Digital Computer Laboratory
Massachusetts Institute of Technology
Cambridge 39, Massachusetts

SUBJECT: PROGRESS REPORT MAY 17 THROUGH JUNE 13, 1954

To: Jay W. Forrester

From: Scientific and Engineering Computation Group

1. MATHEMATICS, CODING AND APPLICATIONS

1.1 Introduction

This report covers the four week period beginning on 17 May, 1954. During this period 231 coded programs were run on the time allocated to the Scientific and Engineering Computation (S&EC) Group representing work that has been carried on in 35 problems.

Section 1.2 below contains progress reports as submitted by the programmers together with an indication of the programming and machine time expended on each problem. Abstracts are no longer included with each problem. However, as in the past, a more detailed description will be presented in the initial progress report for each new problem. The reader is reminded that the laboratory issues summary reports every three months containing detailed descriptions of the problems studied during that period. In particular terminating reports for completed problems will be found in these summary reports.

Three problems (#113, #119, and #161) were completed during this period. Machine runs on problem #101 (Optical Properties of Thin Metal Films) have been completed and the results are being written up for publication. Programming on this problem will be continued when Dr. Loeb returns from Europe.

Detailed initial reports are given below for problem #181 (calculation of proton-deuteron scattering), #187 (response of a fuel-flow controller), #188 (relative water production in an oil reservoir), and #192 (frequency and phase spectrum analysis of seismograms). Satisfactory results have been obtained for problem #181 and the problem is now terminated.

1.2 Programs and Computer Operation

100. The Comprehensive System of Service Routines:

Best, 67 hours; Combelic, 49 hours; Demurjian, 27.5 hours; Denman, 23 hours; Frankovich, 36 hours; Siegel, 52 hours; WWI, 447 minutes

This system (CS) provides for the automatic selection and use of utility programs during computer operation. The library of utility programs is permanently recorded on magnetic tape and includes conversion programs, binary input programs, equipment checking programs, and post-mortem programs. The comprehensive system has been operating successfully during the past four weeks. Several difficulties in reading utility programs from magnetic tape to core memory were encountered, but these were explained by a mistake in the program used to re-record utility programs on magnetic tape. This mistake caused marginal recording on magnetic tape.

The following changes are being made in the group 11 program:

1. Two entry points are being added whose use will cause the program to record the title of the tape just read in either on the direct printer or on the delayed printer. In addition, the date and the time will also be recorded.

2. The logging programs are being modified so that standard time will normally be recorded in the log instead of computer time. This will be accomplished by recording the standard time on the buffer drum at the beginning of the operating period.

3. Provisions are being made so that the library of utility tapes used by the group 11 program can be stored on an arbitrary tape unit. This will prove useful in checking out new utility programs or modifying old ones.

The generalized post-mortem program is being modified so that the scope can be used as an output unit for post-mortem results. At present only the direct printer and the delayed printer are available.

The following formal proposals are being issued:

1. It has been requested that a new switch be installed in test control which could cause the computer to stop on the instructions si 11 or si 12. In this way accidental resetting of the computer clock could be prevented.

2. It has been requested that equipment be installed for storing the contents of various computer lights after an alarm in such a way that they can be recorded on an output unit by a program contained in test storage. The lights are presently being recorded by the operators, a process that is time consuming and can lead to transcription errors.

A memorandum describing the group 11 program is being written.

Staff

The program briefly described in the biweekly of May 16 and currently being trouble shot will provide a generalized means of transferring binary information between various external units. Specifically, it will be able to read information from the following sources: 1. 556 tapes via PETR, 2. 556 tapes via MTR, 3. blocks (i.e., programs recorded on a MT unit in a form such that they can be found and read in by an input program) from MT units 0, 1, 2, 3.

It may record binary information in the following ways: 1. 556 tapes on MT unit 3 for delayed punching, 2. 556 tapes on the direct punch for emergency use only, 3. blocks on MT units 1, 2, 3. Unit 0, of course, can never be recorded on directly but only through the recording circuits of unit 1. Any 556 tapes which are punched will have words arranged in order of ascending drum addresses and extensive use of ditto blocks will be made to shorten the tapes.

Some of the uses of this program may be: 1. copying blocks from one tape unit to another just to make sure that there is always a good copy of the magnetic tape programs, 2. modifying a block on magnetic tape by reading in only the mod tape, 3. obtaining a 556 tape containing the same information as a block on MT, 4. shortening (i.e., optimizing) 556 tapes, 5. inserting or lengthening a block on MT without reading in more than one 556 tape, 6. in combination with an input program capable of reading in blocks from any MT unit, testing extensions and modifications of the CS II system. Also entirely new systems could be recorded on any MT unit for testing.

Best

101 C. Optical Properties of Thin Metal Films: Loeb, 50 hours; Richmond, 25 hours; WWI, 223 minutes

The present stage of research in electronic digital computation applied to the optical and electrical properties of thin metal films was completed during the past month. The final production runs have taken place, and the next month will be devoted to the analysis and publication of the results.

106 C. MIT Seismic Project: Briscoe, 36 hours; Simpson, 50 hours; Walsh, 60 hours; WWI, 362 minutes

Much of our computer time during the past 4 weeks has been devoted to further analyses of earthquake records along the lines indicated in previous biweekly reports. In the future, progress on this aspect of our work will be reported under a new problem number (#192). The recent work of this type, consisting of frequency studies, has indicated that the so-called "T phase" encountered on these records possesses the dispersive characteristics of Rayleigh waves at the ground water interface, but further verification of this theory is needed. A similar study is contemplated for the minor tremors known as microseisms.

Progress on other projects under way have suffered some delays due partially to the school term ending and loss of personnel. In addition there has been difficulty in computing largest eigenvalues of non-symmetric matrices. The WWI subroutine was tried unsuccessfully and then modified for further trial. When this failed to converge satisfactorily a slightly different iteration procedure was programmed and has been checked out.

Modifications in correlation procedures mentioned previously are being included in a new generalized correlation program which is presently being written.

109 C. Fighter Gunsight Calibration: WWI, 27 minutes

A horizontal plane pursuit course program has been written which computes prediction times for a two-gyro gunsight and a three-gyro gunsight.

A slant plane pursuit course program has been written which computes prediction times for a two-gyro gunsight and a three-gyro gunsight and correction time ratios for the latter gunsight.

A test problem has been run using these two programs with comparable initial conditions for each. The results are being analyzed and will be included in the final report on this problem.

It is planned to make a number of runs using the slant plane pursuit course program with the airplane and target initially in a slant plane.

113 C. Shear Wall Analogy, Simultaneous Linear Equations: Sydney, 15 hours; WWI, 11 minutes

The final report on this problem is being written. All production runs are completed.

119 C. Spherical Wave Propagation: Ralston, 5 hours; WWI, 74 minutes

Magnetic tape troubles have prevented the obtaining of any results for the revised problem mentioned in the previous biweekly. However, sufficient results have been obtained for the initial problem proposed and the problem may now be considered to be terminated.

120 D. The Aerothermopressor: Gavril, 10 hours; WWI, 223 minutes

During the past month, computations of aerothermopressor performance for various Mach Number variations have continued. In these calculations the Mach Number is arbitrarily prescribed as a function of gas stream humidity, thereby defining the process. The data thus far accumulated is being studied to determine what Mach Number variation (or, effectively, what geometrical shape of duct) leads to best performance, that is, maximum pressure at exhaust.

A new calculation procedure has been written and successfully tested which to a great extent allows Whirlwind itself to determine the Mach Number variation for best performance. This routine has the advantage of reducing the uncertainty and arbitrary nature of the procedure suggested above and reduces the problem of determining best performance to a routine

WWI calculation in the least possible computer time.

The method of calculation is essentially a Ritz type of numerical solution to the variational problem of determining the Mach Number variation

$$M - M_0 = C_1(X-X_1) + C_2(X-X_1)^2 + C_3(X-X_1)^3 + C_4(X-X_1)^4$$

which renders the final pressure p_f a maximum. The boundary condition is the requirement that the final Mach Number, M_f, be fixed. For a given set of values of the parameters C_i, the value of p_f may be calculated. Four additional sets of calculations lead to values of the partial derivatives

$$\partial p_f/\partial C_1 \ , \ \partial p_f/\partial C_2 \ , \ \partial p_f/\partial C_3 \ , \ \partial p_f/\partial C_4$$

and hence to the gradient, $\nabla p = (\partial p_f/\partial C_1)\bar{i} + (\partial p_f/\partial C_2)\bar{j} + \ldots$

The parameters C_i are then simultaneously adjusted so that a prescribed increase in p_f (2%) occurs for the least change in Mach Number variation. This is accomplished by determining the increment in C_i by the equation

$$dC_i = \frac{\frac{\partial p_f}{\partial C_i} \, dp}{|\nabla p|^2}$$

This calculation procedure shows great promise for providing a routine method for aerothermopressor design contained on one 556 WWI tape. The time required to effect one systematic alteration in the Mach Number variation is seen to be 5 times that of a single run, the latter requiring on the order of 8 minutes. The gross time, however, is considerably less than that required for the larger number of arbitrarily specified cases which would in general be necessary.

123 C. <u>Earth Resistivity Interpretation</u>: WWI, 105 minutes

The program for analysis of the Slichter kernel has been tested with more kernel data in an effort to learn more about its behavior. In addition, a program change has been made which allows an indefinite number of iterations, in contrast to the maximum of 25 which was allowed previously, and which increases the parameter-change multiplier every 20 iterations.

Four different kernels, three theoretical and one observed, were tried. Two of the four calculations (a four-layer kernel and the observed kernel) terminated because of error increase after about three iterations, indicating too large an initial parameter-change multiplier. These have not yet been retested. Another of the four, a theoretical three layer case, was run for 25 iterations and seemed to be converging to the known parameter values. The fourth kernel tested was also a theoretical three layer case. It was run for 21 minutes, giving 90 iterations, and the parameter change multiplier was increased every 20 iterations. The final value of the multiplier was 0.4, and it could have been larger. The correct solution was obtained on the 40th iteration, but the calculation was continued. On the 50th iteration the resistivity and thickness of the second layer went negative and the error increased. Beyond this, the error continued to decrease very slowly, and the second layer resistivity and thickness oscillated about zero. The first layer thickness oscillated around 1.03, whereas the true value was 1.00. The significance of this result will be discussed in the next progress report.

126 C. Data Reduction: Hamilton, 20 hours; Ross, 10 hours; WWI, 19 minutes

The past period has been used entirely in abortive attempts to make a test run of the complete Data Reduction Program with the mistake diagnosis routine. Tape preparation, conversion, tape loss, and PETR and drum difficulties have precluded even a post mortem.

131. Special Problems (Staff training, demonstrations, etc.): Kopley, hours; Ackley, 16 hours; Denman, 26 hours; WWI, 151 minutes

Tours: On June 1, twenty-two people attended the monthly tour which included Flexowriter and computer demonstration, a tour of Whirlwind installations, and an informal twenty minute talk.

Kopley

132. Revision, Extension and Testing of Subroutine Library Used in Programs for Obtaining Data for the Numerically Controlled Milling Machine; routine numerical and logical operations: Runyon, 40 hours; Kopley, 4 hours; WWI, 64 minutes

A subroutine for reading milling machine tape into the computer was successfully tested. This subroutine has been incorporated into programs and is being used to check a long tape.

More errors have been found and corrected in a program for preparing tape for airfoil templates. Results of the latest version are yet to be received.

A program for preparing tape for a conic wing section will be obtained by modifying a program for a conic test piece, which has previously performed satisfactorily.

141. Matrix Diagonalization and Inversion Subroutine: Mahoney, 67.5 hours; Denman, 5 hours; WWI, 46 minutes

The matrix diagonalization and inversion subroutine (LSR MA5) is being rewritten in order that it may operate faster. This program reduces a symmetric matrix to diagonal form, determines the eigen values and finds the inverse of the matrix. All interpretive instructions in the program now in the present library version, except those essential to arithmetic operations performed on the elements of the matrix, have been replaced by WWI instructions. The length of this program, now being tested, will not exceed that of the original program.

142 D. A Study of Shock Waves: Sydney, 60 hours; WWI, 444 minutes

Production runs are continuing on the last phase of this problem. Four more hours of computer time are required to complete the project.

143 D. Vibrational Frequency Spectrum of a Copper Crystal: WWI, 77 minutes

The Spectrum was recalculated for copper assuming a central-force action between atoms. The appropriate central-force atomic constants were taken from the work of Leighton for Copper as set forth in Reviews of Modern Physics, January 1948. The result exhibits the same general character as the more exact spectrum calculated earlier on the Born Theory of Lattice Dynamics, as to be expected. The details are, however, quite noticeably different. The results of both theories (Born and Leighton) will appear in the next quarterly report.

147 C. Energy Bands in Crystals: Howarth, 80 hours; WWI, 575 minutes

Alterations have been made in the routine described previously to calculate and solve the secular equations which constitute the last part of this problem. Elimination of errors in these has proceeded slowly. When completed, the computation time will effectively be reduced by a factor of two.

The solution of the secular equations submitted by Dr. F. Herman of R.C.A. has been completed satisfactorily.

149 C. Digital Methods of Detecting Signal from Noise: Dinneen, 15 hours; WWI, 51 minutes

A program was written to test a detector which measures the density of ones (signal returns) within a given interval as this interval moves throughout the region under study. Whenever a given threshold (corresponding to a density of ones) is exceeded, the start of a signal region is recorded. When the density of ones falls below this region, the end of the signal region is recorded. No results have been obtained. The post-mortem is being studied to determine the error.

155 D. Synoptic Climatology: Miller, 60 hours; Blood, 80 hours; Demurjian, 5 hours; WWI, 727 minutes

Multiple correlation coefficients have been computed for 91 grid points signifying the 24 hour predictability of surface pressure using past surface patterns as predictors. Various combinations of grid sizes have been investigated and, in all, the results have proved extremely interesting.

It was necessary, in carrying out the above analysis, to write a program which would solve an n x n matrix by means of the Crout method for n up to 33. It is felt that this program could easily be extended to an n x n matrix where n is limited only by the auxiliary storage units or roughly n = 150.

Future plans are directed toward constructing a four dimensional model of the atmosphere (x, y, z, t) to predict and specify surface temperature and rainfall.

Miller

This problem will attempt to specify and predict daily surface temperatures at five selected stations using circulation patterns over North America.

Using 14 Z's daily to describe the circulation pattern, regression equations were derived for prediction and specification for each of the five stations. The equations are of the form:

$$\hat{T} = a_0 + \sum_{i=1}^{14} a_i Z_i + \sum_{J=1}^{14} b_J Z_J + cT$$

Correlation coefficients and root mean square errors are also calculated. The first month tested showed a correlation of 0.77 for specification of daily 8 AM temperatures.

Approximately 1/30th of the planned problem is completed. Difficulties encountered mainly involved scale factoring.

159 D. <u>Water Use In a Hydroelectric System</u>: Little, 200 hours; WWI, 300 minutes

A program has been written and fairly well debugged to determine the best way of operating the given hydro system. A program which uses this operation to run the system on the historical river flow has been written but not debugged.

161 C. <u>Response of Mass-Plastic Spring System to Transient Loading</u>: Sydney, 20 hours; WWI, 66 minutes

Production runs are completed on this problem. The final report is now being written.

162 C. <u>Determination of Phase Shifts from Experimental Cross-Sections</u>: Campbell, 24 hours; Denman, .5 hour; WWI, 20 minutes

A phase shift analysis is being made of the elastic scattering of protons by O^{16}. From a partial wave expansion of the differential cross-section those phase shifts required to provide a fit to a number of experimental angular distributions will be determined.

As part of a preliminary program to obtain plots of the sum of the squares of the percentage errors in the cross-section as a function of each phase shift, one tape was successfully run giving the error as a function of S_1, the P wave phase shift.

163 C. Ferrite Phase Shifters in Rectangular Wave Guide: Button, 120 hours; WWI, 61 minutes

The theoretical investigation of the nonreciprocal phase shifter at lower frequencies was described in the last report. Part I of this program provided design information for two phase shifters using two different ferrite materials at this lower frequency. Further analysis of these results has revealed an excellent method of checking the theory experimentally. It has been found that the primary characteristic, the differential phase shift, is of opposite sign for these two phase shifters. The point of sign reversal may be found either as a function of a ferrite characteristic (the saturation magnetization) or of the externally applied DC magnetic field intensity. This sign reversal would not be encountered in phase shifters operating at the original high frequency of 9375 MC.

Formerly, only qualitative experimental verification was possible since the theory is forced to deal with an infinitely long ferrite-loaded transmission line while the experimental apparatus is necessarily finite and involves transitions from empty to ferrite loaded waveguide. Corrections to the measured values had to be estimated. Furthermore, the fundamental formulas for ferrite permeability parameters were presumed to be inadequate at S-band (3000 MC.) because a proper loss term required at these low frequencies has not yet been derived. Experimental measurement near the point of sign reversal is expected to improve the relation between theoretical and experimental findings.

The problem of constructing lossless non-reciprocal phase shifters at frequencies lower than 9000 Mcps. is now being investigated. Data obtained from Part I (evaluation of the differential phase shift) and Part II (evaluation of the attenuation constant at 9375 Mcps.) are leading to the formulation of design conditions for these lower frequency devices. Low frequency non-reciprocal transmission lines are expected to be used much more widely in practical applications than the research devices which have been developed at X-band.

The difficulties encountered in low frequency devices may be described briefly as follows: They must be operated far enough away (on one side or the other) from the gyromagnetic resonance peak to be nearly lossless. This is possible at X-band because the resonance absorption peak occurs at a value of DC magnetic bias of about 2500 oersteds. An operating bias of several hundred oersteds is suitable. However, this resonance value of bias is proportional to operating frequency. At frequencies below 3000 Mcps. the magnetic bias would have to be much too small to provide a usable differential phase shift. It therefore becomes clear that these devices must be designed to operate at values of magnetic bias which are larger than the resonance value. The Whirlwind programs are now being used to predict operating characteristics at frequencies as low as 375 Mcps. About 22 minutes of computer time will be required to complete the investigation.

After this Whirlwind data has been evaluated, the use of Whirlwind time for obtaining solutions for the phase shifter problem will not be required for several months. Theoretical work will be suspended temporarily to await further experimental verification and development.

166 D. Construction and Testing of a Delta-Wing Flutter Model: Gravitz, 110 hours; Porter, 4 hours; WWI, 234 minutes

Substantial progress was made during this period. The basic program for the first cycle of the Error Iteration Procedure has been successfully tested. Two additional tapes, representing modifications to the basic program to enable it to handle the succeeding cycles with input from magnetic drum storage rather than from a separate tape fed into high speed storage, have been completed and satisfactorily tested. The original tapes have been altered for use with CS II and rearranged and combined so that the complete program is represented on four tapes.

The first tape is a Flexo tape, designed for direct read-in, which contains the input to the physical system represented by the three-bay lattice structure; that is, the given influence coefficients, or deflection pattern that the model is to conform with, and the first estimates of the torsional and bending stiffnesses of the component members of the lattice. This is a comparatively short tape which can be easily and quickly modified should theneed arise. The second tape is in 556 form and contains most of the geometry of the system; that is, it describes the three-bay lattice in terms convenient for the subsequent manipulations. The third tape is also in 556 form and corresponds to the computation of the ΔC's; it computes the influence coefficients corresponding to the first trial stiffnesses, compares them with the given values, and prints out the errors. The last tape, in 556 form, corresponds to the formulation of the ΔX's; if the trial influence coefficients are not close enough to the given ones, corrections must be made to the trial stiffnesses. This tape also incorporates a recent modification to the Crout method matrix inversion routine which solves the final set of equations to yield the ΔX's--the now present check column gives a quantitative indication of how large the accumulated errors are by observing how far a second set of solutions to the equations deviates from a column of ones.

The entire program, which will be run on the computer some time in the very near future, works as follows: for the first cycle all four tapes are read into the computer with the PETR and each succeeding cycle will require the reading in of only the last two tapes. The preliminary output from each cycle is stored on the drum right over the corresponding output from the previous cycle; therefore it is unnecessary to repeat the reading in of the initial input which is on the first two tapes--only the tapes corresponding to the actual computations (the last two) need be repeated for each cycle. In the future more efficient use of the drum is planned.

Testing of the completed program has also yielded useful information concerning the physical assumptions which form the preliminary input to the system. It has been deduced from examination of the test results that when an unknown must be eliminated, it is much more satisfactory from the mathematical point of view to assume a given cross-section for a member, thus defining the ratio of torsional stiffnesses of two members. Although both types of assumption are reasonable from the physical point of view, it has been found that the latter type results in a very poorly conditioned final matrix which causes the values for the Δ X's to become unnaturally large due to error accumulation. It is expected that the ill-conditioning of the final matrix will be remedied; in the meantime the check column for the solution of the final set of equations will be a welcome addition to the program in this respect.

A test run was made with accordingly modified input and the ΔC's were observed to have slightly better values than previously. The real test, of course, is what effect on the Δ X's the revised estimates have and it is expected that this will be ascertained in the very near future.

168 C. Indicial Downwash Behind a Two-Dimensional Wing: Hobbs, 160 hours; WWI, 43 minutes

The solution for the indicial downwash, that is, for $\frac{U}{V} = 0$, has been completed for four points behind the wing. The remaining problem consists of utilizing the indicial downwash to obtain by numerical integration the downwash for values of $\frac{U}{V}$ other than zero.

169 Utilizing a General Purpose Digital Computer in Switching-Circuit Design: Hoy, 75 hours; WWI, 26 minutes

Thirty-two switching functions on 5 variables with an average of about ten terms have been reduced by the existing reduction program. The average computation time per problem is approximately 1 second or about 1000 times as fast as a rapid worker.

However, the results reveal that the last of the rules that have been used is not sufficiently general. Examination indicates that it can be rewritten in a much more general form. In addition, the generality, by removing unnecessary restrictions, permits a shorter program. The new program has been written but the results of the tests have not yet been received.

Methods for obtaining the most minimal form or one that is as simple as any other have been studied but, as yet, none seems encouraging enough for programming.

172 B. Overlap Integrals of Molecular and Crystal Physics: Corbató, 160 hours; WWI, 624 minutes

During the last four weeks, all the integrals necessary to make tight-binding calculations of Graphite and Diamond have been computed. In addition Dr. Howarth's (Problem #147) routine for solving secular equations of the non-λ type has been adapted for use with a program which generates, from the essential integral values, the matrix elements arising in the Graphite secular equation. This arrangement is now being used to produce final results for Graphite.

The subroutines for calculating integral values have been revised in order to reduce machine time by 30%. Pending final tests of these revisions, the tapes will be consolidated for the convenience of possible future use.

176 B. <u>Connector Provision in Automatic Telephone Exchanges:</u> Porter, 3 hours; WWI, 148 minutes

Since the last report, two further solutions have been obtained for S = 100, and selected values of P. Results for a total of 8 values of P are now available, and these are sufficient for a continuous set of curves for S = 100, over the desired range of P.

The first of seven runs for S = 200 has also been run, and satisfactory results obtained.

Allowance for a typical distribution of calling rates produces the following equations:

$$P_k = \frac{1}{k} \cdot \frac{p}{1-p} \cdot P_{k-1} \sum_{w=0}^{S-1} (S-w-k+1)\, Q_w \left(1 - \frac{p}{1-p} \cdot \frac{w+k-1}{S-1}\right) \qquad 3a$$

$$\sum_{k=0}^{S} P_k = 1 \qquad 3b$$

$$B(N,S,p) = \frac{1}{S(1-p)} \sum_{k=N}^{S-1} \sum_{w=0}^{S-k-1} (S-k-w) Q_w P_k \left(1 - \frac{p}{1-p} \cdot \frac{k+w}{S-1}\right) \qquad 4$$

These equations have been solved for S=25, and p=0.02(0.01) 0.20. Results differ so little from those given by the original set of equations that it is clear that the effect of the distribution of calling rates may be safely neglected.

179 C. <u>Transient Temperature of a Box-Type Beam:</u> Schmit, 8 hours; WWI, 22 minutes

An investigation of the effect of variable specific heat established, for this particular case, that this effect is not important. The large increases in contact admittance produced by the steel screws in the aluminum structure were estimated. The effective absorptivity of the exposed surface of the box beam was back calculated from test data(measured temperature and total heat energy). It was found that the effective absorptivity was considerably less than values established experimentally for the same surface prior to the field test.

The 179-86-7 tape was prepared. The heat input information was based on the effective absorptivity, the total energy delivered as measured by a calorimeter, and on normalized heat flux time histories obtained by radiometer measurements. The high contact admittance values due to the steel screws were also incorporated in this modification. The 179-86-7 tape ran successfully in 22 minutes.

An error in the basic difference equations which had not previously been apparent, was substantially magnified by the increased contact admittance terms. The physical equivalent of this error was a heat source in the flange near the web-flange joint.

The 179-86-8 tape was prepared eliminating this error. The entire problem was reviewed and the 179-86-8 tape prepared independent of all previous work. This tape is now being tested.

180.B. Crosscorrelation of Blast Furnace Input-Output Date: WWI, 213 minutes

During the past four weeks the summer session crosscorrelation program was rewritten for CS II and combined with the Ross Fourier Transform program. When optimized, the combined program will permit the evaluation of the cross or auto-correlation of a function and the Fourier Transform of the resulting correlation function with a minimum of operating and tape preparation effort. Computer time is also minimized since only one operating period is required for the complete solution of a given correlation transformation problem. It is expected that the problem will be terminated within the next four week period.

181 C. Perturbed Coulomb Wave Functions: Paul, 48 hours; WWI, 40 minutes (Computer time from April 19-May 16)

Nuclear scattering in general remains the most direct way to get information about nuclear forces. Of particular interest is the comparison between neutron-deuteron scattering and proton-deuteron scattering because it may be assumed that the forces involved in the two cases differ only by the addition of an electrostatic interaction between the charged proton and deuteron. The validity of this assumption requires that the specifically nuclear force between two protons be the same as that between two neutrons, and its proof or disproof is of basic interest.

An analysis of the nuclear-deuteron scattering data requires knowledge of the scattering that would result with only an electrostatic interaction between proton and deuteron. In the case of two point charges, this is given by the so-called Coulomb wave functions, tabulated in some detail by the U.S.Bureau of Standards. For proton-deuteron scattering, the charge distribution of the deuteron cannot be considered at a point and the corresponding functions must come directly from the linear second-order differential equation by a numerical solution.

With these functions at hand, one can use the neutron-deuteron scattering data to predict proton-deuteron scattering. Sufficient data of both kinds have been taken in this laboratory to make a significant comparison.

A test of this so-called charge-symmetry of nuclear forces may be obtained by comparing p-D and n-D scattering. To do this, one compares the experimental p-D phase shift δ with that calculated from

$$\frac{\Phi'(b)}{\Phi(b)} = \frac{G'(b) + \cot\delta\, F'(b)}{G(b) + \cot\delta\, F(b)}$$

where G(r) and F(r) are the regular and irregular solutions of the p-D wave equation

$$\frac{d^2\varphi}{dr^2} + \left[k^2 - \frac{1-e^{-\frac{2r}{a}}}{Rr}\right]\varphi = 0$$

k=wave no.
R=protonic bhor radius
a=scattering length

The numerical solution of this differential equation has been done on WWI by the following procedure.

The solution is started by a power series

$$\varphi = \sum_{n=0}^{\infty} b_n r^n$$

Regular Sol. $\begin{cases} b_0 = 0 \\ b_1 = 1 \end{cases}$

Irregular Sol. $\begin{cases} b_0 = 1 \\ b_1 = 0 \end{cases}$

$$b_n = \frac{-k^2 b_{n-2}}{n(n-1)} - \frac{1}{Rn(n-1)}\left[\left(-\frac{2}{a}\right)b_{n-2} + \left(-\frac{2}{a}\right)^2 \frac{b_{n-2}}{2!} + \cdots + \left(-\frac{2}{a}\right)^{n-2}\frac{b_1}{(n-2)!} + \left(-\frac{2}{a}\right)^{n-1}\frac{b_0}{(n-1)!}\right]$$

The function is then generated by the Manning-Millman Method

$$\varphi_{n+1} = \frac{2\varphi_n - \varphi_{n-1} + \frac{h^2}{12}\left[10\varphi''_n + \varphi''_{n-1}\right]}{1 + \frac{h^2}{12} f_{n+1}(x)}$$

$$\varphi'' = f(x)\,\varphi$$

$$f(x) = \left[k^2 - \frac{1-e^{-\frac{2r}{a}}}{Rr}\right]$$

The regular and irregular solutions have been done successfully for $0 \le r \le 3$ at intervals of .05, for a = .216, R_1 = 2.147 and R_2 = .447, and k_1^2 = .2158, k_2^2 =.4316, k_3^2 =.6474, k_4^2= .8632, k_5^2 = 1.0790, k_6^2 = 1.6185, k_7^2 = 2.1580. This concludes the problem.

183 D. Blast Response of Aircraft: Sternlight, 40 hours; Demurjian, .25 hour; WWI, 144 minutes

Two more parameter tapes were run successfully during this period. The automatic $\Delta\tau$ reduction program is giving trouble. A new feature was added to allow for linear curvature when desired in the calculation. Results are almost completed for time-history runs. When the $\Delta\tau$ reduction section is checked out, peak print runs will begin on a production basis.

184 D. Scattering Electrons from Hydrogen: WWI, 175 minutes

A program has been written to perform the two dimensional integrations. It is being tested on an analytically evaluable integrand.

Another program to calculate several of the integrands involved is being tested.

187 C. Response of a Fuel-Flow Controller: Merwin, 8 hours; WWI, 48 minutes

The following system of first order nonlinear ordinary differential equations describing the response of a fuel-flow controller has been solved on WWI making use of CS II.

$$\dot{y} = c_1 y + c_2$$

$$\dot{x}_3 = -c_3 \bar{k} y - c_4 x_3 - c_5 x_3 - c_6 \omega_2 + c_7$$

$$\dot{x}_4 = c_8 x_3 \begin{cases} \sqrt{\omega_1 - \omega_2} & \text{if } x_3 > 0 \\ \sqrt{\omega_2} & \text{if } x_3 < 0 \end{cases}$$

$$\dot{z} = c_9 \left[-z + c_{10} \right]$$

$\bar{k} = f(z)$

$\omega_1 = \text{const.}$

ω_2 is quadratic function of x_4.

The solution did not prove to be physically realistic so a second problem is now being solved using the same equations with different constants. The Gill Method, an adaptation of the Runge-Kutta, has been used throughout the program.

188 C. Effect of Gravity on Relative Water Production in Oil Reservoirs: Porter, 14 hours; WWI, 374 minutes

In a large number of oil reservoirs water, which underlies the oil, is produced along with the oil. The relative amount of water production depends for a given geometrical configuration on the effect of gravitational forces relative to the imposed pressure forces. In order to enhance the effect of gravity the common practice is to plug the bottom part of the well bore so that fluid is produced from near the top of the formation; in some instances the imposed pressure forces are held to a minimum.

This problem has been undertaken in an effort to gain quantitative information concerning the effect on relative water production of partially penetrating wells and reduced pressure forces.

The interesting feature of this problem is the demarcation surface separating the oil and the water. This is a free surface in the sense that its location is not known beforehand but must be determined in the course of the computation.

The pressure P in either the oil or water zones obeys the following equation:

$$\frac{1}{r} \frac{\partial}{\partial r} \left\{ r \frac{\partial p}{\partial r} \right\} + \frac{\partial^2 p}{\partial z^2} = 0 \qquad (1)$$

where r is the radial distance from the center of the well bore and z is the vertical depth below the top of the reservoir.

Since no fluid moves across the upper and lower boundaries of the reservoir nor across the cylindrical surface where the well bore is plugged, simple boundary conditions in terms of the normal derivative of P are obtained at these boundaries. At the well bore and the outer radius of the formation the pressure is a predetermined function of depth. At the interface between the oil and the water the pressure in the water zone must equal the pressure in the oil zone; furthermore, since no fluid moves across the interface, the normal derivatives of water and oil pressures are simply related.

The proposed method of solution is to assume a fixed interface position and solve equation (1) for the water and oil zones independently. The interface position and the pressure difference between the well bore and the outer radial boundary are then adjusted so that water and oil pressures at the interface are equal in the least squares sense. The procedure is then repeated with the new interface position and new boundary pressures.

In the actual calculation the procedure has been simplified by making a linear transformation on pressure; a logarithmic transformation has been made on r to increase accuracy near the well bore.

Preliminary results have indicated that the logarithmic transformation greatly decreases the rate of convergence of the numerical solution of equation (1); furthermore it appears that equation (1) must be solved with a great amount of precision before the proposed adjustment of the interface is stable.

For this reason an effort will be made to improve the procedure of adjusting the interface from physical concepts and results in the immediate future.

192 D. Frequency and Phase Spectrum Analysis of Seismograms: Walsh, 60 hours; WWI, 238 minutes

In this section it is desired to determine the contribution of various specified frequencies to the reflected and refracted energy recorded on prospecting records. It is hoped that this knowledge coupled with information of the noise spectrum will give rise to signal-to-noise ratios which will assist in the design of electronic and mathematical filters to be used in putting these reflections and refractions into a better relief in time.

In this part--as in the above--it is desired to ascertain the spectrum (both phase and frequency) of the various direct, reflected and refracted body waves recorded at a number of seismic stations situated on the continent of North America. It is hoped that if such information were displayed in time that a great assistance would be rendered seismologists in the determination and "picking" of these phases. Furthermore, it is intended to apply similar analysis to the surface wave and "coda" section of earthquake records in the hope of determining the magnitude and presence of dispersion, which knowledge would in turn be instrumental in the determination of the type of continental and sub-oceanic layering.

In addition to the above a frequency analysis of microseisms and the so-called T-Phase will be made. The intent here is to obtain knowledge which should be most instrumental in deciding the nature and origin of these phenomena.

For the past two weeks computation was confined to the calculation of traveling spectra of the various component seismograms of a T-Phase whose origin occurred on the North Coast of the Dominican Republic. These spectra were plotted according to a density plot routine. The results clearly show that this phase has dispersive characteristics peculiar to Rayleigh waves traveling at a ground water interface. Additional computation on other phases originating at different places must transpire, however, before definite conclusions can be made as to the nature of this phase.

In the following weeks it is intended to investigate by spectral analysis microseisms recorded at Weston, Mass. in the hope that additional proofs may be made concerning the nature and origin of these waves. Thus far, analysis has shown them to be Rayleigh waves of high frequency generated by standing ocean waves.

The following problems used computer time but did not report.

107 C.	(a) Autocorrelation and (b) Fourier Transform, Evaluate Integrals	147 minutes
108 C.	An Interpretive Program	44 minutes
144 C.	Self-consistent Molecular Orbital	62 minutes
167 D.	Products of Batch Distillations with Holdup	140 minutes
171 C.	Improved Power Spectrum Estimates	48 minutes
173	Course 6.537 Digital Computer Application Practise	332 minutes
174 C.	Tight Binding Calculations in Crystals	5 minutes
175 C.	Impurity Levels in Crystals	108 minutes
190 D.	Zeeman and Stark Effect in Positronium	9 minutes

1.3 Operating Statistics

1.31 Computer Time

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

Programs	116 hours, 26 minutes
Conversion	13 hours, 03 minutes
Magnetic Drum Test	76 minutes
Magnetic Tape Test	119 minutes
Scope Calibration	62 minutes
PETR Test	27 minutes
Demonstrations (#131)	2 hours, 26 minutes
Total Time Used	136 hours, 39 minutes
Total Time Assigned	170 hours, 52 minutes
Usable Time, Percentage	80%
Number of Programs	563

1.4 Academic Program

CS Programming Course

Sixteen students were enrolled in the two-week CS programming course which started on June 7. A revised version of the manual covering the first week's work was issued to each student. Whereas the original manual reflected CS I, the revised version has been made consistent with the provisions available in CS II. Preliminary notes on part of the second week's curriculum have been issued to the students. These will eventually be incorporated in the manual covering the second week's work.

Movie

The S&EC Group's movie "Making Electrons Count" has been completed and will be shown to Digital Computer Laboratory personnel in the very near future.

2. COMPUTER ENGINEERING

(S.H.Dodd)

Computer reliability decreased during the past biweekly period, partially because of troubles introduced by modifications of terminal equipment. Bugs in the recently installed Ferranti photoelectric tape reader and failures of the auxiliary drum were the major contributors to the lost computer time.

The auxiliary-drum write-group-selection system is being converted to electronic switching, digit by digit. It was intended to do this without interfering with the use of the auxiliary drum by WWI. However, by some means as yet undetermined, the information on group 11 is occasionally altered during the switchover of the write circuitry. Since the read-in program is on group 11, this has caused programmers some inconvenience.

2.1 WWI System Operation

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

The second magnetic-tape-printout system has been completely checked out and has been placed in operation. A memorandum is being prepared that will explain the operation and flexibility of the two systems.

(D.A.Morrison)

Tube data continues to be collected for the computer-reliability study. The data is being arranged to allow consideration of blocks of equipment and/or the complete computer.

Measurements are being taken of the in-out control matrices' input and output voltages to assure proper operation. These matrices are not marginal-checked.

2.12 Typewriter and Paper Tape (L.H.Norcott)

It has been proposed that the remaining short-carriage Flexo be sent to the factory to be equipped with a 20-inch carriage and a pinfeed platen capable of handling our wider forms. We are awaiting a quotation from the manufacturer before proceeding further.

2.2 Terminal Equipment

2.21 Magnetic Drums (L.D.Healy)

Work has been begun on the circuit additions and modifications necessary for the addition of two groups of auxiliary storage to the buffer-drum system.

3. ADMINISTRATION AND PERSONNEL

New Staff (J.C.Proctor)

Francis R. Drugin is working as a DDL Staff Member. He had been employed, until recently, as a Technical Engineer for IBM.

Gerald E. Mahoney is a new DIC Staff Member working for Charlie Adams for the summer. Until recently he was a Teaching Fellow, Ph.D candidate at Boston University.

Staff Termination

William Klein

New Non-Staff Personnel (R.A.Osborne)

Jean Bowse has joined Group 62 as a secretary.

Judith Brask is a new secretary in the Publications Office. She is a transfer from Group 3.

Lillian Connors is a new secretary for Frank Ryder.

Frank Vecchia is a new technician in the Construction Shop. He transferred from the Flight Control Laboratory.

James Johnson is also a technician from the Flight Control Laboratory who will be working in the Inspection Department.

Jean Randall is a new member of the Drafting Room.

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B136	Brainerd, Koehler, Reich and Woodruff	Ultra-High Frequency Techniques
B227	Jacques Cattell(ed.)	American Men of Science
C141	IBM	IBM Assembly Program 701 to 701
C142	Univ. of Illinois	Illiac Programming
C143	John L. Jones	A Survey of Automatic Coding Techniques for Digital Computers
C144	Harwood G. Kolsky	Numerical Solution of Three Simultaneous Second-Order Differential Equations Arising in the Low Energy Meson Theory of the Deuteron
C145	Joint IRE AIEE ACM	Proceedings of the Western Computer Conference 1953
C146	Joint IRE AIEE ACM	Trends in Computers: Automatic Control and Data Processing - West. Comp. Conf. 1954
C147 Vol.I- Vol.IV	Univ. of Penn.	Theory and Techniques for Design of Electronic Digital Computers
C148 Vol.I Vol.II	Univ. of Penn.	Report on the ENIAC
C149	E. G. Kogbetliantz	On the Solution of Linear Equations by Diagonalizing the Coefficients Matrix
C150	Herbert B. Hilton	Problem Programming for the EDVAC
C151	Charles R. Williams	A Review of ORDVAC Operating Experience
C153		Circular Functions
C154	King, Brown, and Ridenour	Photographic Techniques for Information Storage
C155	Russell J. Brooke	Applications of Computing Machines to the Problems of General Staffs
C156	M. E. Davis	The Use of Electronic Data Processing Systems in the Life Insurance Business
C157	ONR	The Elliott-N.R.D.C. Computer 401 Mark I
D41	Fritz John NBS	On Integration of Parabolic Equations by Difference Methods
D42	Alan L. Leiner NBS	System Specification for the DYSEAC
D37	John Todd NBS	The Condition of Certain Matrices II
D38	John Todd NBS	The Condition of the Finite Segments of the Hilbert Matrix

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D39	John Todd NBS	Experiment on the Inversion of a 16 X 16 Matrix
F173-101	Herbert J. Brun	Evaluation of an Integral Equation on WWI
F173-111	Harold A. Schapiro	A Checker Playing Program for the WWI Computer
F104	R. Cypser	Computer Search for Economical Operation of a Hydro Thermal Electric System

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