attempt is being made to obtain some idea of the time expended in the preparation of tapes. During the past biweekly period a check was made on the tapes processed.

Due to the variations in procedures involved we have distinguished among original complete tapes and the following three types: typed modifications - changes of 11 or more registers which must be typed, converted and then attached to the main program, or changes which must be made in the body of a Flexowriter tape; manual modifications - changes punched directly in 556 form and attached to a converted tape; combined tapes - which require duplication of two or more complete tapes.

The following information was compiled:

	<u>Complete</u> <u>Tapes</u>	<u>Typed</u> <u>Mods</u>	<u>Manual</u> <u>Mods</u>	<u>Combined</u> <u>Tapes</u>
No. of Tapes	122	66	30	8
No. of Registers	28066	1497	139	
Time Consumed	72hrs.25min.	41hrs.13min.	3hrs.17min.	5hrs.34min.

Thus, it may be seen that the average length of an original complete tape is 230 registers requiring 35.6 minutes to prepare. A typed modification averages 22.7 registers in length and requires 37.5 minutes to prepare while Manual Modifications average 4.6 registers and require 6.6 minutes for preparation.

In addition to the time accounted for above, a total of 7 hours and 15 minutes was spent printing computer results for photographic reproduction.

## 2. ACADEMIC PROGRAM

### CS Programming Course

The CS Programming Course was completed on March 26. Many of the students have already begun programming problems for the machine, using Comprehensive System II.

The CS Programming Course will be given again during the first two weeks in May if there are enough qualified applicants.

### Seminar on Advanced Programming Techniques of the Digital Computer Laboratory Staff

On Friday, April 9, Professor C. W. Adams will talk on "Recent Developments in the Digital Computer Field Including Current Trends and New Computers". This seminar will take place at 3 PM in Room 10-275.

### Seminar on Computing Machine Methods

On Tuesday, April 20, Hrand Saxenian, staff member with Operations Research at MIT, will speak on "The Solution of Linear Programming Problems by the Simplex Method of Computation." The seminar is held at 4 PM in room 12-182.

### 3. COMPUTER ENGINEERING

#### 3.1 WWI System Operation

##### Core Memory (L.L.Holmes, A.J.Roberts)

The majority of the transfer-check alarms have been eliminated by the replacement of several tubes and crystals in the operation matrix. There still appears to be some intermittent trouble in the TPD counter panel. Scope post mortems have proved extremely valuable in tracing the cause of the alarms.

Several changes are in progress in clock-pulse control to improve circuit reliability. The major change is the replacement of the matrix driver 6V6 tubes with 6L6's. This will provide better cutoff of the CPC gate tubes.

The magnetic-tape system is now being maintained by the Systems group. Any questions about the system or any difficulties encountered should be referred to Larry Holmes, Al Roberts, or Al Perry.

##### Magnetic Tape (A.X.Perry)

The 2 reels of Audio-tape brown-oxide tape have been removed from service because of excessive wear of oxide surfaces and elongation. These have been replaced with 3-M green-oxide tape.

The toggle-switch "Unit 0 Rewind" on the console table will be replaced by a pushbutton to increase operating efficiency.

The remainder of panels necessary to complete the Unit 2 delayed print-out system will be ready by 6 April 1954; it is hoped that by the next biweekly it will be in operating condition.

A design change in the head circuits of the read-record switch and reading amplifiers is now being made in the 3 spare units. This change will bring the voltage level from 150 volts down to 0 volts, enabling the unit-selector amplifier to be eliminated from the system and decrease the insulation break-downs of read-record heads.

##### Flexowriter and Paper Tape (L.H.Norcott)

Two new FL Flexowriters have been delivered by the manufacturer. A third is scheduled for delivery shortly. One machine was equipped with a defective punch which has been returned to the manufacturer for replacement. Work of modifying these 2 FL machines for use at Whirlwind is now underway.

Gears on 2 of our short-carriage Flexos have been changed to drive the translator about 3 per cent faster than the readers. This change was made to eliminate timing troubles with these older machines.

#### 3.2 Terminal Equipment

##### Magnetic Drums (K.E.McVicar)

Reliability of both drum systems has been good during the past biweekly period. Some inconvenience to operators has occurred due to the work currently being carried on in the drum bays. The technicians making circuit and cabling changes must do this work during system operation, but every effort is being made to minimize interference with computer operation.

The bay wiring for the electronic write-group selection in the auxiliary drum is now being installed and the chassis are under construction by the production department. The temporary cables which connected the drum systems to test setups are being removed.

Work is in progress on the buffer-drum system on minor circuit changes which should improve the operating margins. The write pulse will be widened to increase the writing current. A new level setter for the enables is being designed, and work is in progress on a gated power supply for the writer plates which should eliminate our trouble with writing between the slots.

(H.L.Ziegler )

Final tie-in of the auxiliary-drum system for write-switching of heads requires the delivery of at least 15 new type-3 chassis. Present outlook is that these will not be available until late May when the necessary transformers are promised for delivery. In the meantime, wiring except for final tie-in will be completed, probably during the coming biweekly period.

The new monitor system for the magnetic drums and the PETR is complete except for final installation of the panel. This is planned for 29 March.

Addition of a parity digit to Groups 4-7 of the buffer drum has been worked out, and the necessary prints and wiring schedules drawn up. Work has already started on this job which should take several weeks to complete.

Ferranti Photoelectric Tape Reader (F.E.Irish)

The brake mechanism of the Ferranti PETR caused a reduction in tape speed by binding the friction-drive cylinder. Apparently, this resulted from the tightening of an adjusting screw that determines how far from the cylinder the brake shoe will normally rest. The entire brake-clutch mechanism of this reader has been removed to permit its complete overhaul. It has been replaced by a spare.

Lately, there have been a great number of program tapes which have failed to read in or have read in intermittently. Part of this trouble was caused by a layer of dust on the exciter lamp of the reader which lowered its intensity and reduced the signal amplitudes out of the reader, but the elimination of this source of trouble has not greatly improved the reliability of the read-ins. The remaining troubles seem to be caused by dirty tapes (chaf and dust) and by tapes that have been punched on a tape improperly inserted into the punch.

Output-Input Equipment (M.S.Demurjian)

The delayed equipment is temporarily connected to the new sound-proofing box. As soon as the transfer switches and cables are received and installed both units will be operable. A shelf or a slot will be installed to support the paper already printed on the Flexowriter.

A tape holder for use with the Ferranti readers is being designed. This will feature single-handed handling of the paper tape prior to insertion in the reader.

4. ADMINISTRATION AND PERSONNEL

Transfers (J.C.Proctor)

Edward P. Farnsworth has transferred from Division 6 to Division 4 of Lincoln.

Terminated Non-Staff (R.A.Osborne)

Lorraine Bruzzese

Arnold Klayman

Robert Zepperneck