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Memorandum M-364

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Project Whirlwind  
Servomechanisms Laboratory  
Massachusetts Institute of Technology  
Cambridge, Massachusetts

SUBJECT: BI-WEEKLY REPORT, PART II, APRIL 16, 1948

To: 6345 Engineers

From: Jay W. Forrester

6.0 MATHEMATICS

(P. Franklin)

In using a polynomial approximation for an empirical function, as compared with linear interpolation, the storage is much less but the time and number of orders is increased by over three for cubic polynomials and about two for quadratic polynomials. For many purposes quadratic polynomials are adequate and the time compares favorably with second difference interpolation. This applies to functions of several variables as well as to functions of one variable.

(C. W. Adams)

A rather brief consideration of coding binary to binary-decimal conversion has been submitted to R. R. Everett in M-345. The conversion can be very satisfactorily carried out in 48 orders or less, and should take less than a millisecond per conversion. The converse problem of binary-decimal to binary conversion is rather similar and should take roughly the same amount of time.

At present, attention is being given to coding a continuous solution of a system of  $n$  linear first order ordinary differential equations by numerical methods. A still more general type of equations may then be considered.

(Edgar Reich)

Various means of instructing the machine when to stop iterating with the Seidel process are being considered. The basic difficulty lies in the fact that round-off disturbs the convergence behaviour near the limit.

6.0 MATHEMATICS, Continued

(M. Daniloff)

The function  $f_1(d, \delta F, \Sigma \pi'_{2+3}) = f_1(d, 0, \Sigma)$  where  
 $\Sigma = \Sigma \pi'_{2+3}$  has been completely simulated for the ranges  $0 \leq \alpha \leq 10^\circ$   
 $\delta F = 0; 0 \leq \Sigma \leq 0.4$  (prescribed in memorandums M-65, M-6 of Mar. 31  
 and Apr. 4, 1946, respectively by H. Fahnstock) by a polynomial  
 with terms up to  $\Sigma^2 \alpha^3$ .

The simulation is accurate to one unit in the third place.  
 This is to be considered as a perfect rendering of the function  
 since the accuracy of Figs. WBWT-B-38000-G to B-38002-G inclusive  
 is of the order of 2 or 3 in the third place.

The results of these investigations are being collated in  
 a memorandum at present under preparation.

In appraising the accuracy of simulation obtained it should  
 be noted that Pflieger of the Bell Laboratories (R-14) accepted an  
 error of estimate of several units in the second place in a similar  
 simulation problem relating to aircraft engines.

Translation is under way (from Russian) of Dr. Ivanov  
 "Solution of a Large Number of Simultaneous linear equations by  
 methods of successive approximations" (Transactions of the  
 Academy of Sciences of USSR, (1939).

7.0 INPUT AND OUTPUT

7.3 Binary to Analog Conversion

(E. W. Sard)

My thesis proposal on conversion of a binary pulse code to voltage amplitude (M-345) was approved on April 14 by the E. E. Department, Committee on Graduate Study and Research.

Design, construction and some testing of a 100 kc pulse generator, a timing pulse source, and a 7-digit parallel binary coder has been completed. The remaining construction of a decoder and a decoder gate generator is underway.

It appears that the difficult problem of building a high gain amplifier may be avoided by using the Ballantine voltmeter amplifier together with the Ballantine decade amplifier. This combination will give a gain up to 300,000 and can handle an input signal of about 10 or 20  $\mu$ v without excessive noise.

7.4 Magnetic Recording

(Edwin S. Rich)

The thesis report covering the investigation of pulse recording on magnetic tape is being written.

7.6 Output Printers

(F. A. Foss)

A transmitter distributor has been used in conjunction with the relay selector circuit to generate standard teletype signals. An intermediate power amplifier stage has been added to provide for the necessary level of operating current through the line to the teletype printer.

The transfer of digits which will be synchronized with the transmitter distributor motion has been under study. An additional register has been provided for this purpose.

8.0 STORAGE TUBES

8.1 Tube Construction and Testing

8.11 Tube Construction and Processing

(J. H. McCusker, T. F. Clough and P. Youts)

The second five-inch storage tube has been constructed and processed. A fault developed in the cathode of the holding gun during processing. It is necessary to cut out both guns and reprocess the tube. This tube and the third five-inch storage tube will be processed next week. These five-inch tubes pumped satisfactorily. The first tube has been operating two weeks without developing any noticeable gas. We expected to encounter difficulties in pumping these tubes to a satisfactory vacuum.

The first few five-inch storage tubes will have a calcium tungstate on  $Al_2O_3$  storage surface.

Techniques for evaporating a beryllium mosaic on a five-inch  $Al_2O_3$  surface are being investigated. We expect to evaporate several such surfaces during the next fortnight.

A storage tube will be constructed with a storage surface of 40 mesh beryllium mosaic on 1 3/8 inch-diameter  $Al_2O_3$  surface using a 40 mesh, 2 mil evaporating mask. This type of surface is expected to have better secondary emission characteristics and more stable storage. A research tube will be constructed to study secondary emission characteristics of the beryllium mosaic surfaces having 85 percent conducting areas.

A series of research tubes to study secondary emission characteristics of beryllium with varying thicknesses of beryllium oxide have been constructed and are being processed.

Tests indicate that removing the deflection plates and enlarging the apertures of a 5 UP electron gun does not give a uniform beam of sufficient intensity over a five-inch surface. Considerable effort will be put into the design of new-type holding guns.



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8.11 Tube Construction and Processing (cont'd)

The hydrogen-firing ovens of RLE were serviced and did not delay any of our work.

The exhaust systems, operated under supervision only eight hours a day, are not adequate to handle the present schedule of tube construction. Under consideration is the design of a system to evaporate materials, vacuum fire and could be used to braze in an atmosphere of hydrogen.

(F. H. Caswell)

Five evaporation tubes, five research tubes and one large 5-inch storage tube were fabricated and assembled during the past two weeks, with their particular envelopes and gun modifications. Another large 5-inch storage unit with major changes is ready for assembly. Photographs of any new types of construction are kept up to date. New jig construction continues, to facilitate glass work and tube fabrication. Our own calcium tungstate settling continues to be quite successful and was used in the second large storage tube. A small oven of transite, for drying calcium tungstate, has been constructed. A temperature of 155<sup>0</sup>C can be reached in two hours.

(R. Shaw)

One more signal plate assembly has been completed and installed in ST-26. An assembly of improved design is now under construction. Another set of parts are on hand and will be assembled during the week of April 20.

The stretching fixture mentioned in the previous report has been received and appears satisfactory; however, it cannot be used until a new supporting table is also received.

A start has been made on the mechanical design of a new holding gun based on data supplied by P. Youtz.

M-353 has been issued describing signal plate assembly for ST-25.

M-344 gives recommended procedures for machining nickel.

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### 8.12 Tube Testing

(S. H. Dodd)

ST-25 has been tested for storage operation (see section 8.11 of M-332 for construction details). A heater was burned out in the holding gun during activation on the pumps and the gun was out of the tube and the heater changed. Exposing the cathode to the air was probably the cause of the very low holding beam current density. The total current to the target end of the tube was only 10% of the expected current. This current, however, was enough to observe operation. The tube storage characteristics were quite similar to ST-18. The signal plate output capacitance of ST-25 is 225  $\mu\text{f}$  as compared to 30  $\mu\text{f}$  for ST-18. This gives slower rise times on the output pulse but in general operation/ST-25 was quite satisfactory.

(M. I. Florencourt)

The fifth in a series of holding-gun research tubes, ST16A, contains a 5 UP gun modified so that the electrode apertures are enlarged, second grid and second anode are separated, and narrow deflection plates added.

Test results on this tube were quantitatively disappointing in most respects. Beam current was low - about 250  $\mu\text{a}$  at a maximum and only about 70  $\mu\text{a}$  for the largest area of covering obtained. The area of covering was small - about a 2 1/2-inch diameter circle. However, uniformity of covering was fairly good in that, for optimum focus conditions, there were no reflection patterns visible from any of the electrodes or plates. Deflection sensitivity was satisfactory.

Future holding-guns will be designed to have most of the cathode current channelled into the main beam and not intercepted by the second grid.

### 8.13 Storage Tube Demonstration

(J. S. Rochefort)

The report on E.S.T. Demonstrator is still in preparation. The majority of drawings are complete, and the remainder are being processed by the drafting department. The first draft of the report should be completed next week.

## 5.2 Storage Tube Research

### 5.21 Surface Material Characteristics

(H. L. Haydt)

Design and construction of the secondary emission life-test rack has been completed. The life rack can accommodate twelve research tubes, six of which will be operated at low primary velocities, and the remaining six will be operated at high primary velocities.

Considerable testing was performed on a special research tube, RT 17. This tube had two separate targets, the first a  $1/4$ " diameter nickel target located two inches from the second anode of the gun, and the second, a larger target located concentrically  $1/8$ " behind the first target. Results on RT 17 show that the proposed technique for secondary emission measurements and life-testing on the new type research tubes is adequate. It was shown that during life-testing the beam may be sufficiently de-focused to more than cover a target area  $1/4$ " in diameter. It was also shown that in making secondary emission measurements, over 98% of the primary beam will strike the  $1/4$ " diameter target area for all values of primary velocity.

Research tube RT 15-2 was subjected to secondary emission tests, but a low-resistance short between the beryllium surface and the signal plate made measurements impossible.

Research tube RT 18, containing an evaporated surface beryllium on  $Al_2O_3$ , has been studied briefly using both d-c and dynamic techniques. The first crossover in the secondary emission curve for the surface is near 50 volts, while at 1500 volts, the secondary emission ratio exceeds 2.7. This tube will be subjected to life-tests, and secondary emission measurements will be made on it periodically.

(W. J. Nolan)

Life tests on the 931-A phototubes are continuing. The present tubes have been in operation about 400 hours. Deterioration of secondary emission characteristics was quite rapid during the first 100 hours of operation but there now appears to be little change. Secondary emission ratio and first crossover voltage are still entirely satisfactory for use in a storage tube.

### 8.23 Output-System Circuits

(C. H. R. Campling)

Tests to determine the feasibility of using the method of voltage cancellation to couple the signal-plate of the storage-tube to an amplifier have continued. It has been found that, even with back-to-back crystals on the output of the network, the transients caused by the leading and trailing edge of the switching pulse, while of reasonable amplitude, have decay-times of the order of twenty to thirty microseconds. This unfortunate situation can be attributed to the oscillatory transients which are associated with the pulse transformer. Furthermore, no network has been found which will at the same time give effective cancellation of the switching transients and pass the signal pulse.

More success has been attained with the system of transformer coupling. Tests have been made to determine the nature of the transients which occur at the secondary of a No. 103 pulse transformer when a capacity of 200 micromicrofarads is charged through the primary winding by a 350-volt gate. The 200 micromicrofarad capacitor was used to simulate the capacity to ground associated with the signal-plate. The transients are large but they can be reduced effectively by loading both the primary and secondary of the transformer with back-to-back crystals. Spikes of about two volts amplitude are obtained, and again the decay times are 20 or 30 microseconds. However, it has been possible to reduce these decays to 6 or 7 microseconds by using a shorted delay line to differentiate the output. There is every indication that the circuit will pass signals of the order of one-tenth volt up to several tenths of a volt without attenuation.

### 8.4 Deflection Circuits

(John O. Ely)

Power supplies and test equipment for testing the 3.2-position deflection-voltage generator have been set up and checked for satisfactory operation. The deflection-voltage generator itself was delivered this morning (4-16-48) by the shop and is ready for power cabling and installation of tubes. Preparation of the report on the design of this unit is continuing.



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8.4 Deflection Circuits (Cont'd)

Analysis of the operation of the decoding circuits indicates that selection of crystals in the increment switches probably is unnecessary beyond testing for acceptable back resistance at -20v.

(L. J. Nardone)

Testing of the single increment deflection voltage generator was completed. Voltage and timing measurements were obtained for all grid and plate waveforms for the single increment deflection voltage generator. Photographs of these same waveforms were also obtained.

## 9.0 SERVOS AND SIMULATION

### 9.1 Cockpit

#### 9.11 Cockpit Structure

(E.S. Prohaska)

The final design of the potentiometer and tachometer drive is partially completed and is expected to be ready for detailing by the end of next week. The potentiometers selected are Fairchild type 748 and the tachometers, Arama type 5 Induction Generators. Although these have an extremely large inertia (2.7 oz. in<sup>2</sup>), the low noise level (1<sup>mv</sup> in phase, 2<sup>mv</sup> quad.) makes it desirable to use them.

Two tachometers in each axis are necessary. It is expected that the excitation of the velocity measuring tachometer will be varied by the computer signals to produce the changes in damping at the controls while the excitation of the acceleration measuring tachometer will be constant because the inertia of the controls will be considered constant.

#### 9.13 Control Force Loading

(C.G. Eaton)

The past two weeks have been spent in modifying the regulator valve, and the linkage of the torque motor.

The machine work has just been completed, and the re-installation of the regulator valve and torque motor is now being completed.

### 9.2 Sampling Servo Stability Study

(W. Linvill)

Some progress has been made in the determination of overall system functions which result from simplified impulse-response functions. An approximation of the impulse response of the feed-forward system by additive components other than exponentials of differing decrements, as was done by Hurewicz, has resulted in system functions which are considerably simpler than those of Hurewicz. As soon as results are complete, it is proposed to include them in a separate report.

Present indications are that the characteristic times of an overall system with switching after the error detector can't be decreased to less than 2 or 3 times the switching period.

10.0 TRAINING

10.1 Seminar Series

(R.R. Everett)

No seminars will be held the week of April 19 because of the academic vacation.

The block diagram or computer description part of the seminar has been completed. Beginning April 26, detailed consideration will be given to mathematics, coding, and applications.

(R.P. Mayer)

LECTURE I, INTRODUCTION, is on file in the library.

The present plan is to distribute these conference notes only in groups of six, which will be bound in blue Whirlwind backers.

Other lectures are now being processed.

11.0 FACILITIES AND CENTRAL SERVICE11.1 Publications

(J. N. Ulman, Jr.)

The following material has been received in the Library, Room 217, and is available to 6345 Personnel.

<u>No.</u>	<u>Title</u>	<u>No. of Pages</u>	<u>No. of Drwgs.</u>	<u>Date</u>	<u>Author</u>
E-108	Sylvania Test Equipment	1	-	3/26/48	N. H. Taylor
E-109	6AS6 Vacuum Tube Life Data	2	2	4/5/48	J. J. O'Brien
M-328	Double Length Operations in WWI	11	-	3/31/48	C. W. Adams
M-329	Modification of Basic Circuit Ind-1	4	3	4/2/48	J. M. Hunt
M-331	Bi-Weekly Report, Part I, April 2, 1948	18	-	4/2/48	J. W. Forrester
M-332	Bi-Weekly Report, Part II, April 2, 1948	21	-	4/2/48	J. W. Forrester
M-334	Wedge Sleeve Clamp for BNC Connectors	1	2	4/5/48	H. Fahnestock
M-335	Progress Report: A Trouble Location Scheme for a Digital Electronic Computer	2	1	4/5/48	E. Blumenthal
M-336	Progress Report: A Trouble Location Scheme for a Digital Electronic Computer	2	-	4/5/48	G. Hoberg
M-337	Progress Report: A Storage Tube Output System	2	-	4/3/48	C. Campling
M-339	WWI Rack Door Material	1	-	4/5/48	J. W. Forrester
M-340	B-Register Prototype Drawing Approval	2	-	4/6/48	H. Fahnestock
M-341	Trip to Power Equipment Co., Detroit, Mich., on March 29th	3	-	4/6/48	H. R. Boyd
M-342	Standards Committee Approval of Mechanical Parts Designed by Sylvania	1	-	4/7/48	C. W. Watt, Jr.
M-343	17S Dural Channel	1	-	4/7/48	C. W. Watt, Jr.
M-344	Machining of Nickel	2	-	4/7/48	R. Shaw, Jr.
M-345	Binary to Binary-Decimal Conversion	4	2	4/8/48	C. W. Adams
M-346	Power Supply Proposal No. 2	4	1	4/8/48	H. R. Boyd
M-347	Receptionists and Guard Duties	2	-	4/9/48	H. R. Boyd
M-348	Master's Thesis Research Proposal: Conversion of Binary Pulse Code to Voltage Amplitude	9	6	4/6/48	E. W. Sard



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<u>No.</u>	<u>Title</u>	<u>No. of Pages</u>	<u>No. of Drwgs.</u>	<u>Date</u>	<u>Author</u>
M-351	Meetings of the Electronics Group, March 26 and April 2, 1948	1	-	4/8/48	J. J. O'Brien
M-353	Signal Plate Assembly for ST25	2	-	4/13/48	R. Shaw, Jr.
M-354	Control Drawings	1	-	4/13/48	H. Fahnestock
M-355	VVVI Panels, Provisions for Spare Tubes	1	-	4/13/48	H. Fahnestock
M-356	Whirlwind I Panel Wiring Diagrams	1	-	4/13/48	H. Fahnestock
M-358	Time Pulse Distributor - Counter Panel: Circuit Schematic Corrections	1	-	4/14/48	H. Fahnestock
M-359	Bus Driver Prototype Drawing Authorisation	1	-	4/14/48	H. Fahnestock
M-360	Drafting Requirements	1	-	4/15/48	A. M. Falcione
A-55	Security and Classification	4	-	2/20/48	(J. Forrester H. R. Boyd)
A-56	Procurement of Mechanical Parts and Assemblies	3	-	4/13/48	H. R. Boyd
C-27	Project Whirlwind Seminar No. 1, Introduction	4	-	1/12/48	J. W. Forrester

Library Files

64	Numerical Inverting of Matrices of High Order				von Neumann and Goldstine
Book	A Symposium on Large-Scale Digital Calculating Machinery				Harvard

Reports on Loan from Library of Congress until April 23, 1948.

B U242	Fundamental Research on Bolometers of the Semi-Conducting Type. Interim.
B U243	Fundamental Research on Bolometers of the Semi-Conducting Type. Annual.
G U263	Thermionic Emission of Various Materials

11.2 Standards Committee

(S. Abbott)

The survey of tubes required for the Storage Tube Test Equipment, and test equipment made in the laboratory has been completed.

Tubes required for the Commercial Test Equipment is being surveyed.

The present Standard Tube list will be revised to include any additional tubes required for this test equipment.

As suggested by the Standards Group, a list of Western Electric fuses, (indicator alarm type), has been prepared and submitted to procurement.

(C. W. Watt)

The specifications mentioned in the last bi-weekly report have been approved by Fahnestock and Stevens and are now a part of the WWI standards book, with the exception of P 7.018 Channel, which will be deleted.

No new specifications were issued during this two-week period.

Power Connectors

A sample Power Connector was received from Industrial Products Co., which was better than the Waltham Horological Co. sample. It was decided to use this Connector for WWI. Delivery of 6 sample pairs to be used in prototypes is expected in 3 weeks. Drawings of this connector are available, and future layouts will incorporate it.

11.3 Purchasing - Stock

(H. B. Morley)

In anticipation of increased demands on the stockroom, a program is now in effect to increase stocks of standard components to adequate levels.

An increasing amount of administrative time in this office is being spent on problems such as locating special components or manufacturers who can produce them, determining test specifications and tolerances, and similar matters.

11.3 Purchasing - Stock (Cont.)

It is urgently requested that engineers hold in abeyance requests for price, availability and delivery information on proposed components, until it has been determined with reasonable certainty that there will be actual requirements for such components or closely similar ones. Such inquiries often set up a chain of correspondence and calls from sales and engineering representatives of vendor companies, which may represent time and effort spent investigating an item in which we are no longer interested.

(H. R. Boyd)

Raymond Fairbrother has joined the project to administer the stockroom. The present procedures will be continued with these additions.

1. An inspection department for testing electrical components is being set up. Doyle and Hannon will perform the inspections.
2. Mr. Fairbrother will coordinate material needs and help Mr. Morley in anticipating material requirements as far ahead of the need as possible.

In addition, he will take over the responsibility for equipment and tool records and inventories about May 15.

11.4 Electronic Construction

(A. J. Taylor)

Work on the vacuum tube life test panels has been delayed for lack of parts. The fuseholders were received this morning and work has been resumed. This will permit delivery of 40 units by the end of this month.

(Robert H. Murch)

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

1. 4 d-c Bench Outlet Boxes.  
These units are being held until a relay is available so that a control for +500 volts can be added to them.
2. Accumulator Proto-Type.  
This will be completed about April 23.

11.4 Electronic Construction (Cont.)

3. Restorer and Push Button Pulse Generator for Time Pulse Distributor.  
This is completed except for pulse transformers which are out of stock.
4. Rack Power Control Unit Proto-Type.  
This unit will be completed about April 22.
5. Pulse Code to Pulse Time Decode Breadboard.  
This will be completed April 20.
6. Time Pulse Distributor Control Breadboard.  
This will be completed about April 24.
7. Decoder Gate Generator Breadboard.  
This will be completed about April 24.
8. Gate and Delay Unit Proto-Type.  
This will be completed about April 24.
9. Horizontal Coordinate of Deflection Voltage Generator.  
Construction of this panel will start as soon as tests are completed on vertical coordinate.
10. Arithmetic Control for WWI.  
Construction of this unit will proceed according to time schedule C-31654.

Jobs 1 to 8 inclusive represent about 5 days work for the Lab. Job #9 will require about 5 man-weeks when it is available.

(F. H. Caswell)

Construction, installation and checking of the video amplifier in a P5 Syncroscope has been completed. All oxygen, gas, and air lines of the new glass working bench have been checked. Permanent wiring for supply to portable annealing oven has been started. The secondary omission life test rack has been completed. The full time of two technicians was utilized in the above work.

11.5 Drafting

(A. M. Falcione)

Work Load on Drafting Department

1. It is expected that the drafting load for the balance of the year will be quite heavy on this department. Several schedules



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11.5 Drafting (Cont.)

have already been received which substantiate the above opinion. In order to determine the future work load on this department, a memo will be written to all Group Heads and System Engineers for their anticipated drafting requirements. From this information, a tentative schedule can be compiled for consideration as to our overall personnel requirements.

2. Mr. Allan Greeves, Jr. Mechanical Detailer, a new employee, will work under Mr. Graff on the detail work for the cockpit program. He will be located temporarily in Room 263.

Requisitions are in for three additional draftsmen. Additional drafting facilities will be set up in the basement area adjacent to the conference room.

11.6 Unclassified

(A. J. Taylor)

Fifty percent of the machine shop time is being devoted to the manufacture of storage tube parts. The backlog contains about 32 man-hours of work.

The sheetmetal shop has been moved to the basement. The sheetmetal backlog is about 10 man-hours.

12.0 GENERAL

New Non-Staff Personnel

(H. R. Boyd)

RUPPENTHAL, Mrs. Nagel Mahan, Secretary to Mr. Ulman, Mr. Proctor, and in charge of the Library. Mrs. Ruppenthal attended Florida State College for Women and University of Alabama. Her husband is at present attending Harvard Law School.

WEIL, Mrs. Elise Jean, Secretary to Mr. Boyd and Mr. Fahnstock. Mrs. Weil graduated from Brooklyn College. Her husband is at present attending Harvard Medical School.

HEYDT, Almira D. Mrs. Howard Heydt attended Katherine Gibbs. She is secretary for the Storage Tube Group.

WALKER, William, is a Jr. Electronic Technician working with Al Taylor. He was in the Navy and has considerable experience in fire control and servo work.

New Staff Member

(H. R. Boyd)

Raymond Fairbrother joined the project to direct the stock room, set up an inspection department as part of the stock room, coordinate material requirements with H. B. Morley, and look after equipment and equipment records. He is a graduate of Middlebury College as a Physics major, has done graduate work at M.I.T. in physics and meteorology. He was in the service seven years as a meteorologist and left in 1947 as a Lieutenant Colonel.