

6345  
Memorandum M-221

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Project Whirlwind  
Servomechanisms Laboratory  
Massachusetts Institute of Technology  
Cambridge, Massachusetts

SUBJECT: BI-WEEKLY REPORT, PART II, JANUARY 23, 1948

To: 6345 Engineers  
From: Jay W. Forrester  
Date: January 27, 1948

6.0 MATHEMATICS

(Professor Franklin)

Studies on codes, elimination methods for linear equations, and aerodynamic equations in the plane are being continued in the mathematics section.

Estimates on forces acting on the storage meshes were made in M-216.

(M. Daniloff)

I. Study of simplifications and condensations of equations of motion of an airplane was continued. Equations for power-off and power-on flight in a vertical plane were formed for the cases of:

- a. A fixed elevator.
- b. An elevator controlled elastically.  
(These equations include computable aerodynamic coefficients only, and as a consequence, do not use up any storage space permanently.)

Equations for take-off have been considered. The all-important input function  $\delta E(t, V, H)$  is determined by pilot reactions and cannot be specified on a-priori grounds; it must be obtained from records of actual or simulated flights.

The theory of the potential flow around a plane surface with a plane control surface set at an acute angle to it has been examined to obtain the conditions under which the lift, drag and moment coefficients can be considered as linear functions of both the angle of attack and of the angle of deflection of the control surface. Results:

1. For small  $\alpha$  and  $\delta E$ ,  $C_L$  is a linear function of both.
2. For  $\alpha \leq 14^\circ$  and a  $\delta E$  such that  $(\delta E/\pi)^2 \ll 1$  the lift coefficient is of the form:  

$$C_L = a_0 [\alpha - a_1 \alpha^2 - a_2 \delta E (1 - a_3 \alpha^2)]$$

correct, theoretically, to 5 in 1000.

(Edgar Reich)

Continuing to write up memorandum on elimination methods. The paper by von Neumann and Goldstine in Bulletin of American Mathematical Society contains a discussion of the desirability and effects of repositioning the variables during an elimination method such that the numbers that are used as divisors are as large as possible.

(C. W. Adams)

The net effect of a given order is being considered from the point of view of an individual coding a problem. This work should lead to a readily accessible source of information on what does and does not happen in the computer in response to any particular order. Certain minor alterations in the operations performed by some of the orders may also suggest themselves.

## 7.0 INPUT AND OUTPUT

### 7.1 Eastman Kodak Recorders.

(H. R. Boyd)

Attended conference at Rochester on Tuesday and Wednesday January 20 and 21 with Dave Brown. H. Knutson and C. Doersam of Special Devices also attended the meetings. Technical discussions occupied all of Tuesday and we saw some of the mechanical assemblies to be used for handling the film. Preliminary layout drawings of these assemblies are available in 206 for inspection. In general, the work is proceeding satisfactorily but has not yet reached a stage where there is much test data available. Wednesday's meeting was in regard to the contract. It has been decided that the Eastman work will be continued under a prime contract with Special Devices rather than under an M.I.T. sub-contract as originally proposed. The quantity of film-reader-recorder units now under discussion is three available by January 1, 1949.

### 7.2 Analog to Binary Conversion.

(Linville, Wieser)

No work on this problem since the last report.

### 7.3 Binary to Analog Conversion.

(Linville, Wieser)

A subtracting device has been conceived which will subtract two serially-coded binary numbers and yield a result in the form of serially-coded magnitude and in addition a signal to indicate sign. A scheme has been proposed which will allow the use of the Bell Laboratories Decoder Circuit along with a phase inverter to change a serially-coded binary number and its sign to a voltage of analogous magnitude and sign. In order to relieve accuracy requirements on the decoder circuit both plus and minus differences must be used. An alternative bias system to eliminate negative binary error signals requires decoding a large binary number for zero servo error. Hence, the decoder would no longer work as a null device.

### 7.3 Binary to Analog Conversion (Continued)

(E. W. Sard)

Breadboard tests of decoder circuit and read circuit (read output of decoder circuit) are underway.

A four-digit (toggle-switch control) serial binary coder is being constructed to serve as a piece of test equipment.

### 7.4 Magnetic Recording.

(Edwin S. Rich)

A system for recording and reproducing pulses on magnetic tape has been built up. Some measurements have been made on the apparatus with recording pulses applied at a comparatively low repetition frequency. A solid metal Vicalloy tape is being used for the recording medium. Data is being taken to show the variation of output-pulse length and amplitude with changes in input-pulse length and amplitude, tape speed, and recording gap width. This data will indicate the optimum recording pulse length and amplitude for further tests.

Problems have been encountered in trying to observe the output pulse without excessive jitter and in reducing tape noise particularly at high tape speeds.

Details of the results obtained to date are given in my Thesis Progress Report No. 4.

## 8.0 STORAGE TUBES

### 8.1 Tube Construction and Testing.

(R. Shaw)

Parts are being made for models of two slightly different five-inch diameter storage tube screen supports. Other designs are being considered. An assembly fixture is also under construction.

### 8.11 Tube Construction and Processing.

(T.F. Clough)

Nonex Stems - Considerable work on the preparation of flares, nonex to tungsten seals, etc., has been done and efforts are being directed toward development of techniques of nonex stem making. This problem will continue to have highest priority during the next period.

Glass Cut-Off Wheels. - An investigation of available glass cutting equipment has been initiated to determine the best equipment for our use.

(F. H. Caswell)

Our aquadag problems were again gone over with a representative of Acheson Colloids Corporation resulting in better

aqueous coatings on envelopes.

Equipment and materials of the Storage Tube Lab. are being cataloged.

(S. H. Dodd)

Parts for several tubes have been constructed to test new designs for holding guns. These tubes will be assembled as soon as presses are available. One gun has the stops for each anode very much enlarged and accelerating grid  $G_2$  brought out separately for increased accelerating potential. The other gun is constructed in a similar way except a wire mesh replaces the control grid  $G_1$  to obtain greater effective cathode area.

(J. McCusker)

The following tubes were processed with RLE facilities:

Storage Tubes  
S.T. Mod. 18B  
S.T. Mod. 23A  
Research Tube  
R.T. Mod. 3A

Tested No. 1 Barta pump system to determine best operating point.

#### 8.12 Tube Testing

(W. J. Nolan)

Tests have been completed on storage tube Mod. 17. In the tests of operation as a storage tube it was apparent that the waffle iron type of surface did not afford significantly better isolation between storage points than the conducting mosaic surfaces of mods 15 and 16. The required holding gun voltage of 260 volts indicated that the aluminum oxide on the sides of the pockets was the controlling factor in determining holding beam velocity rather than the beryllium in the bottoms of the pockets. This grid action was not unexpected and was in keeping with predicted characteristics.

#### 8.13 Storage Tube Demonstration.

(Joel Simmons)

It was found desirable to change the frequency of the power to be rectified for use on the deflection plates of the EST tube from 60 cps to approximately 100 kc in order to decrease the size of the rectifier and filter circuits. This required the construction of a 100 kc power oscillator. A special pulse transformer is now being built to be used in this oscillator.

A single stage amplifier has been built which is to be used in the clamping circuit but its performance has not yet been determined.

(C. H. R. Campling)

A second bank of ten 6AS7's has been added to the regulator for the 300 volt supply in order to make better use of the generator capacity. With the present setup the regulator should be capable of handling loads up to 4 amps. It has been tested with a remote 2 amp. load fed through the low impedance cable mentioned in the last progress report. Under these conditions there is present at the output a small oscillation of about 10 millivolts amplitude. The frequency of this oscillation is in the neighborhood of 10 kc. There is no detectable oscillation of this sort without load.

This performance is better than any hitherto attained with remote load, and furthermore, the response of the system to sudden changes from no load to full load and vice versa is now much improved. There is a momentary holdup caused by failure of the load-switching control, but nevertheless it appears that the whole system may be ready for use before the next report is issued.

## 8.2 Storage Tube Research

### 8.21 Surface Material Characteristics

(M. Florencourt)

Life testing of RT-1 was started. This tube has a plain polished nickel target and a nickel collector; there is no willemite on the collector. Testing on this tube was resumed in order to see if, after long usage, this tube also developed peaks (corresponding to either side of the aperture in the collector) in its secondary minus primary current versus positioning-voltage curve. These peaks developed during life testing of ST Mods. 20, 20A and 20B and it was thought that their development might be attributed to the beryllium covered targets which were used in those tubes. However, RT-1 has also developed these peaks during life-testing; therefore, it is probable that they are not due to target material but are due to some other factor—perhaps cathode contamination.

The SE ratio has decreased from a max. of 1.5 to 1.3 during life-testing of RT-1 and the two crossover potentials have come closer together, now being about 150 and 1100 volts.

### 8.22 Anodizing.

(M. Florencourt)

Calculations were made toward setting up equipment for anodizing the target for the new 5-inch storage assembly. Four small-sized samples were received for anodizing.

### 8.23 Output System Circuits.

(C.H.R. Campling)

The thesis proposal covering work on the development of a suitable clamp circuit for storage tube output will be completed and submitted to the E.E. Department at M.I.T. before the beginning of the next academic term. The way will be clear then to begin laboratory work on this project. Sketches have been prepared and rough draft of certain items for the proposal have been completed. Some library research has been conducted to ascertain whether any existing clamping techniques might be useful.

### 8.25 Electrolytic Tank.

(A. R. Curtiss)

Considerable difficulty encountered during preparation of electrolytic tank. Unit has been made water tight and a reading of approximately 1.25 megohms was obtained between water and outside tank surface.

Salt was added to water in an effort to obtain ohmic values between 2000 and 500 ohms (Ref. R-131). Six coats of Flexi-Blac have been applied, and on January 22, a reading of 20,000 ohms was obtained between water and tank surface. Several low resistance points were located.

It is intended to clear old Flexi-Blac from tank and apply new coats as evenly as possible.

### 8.27 Gas Data Storage.

(R.F. Markel)

A report including a theoretical and experimental investigation of gas-data-storage gaps has been completed as an S.M. thesis, "Gas-Discharge Gaps for Data Storage in Electronic Computers." Results of the investigation indicate that it may be possible to obtain the desired static performance characteristics from a device of this type. The principle obstacle appears to be the achievement of stability in cathode surface characteristics and the prevention of random sparks and arcing in the abnormal-glow discharge.

### 8.3 Unclassified.

(A. R. Curtiss)

Video amplifier for use with Mod 5 Synchroscope nearing completion. Motor and necessary components being assembled for use as grinder for EST presses.

(S.H. Dodd)

Estimates were made of number of tube types and quantities and associated power to allow ordering of WWI power supply equipment. The storage tube circuit estimates were of necessity not as accurate as desired due to lack of data on

some of the circuits directly associated with the tubes such as the clamp circuit and three-way flip-flop. An engineering memo will be issued shortly covering these estimates.

Computation of the range of holding beam current densities required under ideal and adverse storage tube operating conditions were made and results reported in E-94.

#### 8.4. Deflection Circuits.

(John O. Ely)

Special materials needed for construction of a set of deflection circuits of the type proposed for WWI use are being ordered. No excessive delays in procurement are anticipated, but it seems wise to have the materials on hand in case it is decided to start work on construction in the near future.

Preliminary circuit designs have been completed for some time. As yet, no attempt has been made to consolidate the notebook schematics into a complete circuit schematic. As time permits in the near future, a sketch of the complete schematic will be made. This sketch will then be given to the drafting department for re-drawing. A layout of the circuits may be started as soon as the schematic drawing is completed.

The circuit, as proposed, is suitable for deflecting the beams of from one to four cathode-ray tubes to 32 positions in each of 2 coordinates, or a total of 1024 separate positions. Speed of operation is comparable with, although probably faster than, that which will be needed for WWI.

It is felt that this work should take second place to the test-equipment program, since the testing and control of the deflection circuits should be done with items of standard equipment. The circuits proposed, together with a small amount of special display equipment and several items of standard test equipment will be capable of providing an effective demonstration unit.

### 9.0 SERVOS AND SIMULATION

#### 9.1 Cockpit

##### 9.11 Structure.

(E. S. Prohaska)

Layouts of the lower part of the control column assembly have been completed. Further work on the upper part has been deferred until a study of the microfilms of the various types of aircraft has been completed.

H. Boyd has initiated a request to the Navy for a set of B-29 controls to be used on the breadboard model.

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9.12 Instruments

(R. Shaw)

Work on cockpit instruments has been temporarily discontinued.

9.13 Control Force Loading.

(C.G. Eaton)

Steady-state tests on the differential-pressure regulator are being continued in order to check the theory. So far, the theoretical and experimental results have been satisfactorily correlated.

The tests conducted indicate the need for some modifications. The modifications are being planned and the tests are continuing.

9.14 Elastance, Backlash, Coulomb Friction.

(M. Flomenhoft)

Work on the flow diagram of the backlash problem has been progressing steadily, and is now close to completion.

No definite conclusions may be reached now, however, and the remarks that follow are conjectures presently suggested by the flow diagram in a state that does not yet include control stick displacement.

1. Over 80 boxes\* are required.
2. Over 40 of these boxes involve the conditional programming (cp) feature of the computer, thereby indicating the formidable number of contingencies for which provision must be made.
3. It will be necessary to reduce both the flow diagram and the static coding to their most compact forms before use of the computer may be weighed as a practical method for solving this problem.

\* A "box" is a varying number of related operations which are considered as a unit on the flow diagram, and labeled with a Roman numeral.

(E. S. Prohaska)

A redesign of the control column assembly to incorporate some coulomb friction in the controls has been completed.

9.2 Sampling Servo Stability Study.

(Wieser, Linvill)

No work on this problem since the last report.

10.0 TRAINING

10.1 Seminar Series

(R. R. Everett)

No seminar meetings will be held during exams or vacation weeks. Since Monday, February 9, is Registration Day, the next seminar meeting will not be held until Wednesday, February 11.

11.0 FACILITIES AND CENTRAL SERVICE

11.1 Publications

(J. N. Ulman, Jr.)

The following material has been received in the Library, Room 217:

Library Files

49 The ENIAC Technical Report 1, Vol. I, Univ. of Penn.  
50 The ENIAC Technical Report 1, Vol. II, Univ. of Penn.

P. B. Reports

Classification 6. 2. 5.

77746 A Precision Z Sweep Generator, Report 563, Radiation Laboratory, M.I.T.

Classification 10. 9

80604 Notes on the Operation of Wire Recorders at the New London Lab., Columbia Univ., Divn. of War Research.

6345 Reports

M-207 Meeting of Electronics Group, Jan. 7 (H. Kenosian)  
M-196 Paint Schedule (H. Tonsing)  
M-174 On the Dielectric Constant of an Oxide Hydroxide and Oxyhydrate (trans.) (M. Florencourt)  
M-135 Block Diagrams - Electrostatic Storage (R. Everett)  
M-158 Block Diagrams - Input and Output (R. Everett)  
M-132 Vacuum Tube Estimate for WWI (J. Forrester)  
M-213 Project WW - Seminar Schedule Jan 12-Feb 18 (R. Everett)  
M-210 Bi-Weekly Report Part II (J. Forrester)  
M-209 Bi-Weekly Report Part I (J. Forrester)  
M-214 Meeting of Electronics Group (J.J. O'Brien)  
E-91 Standard Bus System (C. Rowland)  
E-89 Deflection Circuits for Electrostatic Storage Tubes (Abstract Report R-120) (J. Ely)  
E-88 The Function of ACO Carry Register (G. Sumner)  
E-94 Storage Tube Holding Beam Current Density (S. Dodd)  
R-133 Timing of Whirlwind I (G. Hoberg & E. Blumenthal)

11.2 Standards Committee

(S. Abbott)

The following property classifications are ready to be submitted for final approval:

Cabinets and Chassis	Lamps
Capacitors	Relays
Chokes	Resistors
Connectors	Sockets
Dials and Accessories	Switches
Fuses	Terminal Strips
Hardware	Transformers
Tube Clamps and Shields	Wire

In addition to preparing the balance of the classification list for final approval, a list of test equipment and tube replacements is to be prepared.

(J. Ely)

Members of Standard's Committee visited B.B. Chemical Company and gave them specifications for materials for coating chokes and pulse transformers. Suggestions on coating materials would be welcome.

11.3 Purchasing - Stock

(H. Morley)

Upon request, this department will arrange conferences or meetings with sales engineers from vendor companies and manufacturers, for engineers and/or technicians who may have special problems concerning components. Such meetings have already been held with several representatives.

A group of engineers visited BB Chemical to observe techniques used in application of their thermoplastic coatings, which may find some application here as a protective coating for RF chokes, pulse transformers, etc. Samples of a new loktal socket from 1/8" panel mounting with grounding lugs, have been received from Cinch. A new stud mounting for CTC type LAB RF chokes is being adopted as standard.

After the recent meeting of Materials Control personnel to discuss reorganization, memos were submitted by each employee outlining duties, procedures, difficulties encountered, and suggestions for improvement. These are being reviewed and will form the basis for a standard operating procedure.

Workload of this department is continuing to increase, much more time than heretofore being required for contacts with sales representatives, ordering stock replenishment and special items, and giving assistance to personnel in choosing components. The trucking strike has occasioned several unavoidable delays in delivery of material. A number of type 6AS7G tubes from stock have been found defective, apparently due to faulty annealing. The whole stock of this type is being tested, and defectives will be returned for replacement.

11.4 Electronic Construction

(R. Murch)

The following units are in the Electronic Lab for construction:

1. 20 d-c bench outlet boxes (in machine shop)
2. 2 d-c bench outlet box covers (in machine shop)
3. 5 rack power control units. Proto-type completed except for filament wiring to Jones plugs. The No. 14 wire needed for this has not come in yet.
4. 40 nameplates for a-c circuit breaker boxes.
5. 10 sets of nameplates for d-c portable disconnect boxes.
6. 4 binary frequency dividers. Under construction-- expect to complete them in about a week and a half.
7. Pulse amplitude Monitor. Completed except for some potentiometers which have to be changed when the correct ones come in.
8. Periodic program control for multiplier completed except for chassis mounting brackets which are out of stock.
9. Variable frequency clock - restorer pulse distributor. Adjustable scale binary frequency divider 16:1 and 32:1 is under construction. Layout for the pulse distributor is being made by Dan Mach.
10. Layout for additional tubes on multiplier control panel. No work being done on this at present.
11. 2 variable delay pulse and gate generators. One completed, second one will be completed in about a week.
12. 4 breadboards. There is approximately five-weeks work in the Electronic Lab at present. This does not include the machine work on jobs Nos. 1, 2, 3, 9 and 10 which is estimated to be about four-man weeks of work.

(Al. Taylor)

Three electronic units under construction for the S.T. Lab. The second high voltage supply for the EST Demonstration unit has been completed.

11.5 Drafting.

(C. Watt)

Administrative memo A-34 was put into effect Jan. 19. A note may be added here regarding the use of parts lists with schematics. The parts listing procedure described in A-34 referred specifically to parts lists for assemblies. Schematics are not assemblies, but the electrical parts required must be specified, and until Sylvania is fully capable of ordering from schematics, M.I.T. should be covered by preparing its own parts lists. Therefore, all graded schematics should have a parts list prepared from it, bearing the same number as the schematic, and graded and distributed as is the schematic. Each schematic should also have the parts list referenced in its notes. H. Mercer will prepare these parts

lists, and the engineers should be aware they exist and that they must be changed when the schematic is changed.

(Falcione)

Drawing of Storage Tubes. Drafting man-hours made available from the cockpit program has been put to use on this program. Although progress is not as fast as expected, it is hoped that this condition will be remedied as soon as familiarity with this type of work is attained.

Administrative Memo A-34 has been in effect since Monday, Jan. 19. It is noted that Engineers are not dating the tracings on approval of same. It is desired that this factor be stressed as it is very important that the date of approval be made part of the approved tracing for record purposes.

Plan file folders have been received from the Art Metal Company. The new files are being put into operation as soon as possible.

#### 11.6 Unclassified

(A. Taylor)

Parts for the 5-inch storage tube assembly are being turned out by the machine shop.

The glass annealing oven has been completed and delivered.

#### 12.0 GENERAL

(J. W. Forrester)

Preparation of Bi-Weekly Reports. A few changes in the presentation of information for bi-weekly reports will make editing easier. The following clarification may help:

- a. The report is primarily a summary of results accomplished, problems encountered, and plans rather than an accounting of time of personnel. Therefore it is not necessary to refer to reports of others for accounting of time, or to state that no work was done on a certain activity except where such information is of special significance. Technicians reports have in the past repeated the information in staff reports but are intended for Section 11.4 as a statement of work load, backlog of requests, and availability of men to take on new jobs.
- b. A narrative reporting form should be used. The A, B, C, D outline form should be avoided where these headings do not fit the text structure and are not explained. Sentence and grammatical construction should be watched since these

bi-weekly reports are used by Ulman, Hoberg and Proctor as a basis for a monthly project report. Improved initial presentation will assist in the monthly editing.

Attention is called to A-34, Section IV, C, D and G asking that drawings relating to WWI not be sent outside the Laboratory until graded to show the reliability of the information.

Add to decimal classifications of bi-weekly-reports Section 8.4 Deflection Circuits.

(G.G.Hoberg)

With J. Ulman, a summary of project activities during the month of December has been prepared.

A complete glossary of Whirlwind terminology is being compiled.