

6345  
Memorandum M-268

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Project Whirlwind  
Servomechanisms Laboratory  
Massachusetts Institute of Technology  
Cambridge, Massachusetts

SUBJECT: BI-WEEKLY REPORT, PART II, MARCH 5, 1948

To: 6345 Engineers

From: Jay W. Forrester

6.0 MATHEMATICS

(P. Franklin)

A description of WWI codes, with detailed effects of orders on AC, AR, BR, and Sx, was completed in M-217. A study of curve-fitting by using Legendre polynomials has been started.

(C. W. Adams)

Memorandum M217, Description of WWI Codes, has been distributed to Math and Block Diagrams Sections, but will be superseded by M217-1 which contains several recent minor revisions in the code. A memo describing the automatic subprogram method of performing double length operations is being completed, and other coding problems may then be considered.

(Edgar Reich)

Work on iterative methods for the solution of systems of linear algebraic equations is being continued.

Suppose the given system to be:

$$L(\vec{x}) = A\vec{x} - \vec{r} = 0$$

where all the elements on the main diagonal of A are 1. Mises (R. V. Mises and H. Pollaczek-Geiringer, "Praktische Verfahren der Gleichungsauflösung, Zeitschr. f. Angew. Math. u. Mech., 9, (1929), 58-76) describes the following iterative method together with conditions for its convergence:

$$x_1^{(v+1)} = x_1^{(v)} - L_1(x^{(v)})$$

A formula has been obtained giving an upper bound on the number of iterations required to obtain a given accuracy in the solution. The formula was tried on a 3rd order system and gave as the upper bound for the number of iterations needed a number approximately twice as large as the actual number of iterations that had to be carried out.

(M. Daniloff)

Simulation of aerodynamic coefficients continued.  
Current results:

- 1) For a fifth-degree parabola representing  $f_1(\alpha, 0, 0)$  the error is least at  $\alpha \approx 6^\circ$  and is of the order of  $\pm 0.2\%$  there. The error is considerably larger, in fact, excessive, at the lower values of the angle of attack.  $\alpha: (1, 2\%)$ .
- 2) It was found that the parabola of lowest degree which simulates  $f_1(\alpha, 0, 0)$  (WBWT; B-38000-G to B-38002-G incl.) with the degree of accuracy required ( $< 1\%$ ) is a complete cubic parabola, which gives a max. rel. error of  $\pm 0.9\%$ , and a max. abs. error of  $\pm 0.001$  ( $\alpha = 1^\circ$ ). The latter parabola corresponds to minimum values of the differences of the variate. It appears, therefore, essential for the calculator machine to recognize the order of the minimum differences, and contemplated coding procedures will take cognizance of the fact.
- 3) The Newton-Cotes method used above does not introduce any smoothing of the experimental functions. A limited amount of smoothing seems desirable, however, and this indicates the use of a least-squares procedure, such as area-moments fits. To render the successive approximations independent of each other, orthogonal functions (spherical harmonics) will be used as approximating function in future work.

7.0 INPUT AND OUTPUT

7.1 Eastman Kodak Recorders

(H. R. Boyd)

I participated in a conference at Eastman on March 2, 1948. The question of separate or combined reader and recorder units was discussed at length. The decision was to prepare the contract on the basis of six combined reader-recorder units and one film-processing machine.

7.4 Magnetic Recording

(E. S. Rich)

Circuits that will allow groups of pulses to be recorded in magnetic tape have been built. The consecutive recording pulses may be of the same polarity or of opposite polarity, and the length, the amplitude, and the spacing between pulses may be varied independently. Some data has been taken on the change in output-voltage waveform as the spacing between pulses is varied.

Since each output pulse consists of a positive and a negative voltage swing, a circuit which will convert these double swings to a single pulse of the proper polarity is required in the playback channel. The resolution that can be obtained between recorded pulses probably will depend on this circuit as well as on the characteristics of the recording medium. The design of a suitable playback circuit is now under consideration.

7.6 Output Printers

(Frederick Foss)

Teletype equipment has been selected for the initial printer application. A circuit has been designed which will convert numbers in coded decimal form, that are stored in a register, into equivalent Bandot teletype code signals. A modified transmitter distributor will be used in the generation of the teletype signals. Machine function orders for the teletype printer can be automatically transferred from this circuit or taken directly from the register.

## 5.0 STORAGE TUBES

### 5.1 Tube Construction and Testing

#### 5.1.1 Tube Construction and Processing

(F.H.Caswell)

Work of the past two weeks has centered on construction of a complete storage assembly for the first large storage tube, working out difficulties in mechanical construction in the assembly and constructing jigs for easy handling and welding of these large elements.

The structure is complete and ready for assembly.

Some time was spent on techniques of flucement coating on the face of envelopes used in some of the R.T. series of tubes.

(R. Shaw)

A complete signal-plate assembly for the 5-inch tube is being assembled. A second assembly will be completed the week of March 8. Since tests have indicated excessive creep of the signal plate, two revised designs are being developed in which no load will be borne by the plate except electrostatic forces and its own weight.

(J.H.McOusker, T.F.Clough and P.Youtz)

Several research tubes were constructed and processed during this period. However none of these tubes processed satisfactorily. The nonex tubing used in these tubes was faulty material. Henceforth we will not use this tubing for tubes.

The vibrations of the vacuum system, which have been causing troubles, have been damped.

Construction of dies for the vertical stem equipment has taken longer than anticipated. Nonex stems have been constructed with hand working tools.

We are ready to start the processing of five-inch tubes. We expect some glass working and exhaust problems in the early models.

We expect an experienced glass blower to join the vacuum tube laboratory within a week. Our laboratory has been rearranged to accommodate extra help and adapted for an accelerated tube construction program.

### 8.12 Tube Testing

(M. Florencourt)

RT 12 is a research tube constructed to test the modifications made on a low velocity gun to make it useable as a holding gun for the 5<sup>th</sup> storage assembly. Initial tests showed that beam current was about 1 ma for 1000 volts accelerating potential and that an evenly dispersed beam covering the entire face of the 5<sup>th</sup> tube was obtained in the presence of no focus voltage. These indications were entirely satisfactory. However, later, with the beam still unfocused, parts of it began to cluster, giving a mottled ring effect against a uniform background; beam current had decreased to about 600  $\mu$ a. Still later the beam covered less and less of the tube face and beam current decreased to about 15  $\mu$ a. The tube was quite gassy which may have accounted for the initial excellent covering results and the ultimate degeneration of the cathode. It is interesting to note that when the tube was turned on the second day, measurable emission from the cathode did not occur for about ten minutes. The third day, emission did not occur for at least an hour. These emission delays were also probably attributable to the gas in the tube. However, indications are that the modifications made on this low velocity gun to produce a suitable holding gun for the larger storage tubes may be adequate. Another tube will be built like this one to check the results at high vacuum.

### 8.13 Storage Tube Demonstration

(S.H.Dodd)

All components in the demonstrator have been connected. Operation is not good enough for use of indicator lights. Large capacitances at signal plate and undesirable transients have handicapped scope presentation. The units and time intervals are being adjusted.

## 8.2 Storage Tube Research

### 8.21 Surface Material Characteristics

(H.L.Haydt)

The secondary emission measurement set-up has been improved by making modifications which chiefly involve more adequate shielding and relocation of parts and equipment. The resulting reduction in amplifier pick-up reduces by 50% the possible error in measurement of secondary and primary currents of low values. It is thus possible to make measurements using considerably less beam current. Such low current is desirable in minimizing fatigue in the secondary emission from surfaces under test.

The literature is being examined for comments on fatigue in secondary emission from cesium-silver surfaces similar to those considered

as possible storage surfaces. Such fatigue was found to have been observed and reported upon in a few cases. Further investigation of the literature concerning this matter will be made.

### 8.23 Output System Circuits

(C.H.R. Campling)

Memorandum M-252 which outlines a time schedule for output-system development has been completed and distributed. To date, the work is running approximately according to this schedule. The gate-amplifier has been designed and a breadboard has been partially constructed. It probably will be completed and ready for testing by the beginning of next week - about one week ahead of schedule. Tentative designs have been worked out for the a-c coupled clamp-circuit and the delay-line differentiator-circuit. Construction has begun on both of these. A new d-c coupled clamp-circuit is being designed for use with standard WWI voltages (only those voltages which are available at present from the common supply system and in addition, + 500 volts) This task should be complete by March 15.

George Hoberg has given valuable assistance in designing pulse transformers to be used with the delay-line differentiator circuit. Three different experimental transformers were designed and have been ordered from the New England Transformer Corporation. Transformers for the transformer-coupled circuit have not been investigated yet, but they should not be too great a problem because it will not be necessary to design them for exceptionally good low frequency response as was the case with the transformers for the delay line circuits. It should be possible to build them here.

To sum up: the work on pulse transformers is a few days behind schedule, while work on the delay-line circuit and gate-amplifier is ahead of schedule.

### 8.25 Electrolytic Tank

(S.H.Dodd)

Pieces of lucite for the electrolytic tank have been machined and partially assembled with G.E. Thinner and coil dope. Work on this unit has been temporarily stopped because of more urgent projects.

### 8.3 Unclassified

#### Time Schedule

(S.H.Dodd) A time schedule has been tentatively written for storage tube construction during the rest of this year. This included discussion of possible lines of research and indicates under what conditions each line will be followed. The schedule

is being made assuming an objective of constructing 32 useable tubes for WWI by the end of 1948. A schedule for testing all tubes will be integrated with the above program.

(W.J.Nolan)

Work has been started on the changes which have been made necessary in the vacuum tube laboratory by the increase in personnel and equipment in that area. The anodizing equipment has been moved to Room 226. The glass working bench has been moved into the space formerly occupied by the anodizing equipment. A second glass working bench is being built and the annealing oven permanently connected. The spot welder was moved out by F. Caswell's bench.

(M. Florencourt)

There will be available in Room 220, a file on each tube constructed by the storage tube group. The file on each tube will contain its objective, an outline of important information or its component-construction and processing, pertinent photographs, and the test results.

#### 8.4 Deflection Circuits

(John O. Ely)

Work on deflection circuits is proceeding under the proposal issued as M-243. Sketches of the circuit schematic are complete. Work on laying out the circuit has been started. It is expected that the layout will be far enough along by Monday, March 8, for the electronics shop to start construction. Time schedules for completion of layout and preliminary design tests should be extended one week from the dates shown on drawing B-31615.

Preliminary design tests indicate that regulation and ripple on voltages supplied to the switching circuits and the output amplifier should not total more than  $\pm 1\%$ . Permissible regulation and ripple on the voltage supplied to the decoder resistors is set by storage-tube characteristics, and will be of the order of  $\pm 1/4\%$  total.

An estimate of power required for WWI deflection circuits has been submitted to H.S.Lee.

During the next two-week period preliminary design testing and layout work will be completed. Construction of the first deflection-voltage generator will be begun, and a write-up of the design work and preliminary testing will be begun.

(Louis J Nardone)

Tests were performed on the output amplifier for the deflection voltage generator. Satisfactory operation was obtained after a

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few changes of circuit elements. Tests are being made to obtain a greater voltage swing of the amplifier. The output voltage of the amplifier, as a function of the binary number, varied only slightly from linearity.

A linear analysis of the amplifier to be used with Whirlwind I was made. Results showed the gain to be 12.4, the input resistance 89.7 ohms, and the output resistance 10.4 ohms.

During the next two weeks, preliminary design tests will be completed and write up of design tests will begin.



9.0 SERVOS AND SIMULATION

9.1 Cockpit

9.11 Structure:

(E. S. Prohaska)

A study of variation in force applied on the controls per unit piston force with control position has resulted in the redesign of the linkage system to limit this variation to 10%.

P. Tilton is checking with Mr. Ball of Boeing Company on the possibility of Project Whirlwind acquiring the pilots' seat and rudder pedals now in Building 32.

9.13 Control Force Loading:

(C. G. Eaton)

The necessary machine work for modification of the differential pressure regulator has been completed. The valve has been reassembled, and performance tests are being started.

9.2 Sampling Servo Stability Study:

(W. Linvill)

The consideration of the variables  $\theta_i$  (input) and  $\theta_o$  (output) at only discrete values of time, namely at the sampling periods, allows one to write transfer functions of a sort analogous to the Laplace transfer functions which apply to continuous linear systems. The use of these analogous transfer functions allows one to predict the stability of the system even if the sampling switching occurs within the servo loop. Unfortunately, the resulting transfer functions are quite complicated and considerable effort is necessary to deduce from them the time response of the system. More simplified analysis will be tried in an attempt to correlate more directly the time response and the parameters of the system.

11.0 FACILITIES AND CENTRAL SERVICE

11.1 Publications

(J. N. Ulman, Jr.) The following material has been received in the Library, Room 217, and is available to 6345 personnel.

6345 Reports

E-103	ION Current Measurements in 7AK7 and 6AG7 Tubes	M.H.Hayes J.J.O'Brien
M-217	Description of Whirlwind I Codes	C. W. Adams
M-243	Proposal for Deflection-Circuit Development	J. O. Ely
M-245	Bi-Weekly Report Part I Feb. 20, 1948	J.W.Forrester
M-246	Bi-Weekly Report Part II Feb. 20, 1948	J.W.Forrester
M-249	Meeting of Electronics Group Feb. 13	J.J.O'Brien
M-251	Standards Committee Meeting on Power Connectors	H.Fahnestock
M-252	Proposal for Investigation of Storage-Tube Output-Circuits	C.Campling
M-253	Vacuum Tubes, Raytheon	J.W.Forrester
M-254	Neon Indicators and Sockets	H. Fahnestock
M-255	Engraving of Whirlwind I Panels	H. Fahnestock
M-256	Form of Change Notices	H. Fahnestock
M-257	B-Register Layout, Sylvania Drawing No. W60BROO-2	H. Fahnestock
M-258	7AK7 Construction	H. Fahnestock

Library Files

52	Progress Report for WWI Electronic Computer for period Jan. 31, 1948 - Feb. 13, 1948	Sylvania
62	Bulletin of the American Mathematical Society- Volume 53, No. 11, November 1947	
63	Science - the scientist's newsweekly. September 12, 1947	
	File Proceedings of the I.R.E. - A Journal of Communications and Electronic Engineering, March 1948, Vol. 36, No. 3	

11.2 Standards Committee

(S. Abbott)

The following specifications (M.I.T.) have been approved and distributed since the last report:

	Standards - General Index
Class P6.04	Connectors
Class P6.05	Knobs and Dials
Class P6.06	Fuses
Class P6.08	Insulating Materials
Class P6.11	Voltage Cells
Class P6.17	Switches

Class P6.19  
Class P6.20

Pulse Transformers  
Tubes, Electron

The following specifications (W/I) have been approved and distributed since the last report:

Class P7.16  
Class S7.21  
Class S7.503

Sockets, Tube  
Wire, Hook-up  
Wiring Standards (Revised)

Class P6.14 Relays, is at present in the Drafting Room and will be ready for distribution within the next few days.

### 11.3 Purchasing - Stock

(H. Morley)

A meeting of Sylvania and M.I.T. personnel was held with representatives of Waltham Horological Company to discuss power connectors for W/I. Details are discussed in Memorandum M-251. Samples are being obtained from Industrial Products and Waltham Horological Company.

Samples of RF chokes impregnated with a new compound have been received from BB Chemical. The compound does not appear to be heavy enough to give the desired protection.

The Kardex cross-reference file has been completely revised to conform with the new standards book, and new cards made up and placed in the file. The work of transferring current information from the old cards is practically completed.

A complete inventory of all standard items in stock has been taken and the inventory figures posted to the Kardex file. An inventory of motors and transformers is now in progress.

The majority of unplaced requisitions mentioned in the last report has been cleared up either through placement, or in cases where need for material has expired, by cancellation.

### 11.4 Electronic Construction

(L. Taylor)

Electronic Construction underway on power supplies for ST group. Delays caused by lack of stock on hand. D.C. Plug-in strips being manufactured for use on racks.

(F. H. Caswell)

Full time of two technicians and one-half time of one technician has been utilized for the past two weeks in lab. maintenance. The construction of the Plexiglass Electrolytic Tank was begun but temporarily discontinued to move the Anodizing bench and install and re-wire it in another room, relocate the glass working bench and repipe it, and install another glass working bench.

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One-half time of one technician was utilized in electronic work. The spot welder has also been removed from the pump room and re-located in the storage tube lab.

(R. Murch)

The following jobs and units are in the Electronic Lab. for construction.

1. 10 D C Bench outlet boxes. 6 completed. Others are being held until new voltages and pin connections have been decided on.
2. Modifications to Single Pulse Synchronizers. Holding until Test Equipment Committee approves.
3. Clock and Restorer Pulse Source. Formerly called Restorer Clock Pulse Distributer. All parts have been received for this job and it will be completed about March 10.
4. 25 Adapter Sockets. 13 completed. Waiting for Amphenol Shells for balance of job.
5. Cable layout for Accumulator. No work has been done on this as all the information needed is not available.
6. Layout and Design of Rack Power Control Unit. Mod. 2. Apprx. 2/3 complete. Will be completed as soon as information of Filament Transformers and relays for plus 500 volts is received.
7. Whiffle Tree Electronic Switch for digit #1 of Multiplier. Will be completed today.
8. 10 A C Circuit Breaker Boxes in machine shop for machine work.
9. Flip-flop Register.
10. Experimental Binary Counter 2:1 and 4:1.
11. Deflection Voltage Generator. Work will start on this March 8.
12. Modification on P-5 Synchroscope to make a 2 gun scope. There is apprx. 2 weeks work for the lab. This includes some time that will be spent on the D C Voltage Changes.

11.5 Drafting

(A. M. Falcione)

1. On the 28th of February, the Drafting Room was reorganized insofar as the physical layout was concerned. Four additional drafting tables were received and placed in accordance with a previous layout.

2. Some time ago a system was established by the Print Room to insure that each of the four master print files was kept up to date on all approved drawings and sketches. However, a subsequent check of the files reveals that many prints previously included are now missing, especially so with the Library Print files. It is possible that these prints are being removed by personnel and not returned.

(Hugh R. Boyd)

The library print file is the master print file for the laboratory, and it is essential that be kept complete. Prints may be removed from this file by A. Falcione, T. Leary, and Mrs. Richardson ONLY.

3. It is expected that within the next few days a locking arrangement will be installed to the Library Print files in order to comply with Section I of Administrative Memorandum A-55. All tracings will be kept locked in the plan files every night.

#### 11.6 Unclassified

(Al Taylor)

A serve system has been built and is now being tested. It is to be used to regulate the output of the D. C. Power Supplies.

The machine shop is now making parts and jigs for the S.T. group. This work consumes about 75% of available machinist time. A small amount of chassis work is being done.

Arrangements have been made to obtain a power hack saw and small radial drill.

(R. A. Osborne)

#### Time Schedules

Whirlwind I time schedule forms (C-31626) have been distributed to all concerned. A separate schedule is to be made, and kept up to date, for all elements of the computer plus auxiliary equipment, and other phases of the program such as test equipment, the cockpit program, and air conditioning.

12.0 GENERAL

(H. Falmostock)

Add a new Bi-Weekly Report classification: 2.16 Basic Circuits.

(H. Boyd)

New Non-Staff Personnel

Flynn, Ernest - is a new guard and cleaner. He was formerly with Polaroid and lives in Cambridge.

Branning, Mrs. Helen - is the new receptionist replacing Miss Carney. She lives in Newtonville and is a graduate of Brimmer-May and Greenbrier Jr. College.

Rounds, Miss Sarah - is also a new receptionist and operator. She lives in Cambridge and is a graduate of Chapel Hill School, Wheaton College, and Cambridge Junior College.

Norato, Mrs. Anne - is a secretary replacing Mrs. Gilchrist who transferred to another department. She graduated from Jamaica Plain High School, Boston Clerical and Burdett College. Her work has been as a stewardess on the Grace Lines, and as secretary at the Rich Construction Company. Her husband is a musician and they live in Boston.

Johnson, Mrs. Loyce - is a secretary who will replace Mrs. Harvey when she transfers to another department. She attended Alabama College for Women for two years and was a secretary in Civil Service for four years. Her husband is a Navy Student at M.I.T. and they live in Cambridge.

Thesis Students

Horton, William - recently joined the project to continue thesis work on the a-c flip-flop. This work was originally carried on by his brother, Bruce, who has left the project.

Foss, Frederick - is an electrical engineering student and is doing a thesis with R.R. Everett on output printers.

Terminations

The following persons have terminated recently:

Mrs. Olga Gilchrist  
Miss Lillian Carney  
John Survelas  
Bruce Horton