Digital Computer Laboratory
Massachusetts Institute of Technology
Cambridge 39, Massachusetts

SUBJECT: BIWEEKLY REPORT, MARCH 7, 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 300 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 26 of the problems that have been accepted by the S&EC Group. Progress on 17 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. Problem #161 will study the response of a mass-plastic spring system (e.g., a structure resting on a soil foundation) to transient loading. This study will be carried out by S. Sydney of the MIT Civil Engineering Department under the supervision of Assistant Professor R. V. Whitman. In problem #168, N.P.Hobbs of the MIT Aeronautical Engineering Department is analyzing the downwash behind a two-dimensional wing in response to a sharp-edged gust. Details on these problems will be found below.

The interpretive program developed under problem #108 (and described in Instrumentation Laboratory Engineering Memorandum E-364) has been used in two problems of varying complexity. In both cases successful runs were obtained by relatively inexperienced programmers.

A complete set of solutions has been obtained in problem #153 for the maximum acceleration of a flexible swept-wing airplane in response to a gust. An Air Force Technical Report is being prepared to describe the problem.

It is hoped to have most of the revised Comprehensive System of Service Routines (CS II) tested and in operation by 15 March. The planned revisions have been described under problem #100 in previous biweekly reports - more complete descriptions will be made available as soon as possible.

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&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, 65.5 hours; Best, 52.5 hours; Combelic, 48.5 hours; Demurjian, 24.5 hours; Denman, 68 hours; Frankovich, 40 hours; Helwig, 50 hours; Kopley, 20.5 hours; Porter, 13 hours; Siegel, 26 hours; WWI, 1257 minutes

Intensive testing is being carried out on CS II. Most of the revisions involved have been described in previous biweekly reports. A more complete description of CS II will be incorporated as soon as possible in the CS Manual.

It is hoped to have most of the testing completed by 15 March. In particular the provisions for automatic logging of programs have been tested and are satisfactory.

Staff

M-2715, to be published in the next biweekly period, will describe the Ferranti reader from the programmer's point of view.

The systems group's Consolidated Test Program and several other terminal equipment testing programs have been optimized and prepared for storing on Magnetic Tape Unit 0.

Best

M-1624-2, "A Short Guide to Coding and Whirlwind I Operation Code", and the "Interpreted Instruction Code of the MIT CS II Computer" are now available.

Kopley

A routine for converting generalized decimal numbers has been written for the new post-mortem programs. It converts (30,15) numbers to their decimal equivalents. The routine has been tested and is working satisfactorily.

M-2269-1 (revised version of Use of the Magnetic Tape and Output Equipment, with added index) is now available.

Denman

Various tests were made on CS I to find the best type of numerical output to give in CS II in cases where no digits to the left are requested. At present, when the number in the MRA is less than one-tenth, a zero is automatically placed at the left of the point whether requested or not.

For regularity in print-out it was agreed that in CS II a programmer will get nothing to the left of the point if nothing is requested.

Demurjian

The revised section of CS for processing programmer's requests for use of terminal equipment has been written and tested successfully. Two more tests will be made before including the program in CS II.

Porter

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), 18 hours; Richmond, 30 hours
:DCL: WWI, 17 minutes

From the results and alarms obtained when data from measurements in the visible and in the infrared were run on WWI, the following broad generalizations can be made.

A. For the visible data, rough first estimates of optical constants are usually available and the iterative method using partial derivatives of the optical constants with respect to reflection and transmission is used to find the true constants.

B. For the infrared, first estimates are rarely available, and the iterative method is usually not feasible because the derivatives are enormous. However, in the infrared, good approximate equations for n and k in terms of R and T are available. These have been programmed for WWI, and partly tested. The "Main Program", which calculates R(n,k) and T(n,k), is then used to check the accuracy of the approximate equation.

Physically it appears that in the infrared the conductivity per square of film is the property determining the reflection and transmission.

R and T are no longer strongly dependent on n, k, or dielectric constant when the films are very thin; this is shown by the enormous partial derivatives of optical constants with respect to reflection and transmission. Therefore, the approximate equations derived from the infrared first determine the conductivity per square and use the theoretical constants only incidentally. In theory there could be developed for the infrared an iterative procedure that is based principally on the conductivity rather than on the optical constants, but in practice the approximate equations actually serve the same purpose.

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, 25 hours; Walsh, 20 hours
:DCL: WWI, 363 minutes

During the past two weeks the group has been filling in with computations on linear operators and spectra which were needed in special studies. In addition, certain anomalous results have been traced to taping errors which are being corrected and rerun. We have also experienced some difficulty with read-in possibly due to inexact hole alignment on tapes.

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) 10 hours; Zierler, 25 hours; Block, 10 hours; Battin, 1.5 hours
:DCL: WWI, 211 minutes

Nine runs were made during this period; four tested the interpretive program and the remaining were problems using this program.

On the problem for M. M. Sullivan (see last biweekly) three runs were made with a shorter time increment. One run was unsuccessful due to an operator's error; the second run gave results that were only partially correct because of a programmer's error; the last run gave 100% useful data.

Laning

Four runs were made to test the interpretive program itself. Several errors were eliminated from function routines $F^{13}$ through $F^{20}$. It is believed that no further errors are present although a final test has not yet been made. The automatic restart routine was rewritten and a modification was made to make use of PETR rather than MTR. Testing of these modifications is now in progress.

Zierler and Block

The interpretive program of Laning and Zierler was used successfully to study the effects of variable viscosity and heat conduction on the boundary layer over a wedge. The original boundary value problem was first solved on REAC to obtain appropriate initial conditions. Whirlwind I was then used to check these values and obtain solutions for various vertex angles. The programmer involved in setting up this problem for WWI had had no previous experience with the interpretive program developed under this problem. The problem ran correctly the first time but the solution became unstable due to too large an interval in the integration procedure. Technically, the problem consisted of solving six simultaneous non-linear differential equations together with some complicated algebraic relationships.

Battin

109 C. <u>An Airplane Pursuit-Course Program</u> is being developed which will take account of airplane dynamics and projectile ballistics and thus determine an airplane pursuit course in three dimensions. The problem consists essentially of solving 14 simultaneous non-linear differential equations by the Runge-Kutta Method which is of fourth-order accuracy.
:for Mr. J. B. Feldman, Instrumentation Laboratory
:by M. H. Hellman (DIC), 20 hours
:DCL: WWI, 115 minutes

The horizontal pursuit course program has been modified to compute and tabulate eight additional quantities. These are prediction times for a two-gyro gunsight and a three-gyro gunsight. A test problem has been run with satisfactory results. A total of 17 quantities are tabulated with this modified program.

The three-dimensional pursuit course program has been modified to compute and tabulate 16 additional quantities. These are two-gyro gunsight prediction times, three-gyro gunsight prediction times, and correction time ratios for the latter. Errors from this program are being eliminated at present. A total of 30 quantities are tabulated with this modified program.

A comparison will be made of a gunsight calibration using the horizontal pursuit course program and a gunsight calibration using the three-dimensional pursuit course program with comparable initial conditions.

Upon the completion of the above program it is planned to make a number of three-dimensional pursuit course runs with the airplane and target initially in a slant plane. From the results of these runs it will be possible to evaluate the errors in the calibration of existing gunsights.

113 C. <u>A Stress Analysis of an L-shaped Homogeneous Planar Structure</u> 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 Eng.
:by S. Sydney(Res. Assist. CMMC), 50 hours
:DCL: WWI, 213 minutes

A simplified program for the problem was prepared in order to obtain an initial set of conditions for the main program. The relaxation procedure converges to a satisfactory solution quite slowly, but by choosing a better set of initial conditions the convergence can be increased considerably.

An initial set of conditions has been calculated for one loading condition and will be inserted into the main 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, 72 minutes

A logical error in the new numerical procedure has been corrected. It should now be possible to obtain useful results in future runs.

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.), 35 hours
:DCL:, WWI, 18 minutes

Successful tests were carried out and Library-type subroutines for the computation of tool center offsets for cones and for obtaining the correct sequence of cuts on a cone.

The writing of a subroutine to facilitate the use of interpolation subroutines was completed. This subroutine selects a suitable group of points to be used in the interpolation formula from a larger group of given points when a particular value of the independent variable is specified.

Error diagnosis of a routine for the determination of cut spacing for constant scallop height is continuing.

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 6.537 and 6.25 and is available to programmers with suitable problems.
:DCL Staff: Best, 7 hours; Combelic, 3 hours; Siegel, 35 hours; WWI, 60 minutes

The version of the SS computer program for recording on Magnetic Tape Unit 0 has been completed, optimized, and tested. Preliminary tests with the new input program were satisfactory.

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.), 15 hours
:DCL: WWI, 133 minutes

The completed program has been assembled and run for 95 solutions. The mesh will be made finer so that approximately 6,000 solutions will be obtainable. This fine a mesh should give a sufficiently accurate sampling of the frequency spectrum. The atomic parameters will be varied so as to ascertain their effect upon the spectrum.

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), 60 hours
:DCL: WWI, 176 minutes

The elimination of errors in the last part of the program has proceeded slowly. A routine to solve secular equations of order up to 30 x 30, involving non-diagonal overlap matrices, has been tested and now exists in a production form, suitable for use by other members of the Solid State and Molecular Theory Group.

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(E.E. Res. Assist.), 4 hours
:DCL Staff: Denman, 2 hours; WWI, 272 minutes

During the past period a series of five parameters of the variable-current problem has been run successfully. The correspondence of the apparent limits of the transient solutions with known analytic results indicates that the logical formulation of the problem is satisfactory. These results essentially complete this problem. However, it is possible that two more parameters may be run when the analysis of the above results is completed.

153 C. Gust Response of a Flexible Swept-Wing Airplane is to be determined for various values of wing loading functions, aircraft configuration and dynamic condition parameters, as input data, giving dynamic output data determining the effect of wing flexibility on gust response. The solution involves the calculation of forcing functions and the evaluation of Duhamel integrals by numerical methods. Approximately 120 pairs of linear integro-differential equations are to be solved.

:for Professor T. H. H. Pian, Aeronautical Engineering Department
DIC No. 6691
:by K. Foss(DIC), 20 hours; Sternlight, 20 hours
:DCL Staff: Denman, 1 hour; WWI, 152 minutes

Twenty-eight sets of integro-differential equations have been solved for the maximum acceleration variable. The program for this purpose will be a permanent Aeroelastics and Structures Research Lab program. A run has been made giving three complete time-histories of the wing acceleration for three parameter-sets. The results are now being checked against expected physical reality.

A complete description of the programs for producing the special functions necessary for solving the equations and for effecting the actual solution, together with a description of methods for their use is being written for the next Whirlwind Summary Report. The results of the equation solutions, their interpretation, and the mathematical and physical background for this problem will appear as Air Force Technical Report No. 6358 Part XIX - "Effect of Structural Flexibility on Aircraft Loading"(Wright Air Development Center).

155 B. Synoptic Climatology. A multiple regression formula is used to predict temperatures from pressure distributions described by Tschebycheff polynomials. The matrix of scalar products which is used in the calculation of the coefficients of the multiple-regression system is being calculated on WWI.

:for Professor T. F. Malone, Meteorology Department
:by R. Miller(DIC), 50 hours; D. Friedman(Res. Assist.),35 hours
:DCL Staff: Denman, 1 hour; Porter, 9 hours; WWI, 258 minutes

Specification of the surface pressure pattern for half-a-hemisphere is being performed using standardized coefficients of orthogonal polynomials. This is in preparation for an attempt at forecasting the surface pressure pattern over a major portion of the North American Continent twenty-four hours in advance. The specification problem is near completion. Steps are being taken for constructing a 52 x 52 prediction matrix using in addition to the variables that specify half-a-hemisphere other similarly computed variables that specify a grid identical to the grid being predicted.

Miller

The fitting of the upper air flow patterns with orthogonal polynomials was completed during the period. A program has been written to obtain the cross-products of the dependent variables with the coefficients of the orthogonal polynomial for a multiple linear regression analysis(See description of problem in Biweekly Report, February 21, 1954). The dependent variables include temperatures at five stations of the central and eastern

parts of the United States and also the integrated daily precipitation over each of three river drainage basins. The program is now being tested.
Friedman

161 C. Response of Mass-Plastic Spring System to Transient Loading: a second 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. Whitman, Asst. Prof. of Soil Mechanics
:by S. Sydney(Res. Asst. CMMC), 30 hours
:DCL Staff: Kopley, 1 hour; WWI, 14 minutes

This problem involves the settlement of a structure resting on a soil foundation. When acted upon by a transient load, additional settlement beyond static load settlement of the building takes place. This settlement is resisted by the soil as more of it comes into action to support the superimposed load. The settlement, and the resistance to settlement, increase until a failure wedge is developed in the soil. From this point on, the soil resistance remains constant with any additional settlement.

As a consequence of this behavior, the resistance and inertia terms in the equations of motion are discontinuous, non-uni-valued functions of the displacement. The settlement conditions in the soil, past action as well as the present state, must be known at all times in order to calculate future settlements. The variables in the basic equations are the size of the footing, slope of the soil settlement curves, and the ultimate soil resistance. The program has been written and tested and several production runs will now be made to obtain a series of load-settlement curves.

163 C. Ferrite Phase Shifters in Rectangular Wave Guide; transcendental equation. The electromagnetic boundary value problem dealing with the non-reciprocal ferrite phase shifter in rectangular wave guide has been solved. Special cases (assuming negligible magnetic losses) of the resulting complicated transcendental equation have been computed by hand. Additional computations by machine are required to investigate other ferrite materials and to establish a frequency dependence. Since magnetic loss is a figure of merit for the system described it is essential that some investigation be made. For cases in which the losses are significant the system will be a non-reciprocal ferrite attenuator. The numerical solution will be obtained by operating on two simultaneous transcendental equations.
:for Dr. Benjamin Lax (DDL)
:by K.J.Button(DDL), 40 hours
:DCL Staff: Denman, 1 hour; Kopley, 1 hour; WWI, 19 minutes

The first half of the program was submitted for a second test run after the location of temporary storage was corrected.

The results of the second test run were incorrect. After consulting the flad table and scope post mortem an error was found in the master tape of LSR No. 6. The error was corrected in the master tape and in the first half of the program. The third test run performed properly.

The error in LSR No. 6 was found before the first test run of the second half of the program was performed. The results of the first test were incorrect, however. The difficulty was generated by an error in the hand calculation that had been performed in advance. Before the program was submitted to WWI, the analytical work and calculation of initial parameters were checked in detail. A slight error was found in the parameter calculation and the number was corrected in the program. This change resulted in the shift of an inverse tangent into the third quadrant. This contingency was not provided for in the program.

Since the program has been found to be very sensitive to the values of initial parameters, it has been decided not to connect the two parts of the program in any single subsequent performance. Part I can be performed for two cases at a time and can be classed as a "short run". The results will indicate the appearance of violent changes particularly in the region of resonance phemonema. This information will assist in predicting the behavior of Part II.

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. Assist. Aero. Eng.), 25 hours
:DCL Staff: Porter, 5 hours; WWI, 6 minutes

In continuing with the process of formulating subroutines which will be integrated into a continuous program for the evaluation of the matrix equation:

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

the following operations have been broken down into subroutines suitable for Whirlwind computation:

1. Matrix multiplication; $[A][B] = [C]$, where $[A]$ and $[B]$ are conformable matrices of order such that they can be stored in magnetic core memory. The general term in the C matrix is obtained as:

$$c_{ij} = \sum_{k=1}^{JA} a_{ik} b_{kj}$$

where; i = row of C matrix = row of A matrix
j = column of C matrix = column of B matrix
JA = number of columns in A = number of rows in B
k = running variable

This subroutine has been successfully tested.

2. Matrix addition; $[A] \pm [B] = [C]$. The general term is:

$$c_{ij} = a_{ij} \pm b_{ij}$$

This operation has been tested with satisfactory results.

3. Formation of a matrix with each element a sum of terms. In order to form a matrix, B, each element of which is composed of a sum of products, the general term is:

$$b_{ij} = \sum_{k=1}^{K} a_{ijk} x_k$$

where: $x_k$ = $k^{th}$ term in the array of numbers forming $b_{ij}$

$a_{ij}k$ = the coefficient corresponding to $x_k$

K = total number of terms forming each element of the resultant matrix.

For elements not involving all K of the known terms, $x_k$, zeros should be inserted in the storage registers corresponding to the appropriate k's of the coefficients, $a_{ij}k$.

This subroutine has been completed and will be tested in the near future.

These procedures utilize high-speed storage exclusively and are limited only by the capacity of the machine.

A plan of attack is being evolved to enable Whirlwind to handle the known coefficients of unknown quantities in matrix manipulations.

168 D. Indicial Downwash behind a Two-Dimensional Wing. In the analysis of the response of an airplane to a sharp-edge gust, and particularly in the calculation of stresses in the horizontal tail, it is important to know the downwash at the tail caused by the lift response of the wing to the gust. In the present solution for the downwash behind a two-dimensional wing, something more than the "indicial downwash" is sought. This is effected by allowing the gust front itself to have an arbitrary horizontal velocity which, combined with the velocity of the airplane, U, results in the wing's penetrating the gust front at a velocity V.

:for N. P. Hobbs (Res.Asst. Aero. Eng.) DIC 6727
:by N.P.Hobbs, 20 hours
:DCL Staff: Porter, 1 hour; WWI, 133 minutes

The equation for the ratio of the downwash to the vertical gust velocity at the dimensionless time s and the dimensionless horizontal coordinate x* is

$$\frac{w_W^{(2)}(s, x^*)}{w_0} = -\frac{1}{\pi}\sqrt{\frac{x^*-1}{x^*+1}} \int_{-1}^{\frac{V}{U}s-1} \sqrt{\frac{1+z}{1-z}} \oint_0^A \sqrt{\frac{A+2-s}{A-s}} \left[\frac{1}{x^*-z} - \frac{1}{s+(x^*-1)-A}\right] \psi'(s)\, dz\, ds \qquad (1)$$

The upper limit on the first integral is to be taken as unity if

$$\frac{v}{u}s > 2 \quad \text{and} \quad A = s - \frac{u}{v}(1+z)$$

$$\Psi'(s) = \frac{4}{\pi^2}\int_0^\infty \frac{J_0 - iJ_1}{\left[H_1^{(1)} + iH_0^{(1)}\right]^2 + 4\left[J_0 - iJ_1\right]^2} \; \frac{e^{-k(s-1)}}{k} \, dk \qquad (3)$$

where the argument of the Bessel functions is (ik).

$\Psi'(s)$ is the derivative of the Kármán-Sears function. Since the most accurate determinations of this function have been made numerically and graphical solution for the derivative is much too inaccurate, it is desired to determine $\Psi'(s)$ by numerical integration of Equation 3.

Near s = 0, it can be shown that

$$\Psi'(s) \rightarrow \frac{1}{\pi\sqrt{2s}} \qquad (4)$$

It is convenient to define

$$f(s) \equiv \frac{1}{\pi\sqrt{2s}} - \Psi'(s) \qquad (5)$$

and to substitute $\Psi'(s)$ from Equation 5 into Equation 1.

It is desired to split the middle integral into two parts, such that

$$\frac{w_\omega^{(2)}(s,x^*)}{w_0} = -\frac{1}{\pi}\sqrt{\frac{x^*-1}{x^*+1}}\int_{-1}^{\frac{v}{u}s-1}\sqrt{\frac{1+z}{1-z}}\left[\frac{C_I(A)}{x^*-z} - C_2(A,x^*)\right]dz \qquad (6)$$

where

$$C_I(A) \equiv \int_0^A \sqrt{\frac{A+2-s}{A-s}}\left[\frac{1}{\pi\sqrt{2s}} - f(s)\right] ds \qquad (7)$$

and

$$C_{II}(A,x^*) \equiv \oint_0^A \sqrt{\frac{A+2-s}{A-s}} \; \frac{\frac{1}{\pi\sqrt{2s}} - f(s)}{s+(x^*-1)-A} \, ds \qquad (8)$$

$C_I(A)$ and $C_{II}(A,x^*)$ will then be found by numerical integration. For the case $\frac{u}{v} = 0$, A is not a function of z (see Equation 2), and therefore, $C_I(A)$ and $C_{II}(A,x^*)$ essentially represent the indicial downwash solution, except for a constant which can be determined analytically. For other values of $\frac{u}{v}$, the downwash may be found by numerical integration of $C_I(A)$ and $C_{II}(A,x^*)$.

The computation of $\Psi'(s)$ has been successfully completed for seventy values of s. These seventy values permit interpolation for any other value of s to the desired accuracy.

A program to determine $C_I(A)$ for 29 values of A has been submitted to the tape room.

## 1.3 Operating Statistics

### 1.31 Computer Time

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

| | |
|---|---|
| Programs | 60 hours, 18 minutes |
| Conversion | 16 hours, 11 minutes |
| Magnetic Drum Test | 23 minutes |
| Magnetic Tape Test | 46 minutes |
| Scope Calibration | 40 minutes |
| Demonstrations (#131) | 29 minutes |
| Total Time Used | 78 hours, 47 minutes |
| Total Time Assigned | 79 hours, 44 minutes |
| Usable Time, Percentage | 98.7% |
| Number of Programs | 300 |

### 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 58.7%
   Output 8.2%
2. Computer Time Lost Due to Programmers Errors
   Technical 22.5% Logical 4.3%
3. Computer Time Lost Due to Other Difficulties
   Tape Preparation 1.3%
   Operator's Errors 1.8%
   Terminal Equipment Malfunction 2.9%
   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:

| | Complete Tapes | Typed Mods | Manual Mods | Combined Tapes |
|---|---|---|---|---|
| No. of Tapes | 95 | 52 | 41 | 16 |
| No. of Registers | 30333 | 3152 | 272 | |
| Time Consumed | 76 hrs. 21 min. | 25 hrs. 56 min. | 6 hrs. 43 min. | 7 hrs. 53 min. |

Thus, it may be seen that the average length of an original complete tape is 319.3 registers requiring 48.2 minutes to prepare. A typed modification averages 60.6 registers in length and requires 29.9 minutes to prepare while Manual Modifications average 6.6 registers and require 9.8 minutes for preparation.

## 2. ACADEMIC PROGRAM

WWI Tours. Six MIT personnel were given a tour of Whirlwind on Tuesday evening, March 2. Four of these people are new programmers with Project Lincoln and the other two are graduate students.

Seminar on Advanced Programming Techniques of the Digital Computer Laboratory Staff. On Friday, March 5, Mr. William N. Papian lectured on Magnetic Core Memory. About 25 persons attended the seminar.

On Friday, March 12, Dr. H. H. Denman will discuss the uses of Magnetic Tape Memory.

CS Programming Course. The next CS introductory two-week programming course will begin on March 15. It is expected that approximately 15 applicants will be accepted for the course.

Seminar on Computing Machine Methods. On Tuesday, February 23, Dr. Frank M. Verzuh, director of the Office of Statistical Services at MIT, described some of the commercially-available digital computers. A group of about 50 persons attended.

Mechanical Engineering Seminar. B. Gavril of the MIT Mechanical Engineering Department described the work he has done for his doctoral thesis in studying the Aerothermopressor. This work has been described in S&EC reports under problem #120. The seminar was held on Friday, March 5 and was attended by about 150 persons. Mr. Gavril emphasized the role that Whirlwind played in making it possible for him to carry out his detailed study.

<u>Industrial Liaison Conference</u>. A conference on "Control Applications in Business and Industrial Systems" will be held April 5-6 at MIT under the sponsorship of MIT's Industrial Liaison Office. Those who plan to attend should contact Miss Wellington at extension 2693.

<u>S&EC Movie</u>. The script for the movie "Making Electrons Count" is being rewritten. It is hoped that "shooting" will soon begin on the revised version of the film.

## 3. COMPUTER ENGINEERING

### 3.1 WWI System Operation

#### 3.11 Core Memory ( N. L. Daggett)

The preliminary model of a new core-memory sense amplifier appears to work very satisfactorily. It is being packaged as a plug-in unit to replace the present amplifier.

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

A number of transient transfer-check alarms have occurred during the last two weeks. Their origin appears to be in the control section of the computer. A thorough investigation of the control circuits is in progress.

A new TPD output panel was placed in service on 27 February.

The new indication system for the WWI air-conditioning system will be installed on Monday, 1 March. The system will include added protective devices.

The power-distribution system in WWI is being revised. Approximately 110 panels that are used for distributing fixed and variable voltages will be replaced in the next three months.

#### 3.12 Marginal Checking (S. E. Desjardins)

This period was spent in working out changes to be made on the marginal-checking equipment to allow the speed of the voltage variation to be controlled by the program when program marginal checking is done. These changes will be incorporated in the system on 1 March.

The consolidated test program has been delivered to Mr. Helwig to be placed on magnetic-tape-unit 1. This will be attempted next week. The program will then be read in daily from magnetic tape rather than from paper tape.

A revised alarm check program is being written to make it more automatic. The modification will allow the program to determine and count what errors (if any) occurred and will print the results after the test.

#### 3.13 Magnetic Tape (E. P. Farnsworth)

Reliability of the magnetic-tape system will be increased by two improvements which are in process. Negative 300-v power now available will permit lowering of the read-record heads to ground potential and elimination of the unit-selector amplifiers. Furthermore, directing a supply of conditioned air on the tape-mechanism motors, gear boxes, and crystal packages will improve performance, increase component life, and permit elimination of five small blowers.

The block schematics for magnetic-tape control and delayed print-out are being redrawn and brought up to date. These drawings should be helpful in resolving any problems which might arise when I move to Lexington next month and Al Perry takes over responsibility for the system.

Magnetic-tape print-out unit 2 has been checked out and is ready to be plugged into the spare FL Flexowriter whenever the second sound-proof enclosure is ready for installation beside the present box. This new box is being designed by Mal Demurjian and will incorporate several improvements and operating conveniences. Junction boxes, cables, and transfer switches for the second printer are also in the process of construction. These switches will permit using the spare Flexowriter as either a normal paper-tape machine or as a second print-out and will permit interchanging Unit 2 and Unit 3 in the same manner as Units 0 and 1 are presently interchangeable.

3.14 <u>Typewriter and Paper Tape</u> (L. H. Norcott)

The Flexo shop built up contact stacks, brackets, and selector switches to be used in modifying the three FL Flexowriters which are ordered for delivery in March.

Farnsworth and Demurjian requested that a convenient switching arrangement be designed to permit a delayed-output typewriter to be used as a conventional Flexowriter. A circuit using an Electroswitch Jr. selector switch has been turned over to Farnsworth for incorporation in his proposed new delayed-output system.

3.2 <u>Terminal Equipment</u>

3.21 <u>Marginal Checking</u> (S. B. Ginsburg)

The "Marginal Checking Panel for Activate Registers" Panel has been installed in the computer and has been checked out satisfactorily. It is now possible to select all activate digits together.

The "Indicator-Light Marginal-Checking" Panel has been bench tested. Ted Sandy is presently getting it installed in the computer.

(T. Sandy)

The marginal-checking panel for the indicator-light registers was bench tested and is now ready to be installed in WWI.

The marginal-checking panel for the activate registers has been installed in the computer and is working properly.

3.22 <u>Magnetic Drums</u> (H.L.Ziegler)

Excellent progress has been made during the past two weeks on the installation of electronic-write switching of heads in the auxiliary drum. All planning, layout, and wire-scheduling work has been completed, and considerable preliminary wiring and metal work have been done in the drum cabinet. Further progress now depends upon delivery of construction and Purchase Requisition items.

4. ADMINISTRATION AND PERSONNEL

New Staff (J.C.Proctor)

Harold D. Houser is working as a DDL Staff Member and has been assigned to Group 61. Mr. Houser received his B.A. is Physics from the University of Buffalo and until recently was associated with the Cornell Aeronautical Lab in Buffalo.

Mrs. Julia Yienger is working as a DDL Staff Member and has been assigned to Group 61. Mrs. Yienger received her B.A. in Math from Emmanuel College and until recently has been working as a Math Programmer for the Ballistic Research Lab, Aberdeen Proving Ground, Md.

Staff Termination

Dee Neville

New Non-Staff (R.A.Osborne)

Eva LeBlanc is a new messenger girl in the Whittemore Building.

George Hanlon is a new member of the Drafting Department.

Margaret O'Brien is Mr. Kromer's new secretary.

Terminated Non-Staff

Alice Biladeau

Janet Landis