

RESTRICTED  
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6345  
Memorandum M-806

Page 1 of 17

Project Whirlwind  
Servomechanisms Laboratory  
Massachusetts Institute of Technology  
Cambridge, Massachusetts

SUBJECT: BI-WEEKLY REPORT, PART II, March 18, 1949

To: 6345 Engineers

From: Jay W. Forrester

6.0 MATHEMATICS

(P. Franklin)

The mathematics group is currently engaged on applications to control problems. Some previous problems are being coded and some new ones evaluated.

(E.Reich and P.Rabinowitz)

The solution of the ship-location problem is being corrected, and study of the logistics paper by Dantzig continued.

A study of the coordination of external and electrostatic storage for the solution of problems by the computer is being started.

(T.W.Hildebrandt)

I have written Conference Note C-99, "Runge-Kutta Method Applied to a Simplified Problem", which was distributed during the past week. I am currently preparing a final conference note detailing the coding of the ballistic problem.

During the past week I have, together with G.G.Hoberg, assumed the responsibility for the meetings of the Applications Study Group.

(M. Daniloff)

An alternative method (Hohenemier-Prager) for the machine calculation of eigen-values was evaluated. This consists of removing

UNCLASSIFIED  
RESTRICTED

RESTRICTED

6345  
Memorandum M-806

UNCLASSIFIED

Page 2

6.0 MATHEMATICS (cont)

one boundary condition and applying in its place a periodic one. In the case of an actual practical problem, however, the calculation of the Kernel of the corresponding integral equation would be laborious in the extreme and probably not feasible. In addition, the method requires the calculation of a) the eigen-values and functions of an associated homogeneous integral equation, which calculation is apt to be voluminous in itself, b) the roots of a function given in the form of an infinite sum.

After considering all the factors involved, the conclusion becomes inescapable that the Hohenemier-Prager method is not well suited for machine calculations.

A similar conclusion (albeit for different reasons) applies to the Engesser-Vianello as well. The deflection of the signal grid of ES storage tubes under a ring load was studied (partly in cooperation with R. Shaw). A theory of the deflection of a flexible, extensible membrane under a ring load, correct to the fourth power of small quantities was developed.

UNCLASSIFIED

RESTRICTED

RESTRICTED

6345  
Memorandum M-806

Page 3

UNCLASSIFIED

7.0 INPUT AND OUTPUT

7.3 Binary to Analog Conversion

(A.K.Susskind)

A survey of existing methods of binary-to-analog conversion had been started but was discontinued in order to pursue more pressing work.

It has been decided to accomplish the binary-to-analog conversion required for display of computer output on a cathode-ray oscilloscope by means of the deflection voltage generator designed by J. Ely. A study of necessary changes in this design to meet the requirements of the display unit is being conducted. The results of this survey will be available in a few days.

UNCLASSIFIED

RESTRICTED

RESTRICTED

6345  
Memorandum M-806

Page 4

UNCLASSIFIED

## 8.0 STORAGE TUBES

### 8.1 Tube Construction and Testing

#### 8.11 Tube Construction and Processing

(F. H. Caswell, T. F. Clough and P. Youtz)

Two storage tubes using the new target assembly were processed and turned over to the test group. One tube (ST75) was in the Be mosaic-on-mica series with a glass spacer in the center between the screen and storage surface, and used a 40 mesh screen. The second tube (ST77) was similar to the first except the screen was made of 100 mesh material.

We have been carefully evaluating all of our evaporation procedures. Toward that end we have made some thermocouple studies. We are now constructing an evaporation tube with a thermocouple attached to the evaporation boiler. The readings will be recorded on a single-point Brown Recorder. Also we have introduced two mica sampling plates along the side of the target to measure the resistance of beryllium strips during the evaporation procedure. This will give us a more careful check when beryllium starts to evaporate.

Our glass spacers have been one-tenth of an inch in diameter. Work has been done this period on spacers the size of the collector mesh. This work is still in progress.

(M. I. Florencourt)

Engineering notes E-212 and E-214 describe the construction, processing and initial testing of ST75 to ST77.

In the thermocouple studies, temperature of the tungsten heating coil has been computed from the input current and measured voltage. This computed temperature has been checked with pyrometer readings on the heating coil and agrees well. The Pt-PtRh thermocouple data agrees very well with published curves of temperature vs. thermocouple output in millivolts.

(R. Shaw)

Four tubes have been constructed each containing a tungsten heating element and a thermocouple. These are being used to develop temperature-measuring techniques.

UNCLASSIFIED

RESTRICTED

~~RESTRICTED~~6345  
Memorandum M-806

UNCLASSIFIED

Page 5

8.11 Tube Construction and Processing (Cont'd)

A new design of evaporation tube is under consideration which will contain a thermocouple for measurement of boiler temperature, an auxiliary target with resistance contacts to measure progress of the evaporation, components which are readily demountable for cleaning, and other modifications which are considered desirable.

Three new storage assemblies have been drawn, and prints of older proposals have been collected for comparison and evaluation.

An assembly fixture to aid in attaching small spacers to the 100-mesh screen was constructed.

Racks for installation of storage tubes into WWI are being detailed.

(W. E. Pickett)

Glass Components - The supply of envelopes for the construction of storage tubes is more than adequate for this next period. The stock of evaporating-tube envelopes prepared from 7" CRT blanks is ample for our needs in this next period. During the last period three evaporating tube envelopes were constructed from 5" CRT blanks in order to use some of the assemblies already prepared. The Alphatron tube has been sealed onto vacuum system number one for further studies on the Protecto-Vac. Approximately thirty glass flares have been punched and ground down for the construction of ten-pin stems. These stems will be fabricated in this coming period.

It is planned to vacuum fire the parts going into the construction of the Be boilers. With this in mind, two new type vacuum firing bell jars were constructed. This new bell jar has been tried and works very satisfactorily and will become a standard glass component for our work.

A thermocouple of platinum vs. platinum rhodium was made for a special tube. The final design of this thermocouple tube, using two arms, sealed to the envelope, into which the thermocouples were sealed worked well and, as of this date, this type thermocouple construction will be incorporated in evaporating tubes to measure heating coil and evaporating cup temperatures.

UNCLASSIFIED

RESTRICTED

RESTRICTED

6345  
Memorandum M-806

UNCLASSIFIED

Page 6

### 8.11 Tube Construction and Processing (Cont'd)

Eight pyrex glass discs were received for the construction of storage surfaces, and inspected in the glass room and appear suitable for our needs.

In general, the stock of glass components is ample for our needs during this coming period.

### 8.12 Tube Testing

(H. Klemperer)

Construction activities are approaching conclusion with the life-test set and the automatic high-speed read-write unit ready for test duty.

In testing, the problems of "upper stability" and "random spots" on the storage surface received foremost attention while in neither case a direct explanation could be formed.

Beam analysis studies turned to the examination of the holding beam. The velocity distribution was found to be very uniform while the intensity distribution across the illuminated 5" disk showed a stray increase towards the center in a tube that gave ordinary gas ion current readings ( $5 \cdot 10^{-6}$  mm Hg). After flashing of the getters and subsequent improvement of the vacuum the intensity of holding beam current across the whole surface was uniform.

(A. H. Ballard)

The two latest storage tubes ST75 and ST77 have been given initial tests. Both of these differ from previous Be-on-mica tubes in that 15 to 25 small positive spots appear scattered over the surface. The size and number of these spots depends upon the holding-gun voltage used. Such spots had been observed in several previous tubes but were never so numerous. Vibrating the collector with a strong a-c signal tends to reduce the number of spots, roughly by about one-half. Since it is planned to open ST75 for microscopic examination in the near future, its performance is being studied and recorded as completely as possible.

The vibration process has given partial success in eliminating unwanted spots from some of the previous tubes also. In two cases, it had the additional effect of raising

UNCLASSIFIED  
RESTRICTED

RESTRICTED

6345  
Memorandum M-806

UNCLASSIFIED

Page 7

8.12 Tube Testing (Cont'd)

the upper stability limit of holding gun voltage. For current tubes, this value averages about 400 volts and it was only for tubes much below this average that any improvement was noticed.

(C. L. Corderman)

Tests on ST77 indicated that the upper limit of stability was a function of the 3rd anode to collector voltage. Going from the condition of  $A_3$  at +180V with respect to the collector to the condition of  $A_3$  at -180V with respect to the collector raised the upper-stability voltage from 250V to 500V. It is felt that the increased holding-gun current density as  $A_3$  was moved negatively was the main reason for the above increase in upper-stability voltage.

The Life-Test Unit has been put into satisfactory operation with two tubes (ST65 and ST48). More tubes will be added as additional units are constructed.

Changes in the ST Summary Sheet have been made to include TV pictures of unstable positive areas which have appeared in recent tubes. Where possible, the orientation of collector to surface spacing and the TV picture of these unstable spots will be the same, as indicated by a notch in the drawing. Some of these spots are eliminated when the collector is subjected to forced vibration and, with two of the tubes, the upper-stability voltage became higher after the vibration was carried out.

(N. S. Zimbel and J. S. Rochefort)

High-Repetition-Rate Write-Read Unit - Preliminary testing of the unit with ST57 revealed that the amplifier limiter was not suited for high p.r.f. operation. A video signal-plate switching panel, which was formerly used in the Reliability Tester, was tried as a substitute for the amplifier limiter and clamp circuit. However, this panel was designed to operate in conjunction with well-controlled supply voltages and input gates. Its operation was unsatisfactory in the High Rep. Rate unit because of fluctuations in standard power supplies. Therefore this panel was discarded and effort was directed toward modifying the amplifier limiter for high p.r.f. operation.

Attempts to modify the amplifier limiter for high p.r.f. operation were partially successful and the time

UNCLASSIFIED

RESTRICTED

~~RESTRICTED~~

UNCLASSIFIED

6345

Memorandum M-806

Page 8

### 8.12 Tube Testing (Cont'd)

required for the read operation was reduced to 80  $\mu$ s. However, in achieving this result definite limitations were imposed upon the upper p.r.f. for the R, W+; R, W- cycle. A p.r.f. of approximately 1.6 kc was reached for this cycle of operation.

A new amplifier limiter (designed by W.J. Nolan) was substituted for the one mentioned above. Once initial troubles were eliminated the time required for the read operation was reduced to 30  $\mu$ s. Satisfactory cycling was achieved up to 30 kc, while preliminary tube tests have been conducted up to pulse repetition frequencies of 15 kc.

(J. H. McCusker)

Results on the RT50 beam analyzer tube indicated that the velocity distribution of the electrons in both the holding-gun and high-velocity-gun beams are uniform.

The current density in the holding-gun beam was non-uniform, with the maximum current density at the center. However, after flashing the getters and decreasing the pressure from about 5 to  $1 \times 10^{-6}$  mm Hg, the current density was uniform.

The current density in the center of the high-velocity beam increased to a maximum (at about -20V on the control grid) and then decreased as the control grid was made more negative. As the control grid was made more negative, the average current density in the beam at first decreased, then increased to approximately the same average current density as at zero volts bias, and then decreased. The spot size and current to the target decreased as the control grid was made more negative.

### 8.13 Storage Tube Reliability Tester

(J. O. Ely and R. Sisson)

A considerable amount of time was spent testing ST68 with the objective of finding the sources of errors encountered when trying to cycle a pattern. This tube was apparently deteriorating during this time and no conclusive results were obtained. ST68 was returned to the ST test group.

Two other tubes (ST73 and ST67) were tried in this equipment. It is evident that for these tubes positioning

UNCLASSIFIED  
~~RESTRICTED~~

RESTRICTED

6345  
Memorandum M-806

Page 9

UNCLASSIFIED

8.13 Storage Tube Reliability Tester (Cont'd)

will be required, and if it is desired to retain the push-button mode of operation direct-coupled positioning is necessary. This will involve modification of the coupling between deflection circuits and the storage tube.

Preliminary tests on these tubes (performed with non-centered arrays) show that their characteristics resemble those of ST68 except that  $V_{HG}$  must be somewhat higher, say 160 volts instead of 110V.

There is evidence of surface leakage or insufficient holding gun current around the edges of the storage area in ST67. Testing with one tube will continue for about one more week.

(J. A. DiGiorgio, Jr.)

The sweep generator was completed for the TV presentation.

Three 100 ohm attenuator spigots were constructed.

The +150V regulated supply was increased from a 2.5 ampere nominal load to a 5 ampere load capacity.

The teletype read-out flip-flop was bread-boarded and tested.

The teletype printing register was completed and is now being tested.

8.2 Storage Tube Research8.23 Output System Circuits

(W. J. Nolan)

The new r-f amplifier mentioned in the last report has been completed and installed in the reliability tester. This amplifier uses a high-level detector having sufficient output to drive a gate tube directly without the necessity for a stage of video amplification and a phase-splitting circuit. This not only reduces the susceptibility of the amplifier to blocking but also improves the signal-to-noise ratio, permitting faster operation.

Work has been started on four similar units for the reliability tester.

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### 8.23 Output System Circuits (Cont'd)

(C. H. R. Campling)

Several changes in the circuit design for the r-f pulser have delayed testing of the unit. Provision has been made to amplify the phase-reference voltage so that detection in the output-circuit amplifiers can take place at a higher level. This phase reference signal will be obtained from a pair of push-pull 6AG7's. The associated circuit has been shielded from the other r-f circuits, but the possibility of oscillation within the amplifier itself exists.

Testing should begin on March 21st.

### 8.25 Electrolytic Tank

(H. Rowe)

Using potential plots obtained in the electrolytic tank, electron trajectories were obtained for the target region of the storage tube. An engineering note (E-216) will be issued shortly summarizing the results.

### 8.3 Unclassified

(H. Rowe)

Work is being done to bring up to date block diagrams and circuit schematics of the TV test setup.

### 8.4 Deflection Circuits

(L. J. Nardone)

The design and analysis of a two-wire shielded transmission line for feeding the deflection voltages to the storage tubes is being carried out. Previous designs are being discarded for unsuitable mechanical or electrical features. Artificial loading, by means of lumped inductances at each storage-tube tap point, is being incorporated in order to reduce the attenuation. A test using RG62/U cable loaded similarly with lumped inductances was performed to note the operation so that an estimate could be made of the feasibility of this type of loading. Performance indicates the loading method is satisfactory.

Mechanical design of the line and loading coils is

UNCLASSIFIED  
RESTRICTED

~~RESTRICTED~~

6345  
Memorandum M-806

UNCLASSIFIED

Page 11

8.4 Deflection Circuits (Cont'd)

being carried out along with the electrical design in order to assure that the components required will be mechanically feasible.

(J. M. Hunt)

A number of deflection-voltage-amplifier circuits have been devised, one of which is now being constructed as a breadboard for further tests. This circuit is designed to drive a terminated transmission line which supplies the storage-tube deflection plates. The deflection plates, according to present plans, will be connected to the transmission line through simple L-C filter sections having, at frequencies below 50 megacycles, a characteristic impedance equal to that of the transmission line. It is hoped that the filter sections and proper line termination will minimize line reflections, thereby permitting a material improvement in the response speed of the deflection system.

RESTRICTED

~~RESTRICTED~~6345  
Memorandum M-806

Page 12

UNCLASSIFIED

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.

6345 Reports

<u>No.</u>	<u>Title</u>	<u>No. of Pages</u>	<u>No. of Drwgs.</u>	<u>Date</u>	<u>Author</u>
R-156	Intact Stability Study Programmed for a Digital Computer (S.M. Thesis: Abstract in E-210)	113	14	3-7-49	C.W. Adams
E-204	Conversion of Binary Pulse Code to Voltage Amplitude (Abstract of Master's Thesis)	2	-	2-24-49	H.W. Sard
E-207	Nomogram for Determining Thickness of Beryllium Film	2	1	3-1-49	R. Shaw
E-208	Storage Tube 73: Construction, Processing and Initial Testing	3	-	2-28-49	H. Florencourt
E-209	Storage Tube 65: Construction, Processing and Initial Testing	2	-	3-4-49	M. Florencourt
E-213	FF Sensitivity in WWI	2	1	3-10-49	R.L. Best
M-792	Tables of Binary and Decimal Numbers	5	-	2-23-49	{R.P. Mayer {C.W. Adams
M-796	BI Weekly Report, Part I, 3-4-49	17	-	3-4-49	
M-797	BI Weekly Report, Part II, 3-4-49	14	-	3-4-49	
M-800	Progress Report: The Solution of Power Network Performance on Large-Scale Digital Computers	3	-	3-9-49	P.A. Fox
M-803	Program Counter Quantities	1	-	3-17-49	H. Fahnestock
A-62	Non-Staff Work Manual	4	-	2-18-49	{H.R. Boyd {R.A. Osborne
C-93	Notations for Coding	10	1	2-14-49	W.G. Welchman
C-99	Runge-Kutta Method Applied to a Simplified Problem	6	-	3-6-49	T.W. Hildebrandt
C-100	Arrangements for Future Meetings	1	-	3-11-49	W.G. Welchman

Library Files

47	Technical Information Pilot, Numbers U-1997-2076	Lib. of Congress
52	Progress Report for WWI Electronic Digital Computer for Period February 26-March 11, 1949	Sylvania

RESTRICTED

RESTRICTED

6345  
Memorandum M-806

Page 13

UNCLASSIFIED

Library Files (Continued)

<u>No.</u>	<u>Title</u>	<u>Author</u>
134	Eastman Kodak Monthly Progress Report No. 7	A.W. Tyler
180	Document Office Bulletins, March 1, 1949 and March 15	{ MIT, Research Laboratory of Electronics
248	Project Squid Technical Memorandum No. PR-3: Flow in Ejectors Driven by Supersonic Jets; by K. D. Miller, Jr.	Princeton Univ
249	The Organization of a Preliminary High-Speed Computer, by T. Pearcey and M. Beard	{ Radiophysics Lab Sydney, Australia
250	Interim Report on Investigation to Determine Most Practical Method of Obtaining Free Air Temperature at Transonic and Supersonic Speeds 12-31-48	{ Franklin Institute Labs for Research and Development
251	Specifications; Project Owned, Commercial Manufactured Test Equipment	{ Servomechanisms Lab, Project WWI sylvania
252	Design and Development of the WWI Time Pulse Distributor	Sylvania
253	Report on Mathematical Aspects of Whirlwind - 11-21-47	F.J. Murray
254	Trajectory Data from Mitchell Theodolite Observations of A-4 (V-2) Round No. 44; 23 February 1949	Ballistic Res Labs
255	Radio Frequency Service Allocations Above 400 MC/S	V.I. Weihe
256	First Progress Report on a Multi-Channel Magnetic Drum Inner Memory for Use in Electronic Digital Computing Instruments; by J. H. Bigelow, P. Panagos, M. Rubinoff, W. H. Ware	{ Institute for Advanced Study, Princeton
257	An Investigation into the Reliability of the Capacitively- Coupled Flip-Flop; B.S. Thesis, May 1948	W.P. Horton
258	Progress Report, Investigation of Pulse Transformers, Period July, August, September, 1948	{ Ohio State Univ Research Foundation
259	General Precision Laboratory Progress Report, April 1, 1947 to May 31, 1947; F. N. Gillette	{ General Precision Laboratory, Inc.
260	Servo Analysis by Locus of Roots Method, 11-1-48	{ North American Aviation, Inc.
559	Technical News Bulletin, March 1949	{ National Bureau of Standards

11.2 Standards Committee

(H. B. Morley)

New standards sheets issued this period:

- S7.411-2 Operation Matrix Driver Panel
- S7.411-3 Clock Pulse Control Unit

UNCLASSIFIED

RESTRICTED

~~RESTRICTED~~

6345  
Memorandum M-806

Page 14

UNCLASSIFIED

11.3 Purchasing and Stock

(H. B. Morley)

A substitute for the standard Dialco pilot lamp has been ordered from Drake at a considerable saving in price.

Small, irregular shaped brackets and parts which are to be finished in black should be black anodized whenever possible, since this process is considerably less expensive than painting small pieces.

The first sample of the dial assembly ordered from Spencer-Kennedy Laboratories has received favorable comment from interested persons. The dial presents considerable improvement over the previous model, and it is believed will be more satisfactory.

New Items: IRC is now manufacturing a line of molded RF chokes similar in appearance to their molded resistors, in standard RMA values up to 10 microhenries. Interest has been expressed and samples are being procured.

(R. Fairbrother)

There are at present no known shortages of any item that will delay production of WWI panels. The stock of pulse transformers is low. However, an order will be placed for more as soon as the last order is received from Amertran and passed inspection satisfactorily.

Parts have been sorted and consigned for 35 check/ comparison registers, 1 synchronizer, 10 indicator panel assemblies with the exception of pilot lights, and 15 synchronizer pulse and interphone bracket assemblies. All parts for the assembly of 73 voltage variation panels have been given to the shop except for several bulky items such as relays and base handles. Parts for two switch panels, control/storage switch will be ready by Monday, March 21st.

11.4 Electronic Construction

(A. Taylor)

WW construction is running on schedule.

There is still misunderstanding concerning the production control system. Many people are still trying to by-pass the production control office. This is not possible since the shop foremen work from papers issued by that office and are not required to take on work from other sources.

~~RESTRICTED~~

~~RESTRICTED~~

6345  
Memorandum M-806

Page 15

UNCLASSIFIED

#### 11.4 Electronic Construction (Continued)

(A. R. Curtiss)

Work was done on the TV set, on RF output system detector, a signal-plate gate amplifier and a deflection circuit.

An electrometer circuit was breadboard assembled.

The following units were constructed:

- 2 HF amplifiers
- Mega sweep booster amp
- Sweep generator

The full time of one technician was assigned to working on the EST life-test racks.

#### 11.5 Drafting

(A. M. Falcione)

At the suggestion of J. A. O'Brien, drawing D-33553 consisting of several of the basic circuits was drawn in an effort to reduce time and work required for the drafting room to produce a finished circuit schematic from an Engineer's sketch. Memorandum M-799 dated March 14, 1949 will be issued today covering the above subject in detail.

The drafting room is keeping pace with present scheduled requirements. The work load is fairly steady.

During the past two weeks the drafting room has lost 31 days of drafting time due to illness of drafting personnel.

(C. W. Watt)

Administrative Memorandum A-34, which covered basic drafting room procedures, has been obsoleted, and the same information has been transcribed to standards sheets which will be available for reference in the drafting room and in Room 112. These standards bear the numbers S1.01 to S1.08. Administrative Memorandum A-83 will shortly be issued covering the application of all our drafting and general standards.

To reduce the amount of printing required, the file of drawings, Engineering File No. 1 in the library is being eliminated.

~~RESTRICTED~~

~~RESTRICTED~~

6345  
Memorandum M-806

Page 16

UNCLASSIFIED

11.6 Unclassified

(L. Prentice)

Machine Shop: Work on an air operated staking tool is nearly complete. Work in progress consists of making multiple punch and die sets for tube sockets plug-in strips and Jones plugs.

The machine shop has successfully completed rolled rings of stainless steel for storage tube group, mentioned in last report. We have also completed a greenlea type 1-1/8" cutter for storage tube.

Sheet Metal Shop: The sheet metal shop has been expanded to include the entire area of Room 014. This will relieve the congestion and confusion which has been attendant to this shop.

Some work remains to be done namely mounting equipment and locating new lighting fixtures.

Nearly all work in progress at the present time consists of panels for WWI.

UNCLASSIFIED  
~~RESTRICTED~~

~~RESTRICTED~~

6345  
Memorandum M-806

UNCLASSIFIED

Page 17

12.0 GENERAL

Naval Officer Assigned to Laboratory to Study Digital  
Computers: Lt. David A. Webster, Post Graduate Naval  
Officer studying fire control at M.I.T.

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