Digital Computer Laboratory
Massachusetts Institute of Technology
Cambridge 39, Massachusetts

SUBJECT: BIWEEKLY REPORT, February 7, 1954

To: Jay W. Forrester

From: Scientific and Engineering Computation Group

1. MATHEMATICS, CODING, AND APPLICATION

1.1 Introduction

During the period covered by this report 279 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 on 26 of the problems that have been accepted by the S&EC Group. Progress on 19 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.

Two new problems were initiated during this period. John Little of the MIT Physics Department is studying the use of water in a hydro-electric system. The present analysis, which is the subject of Little's Ph.D. Thesis, differs basically from previous hydro computations made on WWI by considering river flow probabilities. Progress on this work is described below under problem #159. In problem #166, Dr. M. M. Chen and Mr. S. Gravitz of the MIT Aero-elastic and Structures Research Laboratory are carrying out the construction and testing of a delta-wing flutter model by means of a structurally equivalent lattice network.

Production runs have been completed in problem #138 for the tabulation of the coefficients of the expansion of spheroidal wave functions in associated Legendre functions. Arrangements are being made for the publication of these results.

The CS introductory programming course is being offered again (see #100).

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.

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+E 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, 56.5 hours; Best, 39.5 hours; Denman, 33 hours; Demurjian, 48 hours; Frankovich, 20 hours; Helwig, 57 hours; Kopley, 24.5 hours; Porter, 3 hours; Siegel, 4 hours; WWI, 386 minutes

A tentative input program for use after March 15 has been written and is being tested. The following kinds of paper tape will be identified by means of their initial characters and automatically read in by the program:
1) CS Flexo tapes
2) SS Flexo tapes
3) Basic Flexo tapes
4) Post-Mortem request tapes
5) CS binary tapes
6) Basic binary tapes (present 556 tape)
The programs required for the reading in of these tapes will be stored on magnetic tape unit 0 and will be read into magnetic core memory (MCM) by the read-in program.

Several manual modes will also be provided which will require the setting up of information in an insertion register. These modes will include:
1) automatic read-in of paper tapes on the mechanical reader;
2) recording a stop character on unit 3;
3) examining a selected register on the drum and displaying its contents in the indicator register;
4) selecting a given utility program on unit 0 and reading it into MCM.

The utility programs available on unit 0 will include:
1) a scope calibration program
2) a drum testing program
3) a magnetic tape testing program
4) a Ferranti reader test program
5) several system's group test programs

In certain cases the programs on unit 0 will be read directly onto the

drum and then into MCM. On subsequent requests for these programs they will be brought directly from the drum into MCM provided they have not been altered by the computer.

Helwig

A check has been built into CS II to check for the use of more than 255 flads by programmers in a given program. Work has begun on the drum addressing scheme. The main features of the system were decided upon in discussions with other members of the S&EC Group.

Frankovich

Memorandum M-2661 has been written giving the operation times for all the WWI instructions except bo and bi.

Denman

The dispatcher for the drum post-mortem has been tested and seems to be correct.

The read-in and conversion programs for PM request tapes are being written and tested.

Arden

A memo will soon be written describing the standard Ferranti test tape loop now in use.

Between now and March 15, an extensive series of tests will be made on CS II and the automatic post-mortem program.

Best

The new entry blocks for CS II automatic output were rewritten so that requests of more than one output medium will use the shortest possible total number of registers. In this manner the duplication of similar operations is kept at a minimum.

Work is still being done on the floating point cases with and without scale factor to produce the rounded-off result as accurately as possible.

The CS I was recorded on the new Mylar tape now on magnetic tape unit 0.

Demurjian

Scope output routines are being written for CS II. These programs are being written for use with the character generator.

The CS introductory programming course is being given during the period February 1-12. Of the sixteen students who are attending the lectures, ten are working on problems that have already been accepted for solution by the S&EC Group. These students represent the following departments: Laboratory for Nuclear Science and Engineering; Groups 21, 35, 37, and 61 of Lincoln Laboratory; Solid State and Molecular Theory Group; Aero-elastic and Structures Research Laboratory; Geophysics Department; and the Department of Meteorology

Kopley

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), J. Richmond, 30 hours
:DCL Staff: Denman, 1 hour; WWI, 57 minutes

A program was written and run successfully using an approximate equation to relate the conductivity of a metal film to the infrared reflection and transmission by a simple quadratic equation without having to resort to the long, rigorous equation and program. It was discovered that infrared reflection and transmission of thin films depend on the film conductivity but are practically independent of the dielectric constants of the films, so that optical measurements with infrared radiation cannot give an accurate determination of the dielectric constant.

The quadratic equation for the conductivity was of the form:

$$px^2 + qx = r, \text{ where } 4pr << q^2$$

which has the solutions

$$x = \frac{-q + \sqrt{q^2 + 4pr}}{2p} \quad \text{and} \quad x = \frac{-q - \sqrt{q^2 + 4pr}}{2p}$$

Of these the first gives $x \approx -\frac{q}{p}$ since $4pr << q^2$. For the second solution the difference between two approximately equal terms has to be computed; to avoid loss in accuracy the following transformation is made:

$$x = \frac{q^2 - q^2 - 4pr}{2p\left[-q - \sqrt{q^2+4pr}\right]} = \frac{2r}{q + \sqrt{q^2+4pr}}$$

Since this expression does not contain the difference between two large quantities, it is preferable for use in computation.

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, 18 hours; Simpson, 15 hours; Walsh, 15 hours
: DCL: WWI, 315 minutes

During the past two weeks the group has completed a checking procedure for verifying the preparation and conversion of its numerous data tapes. Various errors were detected and they have been corrected.

Computations involving the reduction of 4 seismic records by 50 linear operators were accomplished in this period; these computations are now being examined. Revisions in procedure for obtaining frequency spectra are being programmed and a matrix program is being altered.

107 C. (a) Autocorrelation and (b) Fourier Transform, Integral Evaluation. Programs were developed for these operations for the purpose of obtaining power spectra. The problem remains open for people who want to use these programs.
:for J.E. Ward, Project Engineer, Servomechanisms Laboratory
:by D.T. Ross (DIC), 1 hour; Hamilton, 40 hours; Tankin, 4 hours
:DCL: WWI, 69 minutes

During the last four weeks, velocity fluctuations of turbulence studies have been correlated using the autocorrelation program of Problem 107 modified for 300t shifts instead of 100.

There have been difficulties with data preparation, minor program errors, and scale factoring. The program has been modified to subtract an estimated mean from the data, and the scale factor may be changed by a 556 hand modification.

113 C. 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 of 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 Engineering
:by S. Sydney (Res. Assist. CMMC), 40 hours
:DCL Staff: Kopley, 1.5 hours; WWI, 113 minutes

An output program has been prepared which gives the results in a more readily usable form.

One production run was made during the last biweekly period.

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, 88 minutes

Work has been resumed on the case which it is thought will lead to a shock. The convergence of the characteristics has caused some numerical difficulty. The programming of a new numerical process to compensate for this and its incorporation into the old program is now in process.

123 C. Earth Resistivity measurements are used to calculate the Slichter kernel function which, in special cases, can be analyzed to give the actual distribution of resistivity. The method involves least-square fitting a set of polynomials to the measured surface-potential function and integrating the product of this set and the zero-order Bessel function.
:for P.M. Hurley, Department of Geology and Geophysics, DIC 5-6915
:by K. Vozoff (Res. Assist. CMMC),4 hours;Madden, 2 hours
:DCL: WWI, 37 minutes

The time used has been spent in continuing the troubleshooting of the Slichter Kernel integration. The first part of the program, which fits Legendre polynomials to a surface potential curve, is working properly. However, from the magnitude of the fifth-order coefficient it appears that more than six terms should be used. The second part of the program carries through the actual integration of the Slichter Kernel by means of the trapezoidal rule. This part of the program is now being tested.

131. The Training of New Personnel, Tours and Demonstrations are among those activities included in this problem. Generally speaking, any approved staff problem relating to training and/or demonstrations is considered to be in this category.
:DCL Staff: Kopley, 3 hours; WWI, 30 minutes

Nine M.I.T. and three Los Alamos people were conducted on a tour of WWI on Tuesday, February 2. The tour included demonstrations on the computer and the Flexowriter equipment and a description of the major computer components.

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, Servomechanisms Laboratory, DIC Project 6873
:by J.H. Runyon (E.E. Res. Assist.),30 hours
:DCL: WWI, 37 minutes

A subroutine for finding the first and second derivatives of the series 16 airfoil cross-section was successfully tested. This completes the set of subroutines for this airfoil. Milling machine tapes for several series 16 templates are to be prepared. Also successfully tested was a routine for selecting cut lengths along plane curves so as to give a constant arc to chord distance.

Four new subroutines have been written. Among these are subroutines for the spacing of cuts on surfaces and for finding tool center off-sets for cones.

134 C. Numerical Diagonalization Procedure. This program computes the eigenvalues and eigenvectors of a symmetric matrix by a method of successive rotations. The program is available for use in any problem in which this calculation is required.
:for Professor J.C. Slater, Physics Department
:by A. Meckler (DIC), 2 hours
:DCL: WWI, 43 minutes

Both modifications of the diagonalization routine now work. The Library of Subroutines form is described in the files under the designation of LSR MA4 and the complete version (input and output instructions plus the basic subroutine) is now in final form. Two further matrices of Dr. Koster have been diagonalized.

138 B. Spheroidal Wave Functions are solutions of the scalar Helmholtz equation separated in spheroidal coordinates. A program has been developed for tabulating both the coefficients obtained by expanding the angular solutions of the first kind in associated Legendre functions and the coefficients obtained by expanding the radial solutions of the first kind in spherical Bessel functions. By analytically substituting these expansions in the separated ordinary differential equations, 3-term recursion relations are obtained for the coefficients, and the radial and angular coefficients are found to be simply related. Both sets of coefficients are then determined by applying an iterative procedure to a continued fraction equation derived from one of the 3-term recursion relations. The iteration proceeds until a value of the unknown separation constant of the differential equation which appears in the continued fraction is found such that it makes the coefficients compatible with their boundary conditions.
:for Professor P.M. Morse, Physics Department
:by F.J. Corbató (Res Assist. CMMC), J.D.C.Little(Res.Ass. Op.Res.)
:DCL: WWI, 212 minutes

The 90 production runs have been completed. However, since the results are on punched tapes and since only a few of these have been printed out, some punch or magnetic tape errors may show up from time to time and require reruns.

140. Summer Session System consists of a conversion program, an interpretive routine, and mistake diagnostic routines stored in WWI. A special mnemonic instruction code has been developed for use with this system thus simulating a computer with characteristics quite different from those of WWI. This Summer Session (SS) computer was developed for the use of students participating in the MIT 1953 summer session course on Digital Computers and Their Applications. The SS computer is being used by the E.E. Department courses 6.535 and 6.25 and is available to programmers with suitable problems.
:DCL Staff: Best, 22 hours; Siegel, 45 hours; WWI, 230 minutes

The second and third passes of the SS conversion program are being studied to determine the sources of error when this program is used in conjunction with the new conversion post-mortem. As a result of these studies, several mistakes in the conversion program have been corrected.

It appears feasible to combine the SS PA, which is now stored on groups 6 and 8 of the auxiliary magnetic drum, into one drum group. This will obviate the need for changes of drum group in reading in the PA routines during the execution of an SS program and will appreciably shorten the time required for the typical SS program.

A portion of the paper tape containing the SS routines has been optimized using the program described under Problem 100 in the preceding biweekly report.

The time of operations has been determined for about half of the SS instructions.

143 D. The Vibrational Frequency Spectrum of a Copper Crystal is to be determined by solving a 3 x 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.), 10 hours
:DCL: WWI, 42 minutes

The complete program is now being assembled and tested. This program is (24,6) and will later be changed to (15,15) to see if enough accuracy remains to allow the eventual programming of a (15,0) high-speed routine. It is thought that this latter step will be necessary in order to obtain a fine enough sampling mesh without using undue computer time.

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), 50 hours
:DCL: WWI, 1193 minutes

Production work has proceeded at a rate greatly exceeding expectation. The work has been completed using two of the three potentials required to describe the energy band structure of copper, and work on the third is nearing completion. As an indication of the size of the computation, it may be mentioned that over 2000 separate numerical integrations of the second-order differential equation have been carried out, and some 4000 zeros of the weighted sum of these functions have been computed. The numbers of parameters involved have been kept to a minimum. Nevertheless, such a large number of results leaves some difficulty

in interpolating an accurate dependence of energy on the wave vector.

A start has been made on programming the last section of the problem. This is a secular equation problem, requiring the computation of matrix elements between the "augmented plane waves" determined by the previous computations. These elements, with many special cases to take into consideration, are weighted sums of the functions $\frac{d}{dr} \ln \left(\frac{P_\ell(r)}{r} \right)$ and $\int_0^R P_\ell^2(r)\, dr$

P_ℓ being the Radial Wave Function. A program to calculate the first of these exists in the previous routine; a program to evaluate the integral using Simpson's rule has been written and successfully tested. The calculation of the matrix elements has also been written and partially tested.

Finally, the solution of the resulting secular equation is being tested. This results from a non-zero solution of the equation

$$\sum_{\nu=1}^{n} (H_{\mu\nu} - \Delta_{\mu\nu} E_j) X_{\nu j} = 0$$

$\underline{H}$, $\underline{\Delta}$ being the real symmetric matrices computed as above. $\underline{\Delta}$ is not diagonal, so a program has been designed to reduce the equation to a form where the overlap matrix is diagonal; Dr. Meckler's secular equation subroutine is then used to determine the eigenvalues. A transformation due to Löwdin is used; writing $\underline{X} = \underline{\Delta}^{-\frac{1}{2}} \underline{C}$, we find the equations may be written as $\underline{H'C} = \underline{C}\, \underline{E}$, where $\underline{H'} = \underline{\Delta}^{-\frac{1}{2}} \underline{H} \underline{\Delta}^{-\frac{1}{2}}$ and this gives the familiar form of the secular equation. $\underline{\Delta}^{-\frac{1}{2}}$ is computed by diagonalizing $\underline{\Delta}$ to produce $\underline{\Delta}_d$, forming $\underline{\Delta}_d^{-\frac{1}{2}}$, and forming $\underline{\Delta}^{-\frac{1}{2}}$ by a unitary transformation. H' is then computed by matrix multiplication. When completed, this program will deal with real symmetric matrices of order up to 30, and will form a production routine for the solution of general secular equations involving non-diagonal overlap matrices.

152 D. Diffusion in an Oxide-Coated Cathode is a program to calculate the effects of combined thermal and electrolytic diffusion that occur in an oxide-coated cathode when current is caused to flow through the cathode.
:for W.B. Nottingham, Physics Department, DIC No. 6345
:by H.B. Frost (Res. Assist. E.E. Dept.), 4 hours
:DCL: WWI, 214 minutes

After one of the runs reported in the biweekly report for 24 January 1954 had been extended far enough so that the results could be compared with the known steady-state values, the results were critically analyzed. The δ used was the largest thus far run. An errorof about 1.5% was found in the value of the integral which corresponds to the coating resistance. This error originated from two causes: truncation error in the integration (trapezoidal rule, not cumulative) and truncation error in the step-by-step solution of the differential equation. Program modifications were made to use Simpson's rule integration and to correct the truncation error in the solution periodically. A re-run showed the error to be about 0.4%, almost entirely due to the truncation error of Simpson's rule.

156 A. The Evaluation of the Reflection Coefficient in a Semi-Infinite Open Rectangular Wave Guide is obtained approximately by using Fourier transform techniques on the integral equations of the Wiener-Hopf type. The integrals are to be evaluated by the trapezoidal rule.
:for Dr. M. Balser, Lincoln Laboratory, DDL
:by A. Balser (Res. Assist., Columbia University)

Three runs were carried out to obtain further values for the range $\pi^2 < \alpha < 100$. These additional values were needed since the variation in successive values obtained in the initial run was too great for suitable interpolation.

The evaluation of the integral corresponding to $\alpha > 100$ was programmed and successfully run.

Programming was also completed for the range $0 < \alpha < \pi^2$. Because the integrals are complex-valued over this range, the calculation is far more involved. A short test run was made and the results were checked against some desk-calculated results. Discrepancies were discovered in the second place. An analysis is being carried out to determine whether the error is in the program or in the check results.

Programming has been begun on the final section of the problem for $\alpha < 100$.

159 B. Water Use in a Hydroelectric System. The big storage reservoirs of a hydro system are used to store water during high flows for use during low flows. The exact amount to use or save at any given time depends on the amount of water in the reservoirs, the probability distribution of future river flows, the anticipated demand for power, and the cost of obtaining power from other sources. The problem is solved by calculating certain expected value functions and finding their minima. The program is fairly general, but specific examples are drawn from the Columbia River system.
:for J. D. C. Little (Res. Ass. Op. Res.),
:by J. D. C. Little, 100 hours
:DCL: WWI, 61 minutes

The operation of a hydroelectric system is made complicated by uncertainties in future stream flow. This is particularly true of systems containing large amounts of water storage, for then, considerable control can sensibly be exercised over the power generation. In particular, if high spring flows are anticipated, water may be drawn out of storage and used during the winter so that the spring floods will not spill and be wasted. In fact, if winter flows are naturally low it may be imperative to use storage. Such a situation exists today on the Columbia River system in the Pacific Northwest.

If storage water is used too soon, all subsequent stream flow is used at lower head and so gives less power. There is also danger of running out of water before spring comes. On the other hand, if the storage water is not used early enough, the high spring flows arrive to satiate all power demands when there is still water left in the reservoir. This water, no longer needed, represents waste. It is clear that best storage water use involves a balance between the dangers of too early and too late use and that it is intimately tied up with stream flow probabilities.

Consider a one dam system. Suppose its performance may be characterized by a cost, for instance, the cost of generating energy by steam to make up any

hydro deficiency. The task becomes that of picking that water use which minimizes the expected cost of operating the system.

Let:

i = index of time intervals
v_i = volume of water in the reservoir
F_i = stream flow
S_i = amount of water to be drawn from storage
E_i = expected value of cost for the rest of the year
C_i = cost in the ith interval
$f(F_i|F_{i-1})$ = conditional probability density of flow

$$E_i(F_{i-1},v_i,S_i) = \int_0^\infty \left\{C_i(F_i,v_i,S_i)+E_{i+1}(F_i,v_{i+1})\right\} f(F_i \mid F_{i-1})dF_i$$

where $v_{i+1} = v_{i+1}(F_i,v_i,S_i)$

The condition that the expected cost for the rest of the year is to be a minimum determines $S_i(v_i,F_{i-1})$, the amount of storage water to be used in the ith interval as a function of the prevailing head and previous flow.

The calculational procedure is to compute the integral by the trapezoidal rule and, by comparing the results for different S_i, pick that which makes the integral smallest. The integrand is formed by polynomial evaluation and table look-up.

So far, a simple special case has been programmed. The results are being checked by hand computation.

160 C. Similarity Transformation of a Matrix desires to develop a routine to perform a similarity transformation of a square matrix; symbolically, to find UAU^t where A is an n x n matrix, U is m x n, and U^t is the transpose of U. The input consists of U and A and the output is UAU^t displayed on the scope.

:for Dr. A. Meckler (DDL) Physics Dept.
:by Dr. A. Meckler, 1 hour
:DCL: WWI, 30 minutes

The program has now been satisfactorily completed. It has been used to perform the similarity transformations required by Dr. R. McWeeny and described in the previous biweekly report. The problem will be kept open for the use of other members of the Solid State and Molecular Theory Group.

166 C. 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. Asst. Aero Eng.), 25 hours
:DCL Staff: Porter, 9 hours; WWI, 16 minutes

To solve the problem of designing, constructing, and testing a delta flutter model which simulates a given set of influence coefficients, the actual wing is replaced by a structurally equivalent lattice network, and the task becomes one of determining the bending and torsional stiffnesses of the component members. Using procedures involving the elastic strain energy of the system, the iteration procedure is evolved for obtaining the desired stiffnesses by successive error corrections which converge to zero. The portion of the problem to be solved by WWI centers around the evaluation of the matrix equation:

$$\Delta C_{mn} = \Delta\alpha_{mn} - \Delta\alpha_{ms}\beta_{sn} - \left[\Delta\alpha_{ms}\beta_{sn}\right]' + \beta_{mr}\Delta\alpha_{rs}\beta_{sn}$$

To this end, the following basic numerical procedures are to be repeated until the error corrections become negligible:

1. $\beta_{sn} = \alpha_{rs}^{-1}\alpha'_{ms}$
2. $\alpha_{ms}\alpha_{rs}^{-1}\alpha'_{ms}$
3. $C_{mn} = \alpha_{mn} - \alpha_{ms}\alpha_{rs}^{-1}\alpha'_{ms}$
4. $\Delta C = K\Delta\alpha$

The initial step has been the formulation of a versatile subroutine which is applicable to the solution of the following problems:

1. $[D] = [A]^{-1}[E]$
2. $[D_1] = [A]^{-1}$
3. $\{X\} = [A]^{-1}\{B\}$

Generalizing the procedures developed by Crout, the latter two problems can be solved as special cases of the first. The auxiliary matrix is first obtained:

For an element in the j^{th} column:

$$b_{ij} = a_{ij} - \sum_{k=1}^{(j-1)} b_{ik}b_{kj}$$

For an element in the j^{th} row:

$$b_{ji} = \left[a_{ji} - \sum_{k=1}^{(j-1)} b_{jk}b_{ki}\right]\frac{1}{b_{jj}}$$

From this, the transpose of the final matrix is obtained:

$$d_{ij} = b_{(J_A+1-j),(J_A+1)} - \sum_{k=1}^{(j-1)} b_{(J_A+1-j),(J_A+1-k)}\, d_{ik}$$

where the total number of rows and columns involved are:

$$I = I_A = I_E \qquad J = J_A + J_E$$

The subroutine has been tested and is satisfactorily completed.

1.3 Operating Statistics

1.31 Computer Time

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

Programs	55 hours, 09 minutes
Conversion	16 hours, 48 minutes
Magnetic Drum Test	29 minutes
Magnetic Tape Test	36 minutes
Scope Calibration	1 hour , 18 minutes
Demonstrations (131)	30 minutes
Total Time Used	74 hours, 50 minutes
Total Time Assigned	77 hours, 03 minutes
Usable Time, Percentage	97.1%
Number of Programs	297

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 70.5%
   - Output 16.4%
2. Computer Time Lost Due to Programmers Errors
   - Technical 4.9%
   - Logical 1.8%

3. Computer Time Lost Due to Other Difficulties

Tape Preparation	1.5%
Operator's Errors	1.7%
Terminal Equipment Malfunction	1.3%
Miscellaneous	1.9%

1.33 Tape Preparation (M. Mackey)

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, 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:

	Complete Tapes	Typed Mods	Manual Mods	Combined Tapes
No. of Tapes	136	52	31	12
No. of Registers	19032	1687	192	
Time Consumed	70 hrs.0 min.	13 hrs.31 min.	2 hrs.32 min.	7 hrs.02 min.

Thus, it may be seen that the average length of an original complete tape is 140.5 registers requiring 30.8 minutes to prepare. A typed modification averages 32.4 registers in length and requires 26.9 minutes to prepare while Manual Modifications average 6.2 registers and require 10.7 minutes for preparation.

2. COMPUTER ENGINEERING

2.1 WWI Systems Operation

(S. E. Desjardins)

The consolidated test program has been tested and now functions properly. It now contains 7 test programs that are program marginal checked daily. Steps are being taken to record this program (T-3432) on the magnetic tape unit 0.

(D. A. Morrison)

The Voltage Interlock Panel is now being assembled.
Work has begun on additional material for the WWI Service Manual.

2.11 Core Memory N. L. Daggett

A number of Core Memory parity alarms have occurred recently because of trouble in the digit-plane drivers. These units were modified recently to remove capacitors which were operated at over twice rated voltage. It appears that minor movement of leads made at this time aggravated the tendency of the circuit to oscillate. Any of several possible lead-length reductions will stop the oscillations. All of these changes will be made.

(L. L. Holmes, A. J. Roberts)

A shield-to-cathode short in a memory-address-register cathode follower destroyed 8 crystals in the Core-Memory matrix. The shields have now been returned to near-cathode potential, and fuse panels have been installed at the outputs of the cathode followers.

A recent modification of the digit-plane drivers resulted in oscillations in these units. This has been remedied by shortening lead lengths and adding a parasitic suppressor.

Digits 0-11 of the parity register are now d-c coupled.

There will be a complete power shutdown over the weekend of 20 February to provide installation and maintenance time for the power shutdown.

2.12 Magnetic Tape E. P. Farnsworth

Power wiring changes affecting MTC have resulted in an unstable condition in the reel-tension servo of several units when the d-c rack power is shut off and a-c power remains on. The instability is apparently caused by operation of the servo alerting relays; corrective measures are being investigated.

New mylar tapes on spare reels have been distributed to the groups using magnetic-tape facilities. These groups have also been supplied with containers fitted out by the shop to protect the magnetic tape and reels from damage, dust, and loss or misplacement.

A new reel of mylar tape for unit 0 is being passed around for recording permanent storage programs to replace the old tape and to reallocate footage. Part of the old reel was recently damaged when the tape was allowed to come off some of the idlers during warmup, but the tape is still readable, even where the mylar is severely stretched.

Snap-on mountings for the original slack take-up covers are being installed on all tape mechanisms. These covers will prevent the tape from slipping off at least some of the idlers when the tension is off and will also simplify threading tape on the machines. The snap-on mounting will alleviate the maintenance problem which was the reason for the removal of the covers.

2.13 Auxiliary-Drum System (K. E. McVicar)

Work is progressing satisfactorily on the power-supply-control-system changes for the auxiliary drum, which should eliminate the bulk of our trouble with writing between the slots. Operation during the past biweekly period has been good except for a few occasions when we have had parity alarms attributed to spurious writing.

The problem of write-group selection has been outlined in a memo which includes some suggestions for improving this function. The memo has been circulated to interested parties for comments, and further work awaits their reply.

2.14 Flexowriters and Paper Tape (L. H. Norcott)

Metal deflector plates have been mounted above the die blocks of our FL punches to cure chad-disposal problems that arose when we started to use our present blue tape.

Three new Flexowriters are scheduled for delivery to us in March. Parts necessary to modify them for our use have been ordered from Commercial Controls and from our shops.

3. ADMINISTRATION AND PERSONNEL

New Non-Staff

Elizabeth Welch is a new messenger girl at the Barta Building. Constantine Rhodes is a new technician in the Systems Group.

Terminated Non-Staff

Philip Chandler
Mary Toner
Delight Nease