Project Whirlwind
Servomechanisms Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

SUBJECT: BI-WEEKLY REPORT, PART II, FEBRUARY 6, 1948

To: 6345 Engineers

From: Jay W. Forrester

Date: February 9, 1948

6.0 MATHEMATICS

(Philip Franklin)

The completed study of elimination methods for solving linear equations (M-206) recommends the Crout method for n small, and the single division method as modified by von Neumann and Goldstine for n large.

The possible approximations of empirical aerodynamic functions in closed form are being studied.

(M. Daniloff)

Results of studies reported in the previous report are being put in Memorandum form (Memo M-212: "Equations of Motion of an Airplane, the Plane of symmetry of which remains vertical and of fixed asimuth."). Further results obtained:

1. The usual empirical expression:
$$C_D = a' + \frac{C_L^2}{b}$$
is justifiable on the ground of potential flow theory.

2. For deflections of the control surface such that $(\delta E/\bar{\pi})^2 << 1$, the potential flow theory gives for the pitching moment coefficient a function of the form:
$$C_m = b_o \alpha + b_o' \alpha^3 + b_o'' \alpha^4 + \delta E (b_1 + b_2 \alpha^2)$$

(Note the lack of symmetry introduced by the term in δE. This is as it should be a-priori). The inclusion of α^4 is essential, since experimental evidence indicates that C_m is not centrally symmetric about the origin.

3. A third order parabola has been fitted to C_L given on B-20013-G, Contract 6295, Report 12:

$$C_L = -0,009 + 73,9 \times 10^{-3} \alpha - 105,4 \times 10^{-6} \alpha^3$$

(α - degrees) with a maximum error of -4% for $-2^0 < \alpha < 12^0$. (This range being prescribed for accurate simulation by 6295, Rep. 15).

This simulation of C_L may be considered adequate.

(C. W. Adams)

An attempt is still being made to clarify the proposed operation code from the point of view of one attempting to code a problem. Emphasis is being placed on automatic subprograms as applied to multiple length operations.

(Edgar Reich)

Memorandum M-206 entitled "Numerical Solution of Systems of Simultaneous Linear Algebraic Equations by Elimination Methods" has been completed, and distributed to the Mathematics Group.

Preparation of a memorandum on iterative methods for solving systems of the above type has been started. In connection with iterative methods, such as the Southwell method, it would be very desirable to get an upper or lower bound (or both) for the number of iterations required to obtain a given accuracy in the solution.

7.0 INPUT AND OUTPUT

7.1 Eastman Kodak Recorders.

(H. R. Boyd)

We have been emphasizing the need for more than the three units which were recently planned. At the present time, six units seem like the probable number to be built. The latest trend is toward separation of the reader and recorder. This would necessitate an additional spare making a total of three recorders and four readers that would be required. M-231 discusses the last two conferences at Rochester with Eastman.

7.2 Analog to Binary Conversion

(W. Linvill, C.R. Wieser)

Development at the Cambridge Field Station on a device for converting a shaft position to a binary-coded number uses a mechanical disc commutator connected to the shaft. There are conducting and insulating strips alternately placed on the commutating ring of each digit in a pattern analogous to the aperture pattern of the Bell Laboratories Coder Tube. Troubles with ambiguous coding occurring when several digits change at once in going from one binary number to the next (0111111 to 1000000, for example) have been eliminated by use of a modified code wherein shaft rotation from one discrete value to the next changes only one digit in the coded number. Electronic conversion from modified code to binary code seems fairly simple.

B. D. Smith of R.L.E. indicated that considerable equipment is required in conjunction with the Bell Laboratories Coder Tube. The use of one Coder Tube for each analog quantity to be coded would require too much equipment.

7.3 Binary to Analog Conversion.

(E. W. Sard)

The four digit serial binary coder is in operation and performs fairly well. The chief troubles are first, dependence of the output on shape and amplitude of input trigger and second, slight interdependence of the amplitude of the four digits. The first trouble is more serious since changes in the laboratory power supply voltages and line voltage are reflected in changes in the model 5 synchroscope output trigger (which is being used as the input trigger for the coder).

The breadboard of the decoder and read circuits operates qualitatively satisfactorily, but quantitative measurements of performance must wait until the above troubles are cleared up.

7.4 Magnetic Recording

(Edwin Rich)

Measurements to show the variation of output-pulse length and amplitude with changes in input-pulse length and amplitude for a Vicallon recording medium drives at speeds from 2 to 20 feet/second have been nearly completed. From this data a method has been worked out for determining an optimum recording pulse length and amplitude for a given tape speed.

Considerable improvement has been made in reducing jitter and tape noise in the output signal. An improved recording amplifier has also been developed.

Investigation of resolution of recorded pulses probably will be begun about February 10.

7.5 Unclassified

(R. E. Hunt,

Have worked in conjunction with J.A.O'brien on a decimal to binary conversion register. My immediate interest being in the decimal keyboard input for the operator's console, however, we feel that one standard converter could have several applications in Whirlwind I.

The mathematics of the conversion has been worked out to our satisfaction and we are now beginning preliminary design.

(J. A. O'Brien)

Decimal to Binary Converter. R. Hunt and myself have been working on the design of a decimal to binary converter using relays for use in the operator's console. The project has met no obstacles as yet and if the type of relays we have in mind are obtainable, then the design of the converter should be pretty well crystallized within a week or two.

8.0 STORAGE TUBES

8.1 Tube Construction and Testing.

8.11 Tube Construction and Processing.

(J. McCusker)

The following tubes were processed with RLE facilities.

RT7 Tubes designed to test holding guns
RT10 for 5" diameter storage tubes.

RT7's emission to first and second grids was normal. However, RT10's emission to the first grid was low by a factor of about 40. The first and second grids were tied together with a voltage of about 2⅔ times normal, but the emission remained the same. The emission to the second grid and second anode during aging was only slightly less than normal.

A series of reports on vacuum tube processing based on our past year's experience with RLE facilities and library research are being prepared.

The following anodized aluminum targets were processed with RLE facilities.

S17
S19

(F. H. Caswell)

Four vacuum tubes were constructed for testing resistance and capacitance of silver surfaces on anodized aluminum discs and given the titles V. M. (Vacuum Measurement) 1, 2, 3 and 4.

A conference was held with Acheson Colloids New York representative to again improve our Aquadag coatings on envelopes and to get us acquainted with a new graphite dispersion which upon testing proved superior to Aquadag. We will probably adopt it. A detailed report will be found in Memoranda M-230.

(P. Youtz)

A program has been initiated to construct storage tubes with five-inch diameter storage surfaces. Cylindrical pyrex envelopes with necks have been prepared. The anodized storage surface has been processed. This will be coated with calcium tungstate. The tests on R-T 7 and R-T 10 indicate that our holding guns do not give a uniform beam of sufficient intensity on a five-inch diameter surface. New guns will be designed and tested to meet these specifications. However we have components to process a tube whenever a collector screen is constructed.

(R. Shaw)

A fixture for pre-stressing the wire mesh for 5" storage surfaces has been made and is apparently satisfactory.

Several methods of attaching the mesh to its support ring have been tried. A spot-welded "sandwich" of the mesh between the support and a backing-strip is the most satisfactory scheme. However other methods, including induction brazing, will be tried.

Nickel is not available in sufficiently large plates to permit "hogging" the support ring out of solid stock. A fixture is being made to be used in producing this part by hammering it from welded tubing. Spinning, drawing, and fabrication by furnace brazing are also being investigated.

A crude experiment has indicated that the heat applied for degassing the tube may warp the signal plate as much as .008 inch. This matter will be investigated further in more carefully controlled experiments.

(W. J. Nolan)

Feasibility of spinning nickel for use in the 5" storage assemblies has been demonstrated.

8.12 Tube Testing

(S. H. Dod

One of the standard 5 UP guns was modified as a holding gun by bringing out a separate connection to accelerator electrode G_2. The apertures in all electrodes except the control grid were enlarged and the deflection plates moved far apart. It was hoped that these modifications would result in a holding gun suitable for a 5" dia. storage tube. Tests on this tube (RT-7) indicated a total current of over 500 microamperes, but non-uniform current densities. This non-uniformity was found to be caused by interception of current by the deflecting plates and the shield between sets of plates. After the testing of a similar gun with a different control grid construction, a redesign will be considered which will probably result in removing temporarily the deflection plates and the shielding electrode between them.

Preliminary tests have been made on mod 23A storage tube which was designed to show the storage properties of a mica dielectric. It was hoped that this dielectric would show stable operation and could be used as a reserve tube for demonstration purposes. These preliminary tests indicate that the mica emission is low, first crossover is low, and the surface non-uniform. This tube had been reprocessed but it is not felt that this is responsible for the non-uniform operation. The unusually low first crossover required some changes in test equipment.

8.13 Storage Tube Demonstration.

(Joel Simmons)

A pulse transformer was designed and built to be used in a 100 kc oscillator to supply power to a rectifying system which was to furnish deflection voltages to the E.S.T. Losses in the core of this pulse transformer were so high that the transformer could not be used.

It was found that an amplifying stage could not be used in the clamping circuit. Further tests were made to clean up the output of the original clamping circuit.

(C. H. R. Campling)

After certain tests were made on the 300 volt regulator it became evident that the oscillation which was present when the system was loaded was induced by ground currents. Beyond this fact the nature of the cause was not immediately apparent. The physical layout of the regulator panels was changed and alterations were made in the ground connections which successfully eliminated the oscillation. The output showed no detectable fluctuations beyond a millivolt or two of random hash.

It was suggested by Bill Nolan that the transient which occurred upon switching from no load to full load might be caused by the winding inductance within the generator. With this in mind, approximately 165 microfarads of electrolytic capacity were connected across the generator output. The switching transient was reduced to a few millivolts.

8.2 Storage Tube Research

8.21 Surface Material Characteristics

(M. Florencourt)

Research tubes RT-3 and RT-4, whose targets were nickel coated with a calcium -silver combination, had been tested for secondary emission charactistics previously. Both tubes were very gassy and it was not certain how reliable the data obtained were, which indicated a maximum secondary emission ratio of 3 to 4.

RT-3 was therefore repumped and reprocessed, becoming RT-3A. Both DC and dynamic secondary emission tests were made on RT-3A which was now free of gas; they indicated a maximum secondary emission ratio of about 1. Reprocessing the tube had evidently destroyed the storage surface.

8.22 Anodizing

(M. Florencourt)

Calculations were made for anodizing the second style of target and its associated spacer ring for the 5" storage assembly. A constant current method was determined which should give results similar to those obtained on the small targets by using constant voltage. The first large target was anodized successfully using this constant current method. Its surface is very smooth and seems to be of the same hardness and color as that of the small samples.

8.23 Output System Circuits.

(C. H. R. Campling)

A meeting to discuss the storage-tube output-circuit problem was held and various suggestions were put forward by J. W. Forrester and members of the electronics group. The details are reported in Memorandum M-233, which will be issued as soon as it can be typed.

The final draft of the thesis proposal which covers this aspect of the program is being written.

The scope and objectives of the research have been altered somewhat by recent developments and this fact may delay the completion of the proposal somewhat. However, the over-all result should be a better approach to the problem as far as the project is concerned.

(W. J. Nolan)

Some work has been done on miscellaneous circuits for clamping and amplifying the storage tube output signal. Results achieved so far indicate that the circuits developed will be satisfactory for use in demonstration of storage phenomena.

8.3 Unclassified

(P. Youtz)

The construction of the glass on the second vacuum system was finished Feb. 5. This system is now being tested and should be ready for processing tubes by Feb. 10.

The problem of nonex stems (presses) has not yet been solved satisfactorily. However we are able to make a nonex stem which is satisfactory for research tubes. The dies for the vertical stem machine will be redesigned.

9.0 SERVOS AND SIMULATION

9.1 Cockpit

9.11 Structure.

(E. S. Prohaska)

A layout of the seat and controls for the preliminary cockpit is being made. This layout is based on the use of B-29 controls to minimize the manufacturing difficulties on the breadboard model.

No information has yet been received from the Navy concerning the procurement of the controls and seat.

No space has been assigned to the cockpit and hydraulic machinery on the preliminary Whirlwind I layout. Consideration should be given to the possible use of the ash hoist shaft for housing the hydraulic machinery.

9.13 Control Force Loading.

(C. G. Eaton)

The steady-state tests on the differential pressure regulator are being continued.

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

52 Progress Report WWI. for Period Jan 2 - Jan 16, 1948. Sylvania Electric Products Inc. Electronics Divn.

58 IBM Selective Sequence Electronic Calculator. International Business Machines Corporation.

59 Electronic Machinery for Handling Information and its uses in Insurance. (E.C.Berkely) Reprint from Transactions of the Actuarial Soc.of America. Vol.XLVIII. Part 1, No. 117, May 1947.

60 Survey of Mathematical Instruments and Machines used in Calculations - Thesis (M.A.) Northwestern University. (Asta E. Bowen)

6345 Reports

M-219 WWI Drawing Procedure. Note to Sylvania (H. Fahnestock)
M-218 Production Quantities of WWI Units (H. Fahnestock)
M-222 D.C. Voltages Required for WWI (C. W. Watt)
M-220 Bi-weekly Report Part I, Jan 23 (J.W.Forrester)
M-221 " " " Part II, " "
M-223 Air-conditioning for WWI (J. C. Proctor)
M-206 Numerical Solution of Systems of Simulataneous Linear Algebraic Equations by Elimination Methods (Edgar Reich)
M-226 Floor Loading for WWI Computer Room (R. E. Hunt)
M-229 Meetings of Electronics Group Jan. 26 and 28th (J. A. O'Brien)
M-228 Whirlwind I. Preliminary Time Schedules (H. Fahnestock)
E-95 Standard Circuits, Gate Generator GG-1 (J. A. O'Brien)
E-96 Ground Circuits for WWI (D. R. Brown)

11.2 Standards Committee

(S. R. Abbott)

The following specifications (M.I.T.) have been approved and distributed:

Class 6.01 Cabinets and Chassis
Class 6.02 Capacitors
Class 6.03 Chokes
Class 6.21 Wire

The following specifications (WWI) have been approved and distributed:

Class S 7.042 Connectors for RG-62U Cable
Class S7.152 Resistors, Fixed Composition
Class S 7.193 Pulse-Transformers
Class S 7.500 Definitions
Class S 7.501 System Standards
Class S 7.502 Layout Standards
Class S 7.503 Wiring Standards
Class S 7.504 Markings

Class S 7.212 Cable (Hook-Up Wire) Electric has been submitted for approval.

11.3 Purchasing - Stock

(H. B. Morley)

Numerous conferences have been held with manufacturers' representatives to discuss motor-generator sets, regulating equipment, and transformers for WWI. Quotations are being obtained on representative pieces of equipment. The principal difficulty encountered has been the extremely slow delivery estimates (12 months or more in some cases.)

With settlement of the trucking strike, deliveries of material are expected to improve.

The catalog files are being reviewed for the purpose of bringing up to date some obsolete files and preparing a cross-reference index of products.

The standard operating procedure previously mentioned is being prepared, and as soon as the standards book is set up, the Kardex cross-reference file will be revised and a stockroom inventory taken and posted to the cards.

The recent addition of one new employee to this group will make possible a more even distribution of the workload, and will permit the institution of some previously planned procedures which have lapsed under pressure of current work.

11.4 Electronic Construction.

(R. H. Murch)

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

1. 10 d-c bench outlet boxes under construction.
2. 2 d-c bench outlet box covers under construction.
3. 5 Rack power control units. Proto-type completed except for No. 14 wire to one transformer. Wire has just been received. No work will be done on other four units until test equipment committee has approved.
4. 40 Nameplates for a-c circuit breaker boxes.
5. 10 Sets nameplates for portable d-c disconnect boxes.
6. 4 Binary frequency dividers 2:1 and 4:1. One completed, other three will be completed about February 11.
7. Variable frequency clock-restorer pulse distributor. The adjustable scale binary frequency divider 16:1 and 32:1 will be completed about February 11. Layouts for pulse distributor will be completed in a few days.
8. Layout for additional tubes on multiplier. No work being done on this at present.

There is approximately three weeks work in the Electronic Lab at present. This does not include the machine work on job No. 3.

(A. Taylor)

Electronic units under construction for S.T. Lab. Modifying other electronic equipment for S.T. Lab.

11.5 Drafting.

(A. M. Falcione)

During the past two weeks we have experienced considerable difficulty with our Ozalid machine due to low line voltage. A voltage of 190 or less causes the mercury burner to shut off automatically. This necessitates cooling off the burner before it can be turned on again. The Ozalid machine has turned off as high as five times in one day. Although this condition has not affected print production to date, it may develop into a serious situation if the line voltage problem is not corrected.

Because of a change in the block form on Albanene tracing paper at Building 32, arrangements have been made to use up all the old style block tracing paper on Project 6345. In conjunction with the use of this old

tracing paper, it is noted that on several occasions in the past two weeks, completed tracings have had to be retraced due to errors or omissions on the original, which could not be effectively removed from the tracing. Ghost lines were visible on the blueprint which might cause a misunderstanding of its contents. Samples of the old Albanene tracing paper were sent to B. L. Makepeace Co., for laboratory examination. It is not known as to the effects, if any, aging has on this type of paper. Albanene is a prepared white tracing paper treated with Albanite, a crystal-clear synthetic solid. A report from B. L. Makepeace is forthcoming. A small sample of #166 Pheonix tracing cloth has been obtained for experimental use. This is a pencil and ink moisture-proof tracing cloth with ghost-proof qualities. Results indicate good erasing, printing transparency, and handling qualities. It is suggested that this type of paper be used on all WWI tracings. This would insure originality, long life, and prevent any chance of errors from retracing. The cost of Phoenix paper as compared with Albanene is approximately 5 times greater; however, the saving in labor, overhead, etc., would more than offset the increase. One roll of this paper is being ordered for trial.

11.6 Unclassified

(A. Taylor)

Parts and jigs for storage tube assembly are being turned out by the machine shop. This work absorbs about 60% of available machinists' time.

12.0 GENERAL

(G. G. Hoberg)

Summary Report No. 3, the first of the monthly progress reports which are to continue the Summary Report series, has been completed.

A glossary of Whirlwind terminology has been compiled.

(J. C. Proctor)

The following people have recently joined the 6345 staff:

M. H. Hayes, Jr. Research Assistant with the electronics group. Mr. Hayes is a graduate of the University of Maine, January 1948, B. S. Electrical Engineering. Served with the Navy 1944-1946 as electronic technicians mate.

R. P. Mayer, DIC staff member, with Mr. Everett on block diagrams. Mr. Mayer is a graduate of Northeastern University, January 1948, B. S. Electrical Engineering. Served with the Navy 1945-46 as electronic technicians mate.

H. S. Lee, DIC staff member, working on the power supply problem for WWI. Mr. Lee took the Lowell Institute courses in Electrical Engineering and Mechanical Engineering before entering the Army in 1942, where he attended the Harvard and M.I.T. Radar Schools. Served in the Southwest Pacific on procurement and distribution of radar supplies, and as assistant director and director of Radar School, Fort Monmouth.

R. A. Osborne, DIC staff member, with Mr. Proctor on administrative problems and time schedules. Mr. Osborne is a graduate of the University of Pennsylvania, 1944, B.S. Economics. He worked with Westinghouse and Raytheon before joining us.

(H. R. Boyd)

The following persons joined the laboratory during the past two weeks:

Araxi Aghajanian - Engineering Secretary. Secretary for Electronics Group. A recent graduate of Hickok School and a resident of Dorchester. She formerly worked at Raytheon as a laboratory assistant; is a radio amateur and a graduate of Mass. Radio School. Has taught and given lectures on the Armenian language and culture.

Mrs. Virginia Andry - Typist Clerk. Works in Library, and on special problems. Has an A.B. in Journalism from the Pennsylvania College for Women. She lives in Somerville and her husband is a Harvard student.

Jeanne Antz - Electronic Detailer. Works in Drafting Room. Attended Northeastern University and studied Electrical Engineering. Worked for General Radio in Cambridge and lives in Boston.

Albert Elliott - Technician. Works with R. Murch. Formerly worked on Boston University high-altitude experiments. Witnessed two V-2 ascents in New Mexico, carrying equipment which he had built.

Roger Emerson - Junior Technician. Works on electrical maintenance for John Proctor. Took an electrical engineering course at MIT for two years. Was a radio technician in the Navy, and lives in Milton.

Mrs. Patricia Farrell - Senior Clerk. Works in Mr. Morley's office. Has a BA in Anthropology from the University of Washington. Worked for the past five years in the Naval Supply Depot. Her husband is a Naval Officer doing graduate work at MIT.

Mrs. Kathryn Richardson - Senior Clerk in charge of Print Room. Comes from Indiana. Attended University of Chicago and is a graduate of the Chamberlain School of Boston. Is a member of the National Honor Society. Previously worked for the War Department and R. H. White's. Her husband is attending the New England Conservatory of Music.

Peter Sorrentino - Electrical Layout Draftsman. Was an MIT student in electrical engineering for three years, & for 2 yrs. has been designing electrical equipment for Raytheon. Is Helen Sorrentino's brother and lives in Cambridge.

Personnel who have terminated:

Robert Goss - Electronic Detailer
Robert Weston - Electronic Detailer
Vernard Woodward - Mechanical Technician.

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