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Memorandum M-210

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Project Whirlwind
Servomechanisms Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

SUBJECT: HI-WEEKLY REPORT, PART II, JANUARY 9, 1948

To: 6345 Engineers

From: Jay W. Forrester

Date: January 12, 1948

6.0 MATHEMATICS

(M. Daniloff)

I. Editing of paper on "Continuous Quasi-Harmonic Oscillations of a Abraham-Bloch Multivibrator" completed. Main results:

- a. An equation giving phase of output oscillation (Equation 11).
- b. An equation giving frequency of self-sustained oscillations (Equations 12 and 13).
- c. An equation for factor of amplification (gain) (Equation 14).
- d. Two equations for input and output amplitudes as functions of the gain (Equation 15).

II. Examination of the 90 equations of airplane performance contained in 6345, R-64 continued with the purpose of achieving simplification and condensation. Main results obtained are:

- a. Some of the aerodynamic coefficients can be expressed through linear equations with an error of the order of 10-15%, for example:

$$C_x(\alpha, \delta F) = C_x(\alpha, 0) + \frac{1}{10} \delta F^\circ$$

the maximum error being 11%.

- b. Lanchester's phugoid is based on assumptions too crude to serve as a "check-and-decimal-point-solution" for WWI; to wit: 1) the plane does not have any moment of inertia about a transverse axis; 2) the thrust is kept adjusted so, that the tangential velocity changes as the velocity of free fall ($\sqrt{2gh}$). An attempt to solve the phugoid equation exactly for the case of a constant thrust lead to inextricable expressions. However, integration in closed form was achieved for the case of near-horizontal flight at nearly constant velocity. The case of constant power does not introduce serious complications, and a solution, in closed form, was also obtained.

(Edgar Reich)

The Spoerl method for the solution of symmetric linear algebraic systems was examined and found to differ but little from the Doolittle method.

(Edgar Reich, Continued)

The November 1947 issue of the Bulletin of American Mathematical Society may contain useful information as regards the accumulation of round-off error in elimination methods.

The rough draft of the memorandum on elimination methods is being prepared.

(C. W. Adams)

Estimates of the elapsed time and the net effect of the various orders so far proposed for WWI are being made. This information is needed in readily accessible form to facilitate the programming of certain solutions. Estimates of time required will be especially needed in cases where alternate programs are available or where use of a special order not yet adopted might be suggested.

7.0

INPUT AND OUTPUT

7.1 Eastman Kodak Recorders

(H. R. Boyd)

The Eastman program was discussed last week with Thaler and Crawford of Special Devices, and it was decided that a prime contract would be given to Eastman by SDC for the film reader-recorders. This is a change from the original negotiations which were on the basis of the work being carried out as an M.I.T. sub-contract.

D. Brown and I will go to Eastman in two weeks to help complete the technical specification and contract details.

7.2 Analog to Binary Conversion

(Wieser, Sard, Linvill)

The use of the coarse-and-fine system for relieving the accuracy requirement on the analog to binary converter seems feasible when the analog quantity is shaft position since coarse-and-fine signals can be obtained from geared potentiometers. Shaft position is probably the only analog quantity measurable with enough accuracy to require a coarse-and-fine conversion system. The problem of switching the binary quantity from the coder tube into the computer is not difficult since the binary quantity is in serial form. A scheme for getting a serially-coded binary number into the computer has been laid out in connection with film storage.

More detailed information on performance characteristics of the coder tube of Bell Laboratories is needed.

(In the bi-weekly report of December 26, the Bell Laboratories Coder tube was incorrectly referred to as a decoder tube.)

7.3 Binary to Analog Conversion

(Linville, Sard, Wieser)

Binary to analog conversion will be accomplished by the use of an analog to binary conversion device in the feedback loop of a control system. The error detecting device will be a serial binary subtracter. The difference, a serial binary number expressed in the form of absolute value and sign, must be converted to a voltage by a conversion device in the forward loop of the control system. A promising device for converting a serial binary number to a voltage has been developed by Bell Laboratories in connection with Pulse Code Modulation. This device needs special adaptation to handle negative numbers. No simple method of adaptation has been devised as yet.

7.4. Magnetic Recording

(E. S. Rich)

A complete system for continuously recording and reproducing pulses on magnetic tape is being built up. The system includes a 30 kc to 200 kc oscillator and amplifier to supply erasing current, a pulse generator to feed the recording head, a video playback amplifier, apparatus for driving the tape at a constant speed, and an A/R scope for observing the pulses.

In initial tests it was noted that:

- a. The scope will have to be triggered by the playback pulses in order to observe them without excessive jitter.
- b. The paper-backed magnetic tape from Minnesota Mining and Manufacturing Company deposits some of its coating on the heads so is unsatisfactory for use in this system.
- c. The erasing-head core must be slightly wider than that of the recording head to give complete erasing.

Two other types of tapes are being obtained and the necessary changes in the apparatus and circuits are being made so that the complete system should be operating satisfactorily by January 15.

A laminated core for the second model of a static reading head has been assembled. After the notches have been cut and the windings have been added it will be ready for testing.

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8.0 STORAGE TUBES

8.1 Tube Construction and Testing

8.11 Tube Construction and Processing.

(P. Youtz)

The following tubes were designed, constructed and processed during the past fortnight:

Storage Tube Mod. 23 (Storage surface of mica)
Research Tube Mod. 4A (Reprocessing of RT Mod. 4).

After storage tube Mod. 23 was processed it was discovered that the lead to one of the deflection plates broke at one of the welds. It is planned to blow out the glass at this weld, repair the lead and reprocess the tube as storage Tube Mod. 23A.

Research Tube Mod. 4A cracked when it was sealed off the pump. This tube was reactivated with as much cathode emission as it had as Mod. 4. However when Mod. 4 was cracked open it was sealed on the pumps immediately. But it was this high cathode emission after being exposed to air which tempted us to reprocess storage tube Mod. 23.

The following tubes are under construction, partially designed and constructed:

Storage Tube Mod. 18B (This has a storage surface of calcium Tungstate).

Evaporation Tubes ET 23, 25 (Tubes to produce caesium actuated silver surfaces).

Research Tubes:

RT Mod. 5 (contains target from ET 23).

RT Mod. 6 (contains Target from ET 24).

RT Mod. 7 (Objective of this tube is to test a new holding gun. Apertures will be larger and second grid will be isolated from the second anode).

We initiated a program to study the problems involved in constructing storage tubes with five inch storage surfaces.

- 1). A study of five inch screens and the associated design problems was started.
- 2). Procured five round bottom 5-1/2 inch diameter pyrex jars. Two necks were put on one cylinder, and one neck on a second cylinder. These necks were graded from pyrex to nonex. When a satisfactory five-inch storage surface and a five-inch screen are assembled they will be put in these cylinders.

- 3). Work on these pyrex cylinders indicate we should attempt to get more satisfactory jars from Corning. A visit to Corning Glass Works is planned for later this month.

The bottleneck in tube construction continues to be satisfactory nonex presses. This problem is under control and should be solved during the next bi-weekly period.

(F. H. Caswell)

H. A. Ladd and myself have fabricated various storage tube and evaporation tube parts to facilitate faster construction of future tubes. This includes modification of several electron guns.

Work on an inventory has been under way by H.A. Ladd and myself. This includes inventories of the storage tube group measuring instruments, of which a file has been kept, special components ordered by members of this group such as special transformers, etc., cataloging of all built up chassis and their corresponding drawing numbers.

(S. H. Dodd)

Professor Franklin is making an analysis of wire mesh screen stresses caused by electrostatic fields in five-inch diameter storage tubes. Richard Shaw is studying the problem of keeping these large size screens under constant tension to prevent distortion during construction and operation.

Goldman's tube has been borrowed and a preliminary study of the effects of two wire mesh screens will be made.

Dies have been designed for the ten-pin nonex glass stems and the Building 32 shops is building them. They should be ready about January 15.

(T. F. Clough)

Glass Lathe - Work was done on the glass lathe to provide for internal blowing and the burners were adjusted for glass blowing. It is now in condition to do many of the usual tasks of glass working.

Nonex Stems - Considerable work has been done during this period and much effort will be exerted during the coming period to prepare for the construction of our own 10 lead stems. With the assistance of Ralph Witthus a beading tool has been completed. Flares are being prepared for stem making. I have made a couple of stems on the vertical stem machine secured by Patrick Youtz.

This has demonstrated the workability of our techniques. Although some difficulties must be expected we are now reasonably well assured that we shall soon be in an independent position with respect to this critical item. During the next period,

techniques and procedures will be improved, necessary tools secured and components prepared for a quantity of these stems.

8.12 Tube Testing

(W. J. Nolan)

Tests have been made on *ST Mods 14B, 15B and 16. In general the characteristics observed for Mods 14B and 15B were the same as those for Mods 14A and 15A respectively. Mod 16 has not shown any marked difference from Mod 15. However, since no storage tests have been made on it, it is not yet possible to tell if the resolution is significantly better than Mod 15. The data observed for these tubes serves principally to confirm the previous belief that the reading and writing operation is satisfactory and that it is the holding beam which is causing unreliable operation. To check this some tests were made at low voltages. The results were not in agreement with any of the present theories concerning the phenomena in question, but apparent erratic operation and doubt concerning the measuring techniques led to postponement of further tests of this nature until completion of the present series of high voltage tests.

8.13 Storage Tube Demonstration.

(Joel M. Simmons)

The Impedance Switch for the EST Demonstration Unit was constructed.

A circuit diagram of a low drain power supply for the deflection plates on the old EST Demonstration Unit was made and one unit was constructed (bread-board style) as a check. Operation was good.

Difficulties in the clamping circuit have been encountered in matching two phase inverters for d-c coupling and in obtaining no overshooting of the pulse. Work is to be continued on the clamping circuit.

(C. H. R. Campling)

It has been decided to operate the 2 amp. voltage regulator with the input to the amplifier taken from the regulator terminals rather than through a long line from the load terminals. The load will be supplied through a cable made up of six number ten wires. A sample cable of this sort has been constructed and its characteristics measured. The indications are that the cable will be satisfactory.

One of the regulator panels has been required to accommodate ten 6AS7's. Tests of the system with these tubes can now proceed.

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8.2 Storage Tube Research.

8.21 Surface Material Characteristics

(M. Florencourt)

Research tubes RT3 and RT4 were submitted to tests. The storage surfaces of these tubes consist of a caesium-silver combination evaporated on a polished nickel base. Both tubes were very gassy. Rough secondary emission characteristics of RT4 indicated a maximum ratio of between 3.5 and 4.0 for 600 volts accelerating potential. Other measurements made and results observed indicated that probably no data taken on these tubes was too reliable. It was decided to try to repump RT5 to see if it could be degassed and then retested.

Life tests were continued on ST Mods 20A and 20B. These tubes although supposed to be identical in construction show very different SE characteristics. Tests show that 20A is still unsuitable for a storage surface, showing a SE ratio of much less than 2.0 in the critical region of 1500 volts, and that on the contrary, 20B is still suitable for a storage surface, showing a SE ratio of greater than 2.0 for all accelerating potentials from 150 to 2000 volts.

(H. L. Heydt)

Life studies of Mod 20A and Mod 20B are being continued. During the first sixty hours of usage the first crossover potential for the surface of 20B never became greater than about 50 volts, while the secondary emission ratio at 1500 volts never dropped below 2.0. The surface of 20A at no time exhibited such satisfactory characteristics, although 20A has been operated for over 200 hours.

Measurements become increasingly difficult the longer the tubes are operated. Apparently more and more precise beam positioning is required. It seems that if extensive secondary emission tests are to be carried on in the future a new research tube design should be used.

(P. Youtz)

ST mod 18B was constructed with the objective of reproducing the results of calcium tungstate storage surface ST Mod 18. We have materials to make similar surfaces of powdered beryllium oxide or titanium oxide. Under consideration are research tubes to study the secondary emission characteristics of these surfaces.

Our caesium activated silver surfaces as reported in M-186 are exposed to air. Several research tubes were constructed in the labs of ATL Inc. of Chicago to study the effect of exposing these surfaces to air. Four surfaces identical to our surfaces were prepared and exposed to air for different lengths of time. Target was sealed in a

vacuum tube with getter and air ionization gauge. All targets emitted gas in proportion to the duration of exposure to air. Thus in RT5 and 6 the caesiated surface will be assembled in a tube and exhausted as soon as possible after it is removed from the evaporation tube.

We studied commercial methods of producing photo cells and multiplier tubes. At the A.A.A.S. meetings in Chicago we discussed with many of the research men in physical electronics the making of alkali halide and alkali thin film surfaces. These techniques are critical. Many believe that exposure of these surfaces to air ruins their high secondary emission ratio of 8 and 10. Since we are satisfied with a secondary emission ratio of 3 we will continue to prepare our surfaces and expose them to air during fabrication. Distillation of the alkali after the tube has been assembled and exhausted would introduce new processing problems.

8.23 Output System Circuits.

(C.H.R. Campling)

An initial study of the requirements for the clamping circuits to be used for storage tube output has been started. A master's thesis proposal is being prepared to cover an investigation of circuits which may be used for this purpose. Steve Dodd and I conferred with Professor Zimmerman on this matter shortly before Christmas and he agreed to supervise the research.

8.27 Gas Data Storage.

(R. F. Markel)

Experimental results on gas data storage tubes have been correlated and preparation of a thesis report is now in progress. The completion date is January 16, 1948.

8.3 Unclassified.

(S. H. Dodd)

Drawings of Storage Tubes Drawings were begun for all the later storage tube drawings about two months ago. Mod 11 drawings have since been completed but lack of drafting time has prevented further work. Mods 12 thru 23 have still to be completed. This is a shorter job than it appears since many of the detail drawings are common to all tubes.

(A. R. Curtiss)

1. Constructed 7 tube gate amplifier.
2. Modified P1 power supply in accordance with Dwg. C-30054.
3. 1 to 100 μ sec. Pulse generator ready for check.
4. Servicing video amplifier.

(Peter Darvizis)

1. Constructed impedance switch for EST demonstration.
2. Completed manifold assembly for glass lathe.
3. Constructing voltage distribution box for use with 375 v. d-c M.G. set.

(Joseph Crowley)

1. Assisting with EST secondary emission characteristic tests, recording, plotting, etc.
2. Preparing Electrolytic tank, sealing and instrument check.

9.0 SERVO AND SIMULATION.

9.1 Cockpit.

9.11 Structure

(E. S. Prohaska)

It has been decided recently that the first model of the cockpit will be a simple test model to be used for the study of cockpit components and computer demonstration.

This preliminary cockpit will have the following features:

1. Single-place controls.
2. Control force loading in three axes.
3. A minimum of instruments and other apparatus.

The following features will be omitted from the immediate program:

1. Simulated control elastance, backlash, and coulomb friction.
2. Noise and vibration simulation.
3. Simulated appearance of aircraft interior.

9.12 Instruments.

(R. Shaw)

Experimental instrument drawings are being revised to accommodate 2 geared potentiometers for coarse and fine data transmission.

Some delay has arisen from the fact that new members of the drafting and engineering departments are not acquainted with Servo. Lab. drafting standards.

9.13 Control Force Loading.

(C. E. Eaton)

The new differential-pressure regulator has been completed and the preliminary static tests of the valve have been initiated.

Some time has been spent in aligning the valve, and at present the valve is in operating condition. From the tests conducted so far, it appears that the regulator holds definite promise.

9.14 Elastance, Backlash, Coulomb Friction.

(M. Flomenhoft)

Efforts to code the "linkage" problem for a control force servo disclosed that a workable solution for static conditions will necessitate using a brake on the control stick.

After discussing these findings with R. Everett and E. Prohaska, it was agreed not only to continue on this basis, but also to introduce the problem of "backlash" at this point rather than postpone consideration of it any longer.

Even in the preliminary stages of organizing a "flow diagram", however, it is clear that "backlash" has added appreciable complexity to the problem, and would probably increase both the computing time and the storage space requirements materially.

Further conclusions must await an evaluation of these requirements.

(E. Prohaska)

In order to reduce the complexity of handling the coulomb friction problem in the computer, some of the friction should be put in mechanically at the controls. This would require a minor redesign of the controls.

9.2 Sampling Servo Stability Study.

(W. K. Linvill)

No reportable results since the last report. Professor Hurewicz paper is Chapter 5 of the Radiation Laboratory Series Volume 25 on theory of Servomechanisms, just released by McGraw Hill

10.0 TRAINING.

10.1 Seminar Series.

(R. R. Everett)

The first session of the seminar series has been postponed until January 12 to allow time to complete clearance procedures on visitors.

11.0 FACILITIES AND CENTRAL SERVICE.

11.1 Publications.

(J. N. Ulman)

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

6345 Reports

- R-120 Deflection Circuits for Electrostatic Storage Tubes, J.O.Ely.
- M-176 Methods of Numerical Integration of Ordinary Differential Equations most suitable for use by WWI and WWII, M.Daniloff.
- M-197 Space and Power for WWI Electrostatic Storage, J.O.Ely.
- M-198 Input-Output Register Panel Space, D. R. Brown.
- M-200 Circuits for Marginal Checking, J.W. Forrester
- M-201 Whirlwind I Installation Conference, H. Fahnestock.

Library and PB Reports

PB Reports Sec. 4 and 10.

80603 The BTL High Fidelity Tape Recorder, Columbia U. Divn. of War Research. U.S.N. Underwater Sound Lab., Fort. Trumball, New London, Conn.

Library Files

- 47 Technical Information Pilot Bulletins 350, 353, 352, 354, 355, 356, Science & Technology Library of Congress for ONR.
- 48 Printed Circuit Techniques, N.B. of Standards.
- 519-L Suppression of Arc-Over, Corona and High Voltage Leakage in the 5TP4 Kinescope, R.C.A.
- 519-M Blower Requirements for RCA Forced-Air-Cooled Tubes, RCA.
- 49 Progress Report for WWI Electronic Digital Computer, Dec. 5 to Dec. 19, Contract DIC:R:12320, Sylvania Elec. Prod.Inc.
- 50 Tracerlog. Jan. 1948, Tracer Lab.

The following reports are on loan from the ONR until January 28:

- 2142 "Kernel Functions in the Theory of Partial Differential Equations of Elliptic Type".
- 2118 "A Theoretical Study of Reproduction of Pulses".
- 2119 "Pulse Transformers."
- 2123 "Delay Lines."

11.2 Standards Committee.

(J. O. Ely)

- A. As a result of discussions in the standards committee about unsatisfactory impregnating materials now used on pulse transformers and R-F chokes, an investigation of Bostik EXE-152 used as an impregnant has been started.

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B. The coating obtained by dipping and baking is very hard, but so far we have not secured a coating which is free from bubbles and holidays. Vacuum dipping in a properly thinned mix, together with thorough drying prior to baking may resolve the difficulty.

C. As time permits, new techniques will be tried.

D. See B. above.

E. -

(S. Abbot)

At the last meeting of the Standards Group samples of standard R. F. Chokes and RNC Connectors submitted by manufacturers were discussed and approved for usage.

Tests on a new type insulating compound and adhesive (Bostik EKE-152) were proposed and results will be submitted at the next meeting.

Relays, capacitors, resistors, sockets and transformers were discussed by the Group.

The advisability of using 1/16" Aluminum Panel was commented upon and further investigation was proposed.

18.3 Purchasing and Stock.

(H. Morley)

- A. Many new catalogues have been added to the files of this department as many manufacturers are printing the first major revisions of this literature since the war. Upon request, this department will obtain catalogues pertaining to special items.
- B. A Cinch Manufacturing Company Representative will call on us the week of January 11 to discuss their products, including problems relative to the application of loktal tube sockets.
- C. Rockbestos Company has submitted samples of their type ACA wire with a cotton lacquered braid instead of fiberglass. This might be adaptable to inter-unit power cabling. They also indicate that they can supply the fiberglass type wire in solid colors. Comments would be appreciated.
- D. If any Engineer or Technician withdraws from stock an abnormal quantity of any item, it would facilitate stock control if they would notify the stock clerk.

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11.4 Electronic Construction.

(R. Murch)

The following Units are in the Electronic Lab for construction:

1. 25 d-c power cables.
2. 5 rack power control units. Expect proto-type to be completed about January 16.
3. 20 d-c bench outlet boxes. In machine shop for machine work.
4. 2 d-c bench outlet box covers. In machine shop for machine work.
5. 40 nameplates for a-c circuit breaker boxes.
6. 10 sets of name plates for portable d-c disconnect boxes.
7. 4 Binary frequency dividers 4:1 & 2:1 terminal boards were started but cannot be completed until clinch type elastic stop nuts are received. Chassis and panels are in machine shop for machine work.
8. Pulse amplitude monitor completed, but has to have several potentiometers changed, when the correct ones are in stock.
9. Gate tube test rack. Panels are completed. The rack for this has not come in as yet. The manufacturers have been contacted and stated that they have been unable to locate the side channels which have been held up due to the truck strike.
10. Periodic Program control for multiplier completed except for chassis mounting brackets which are out of stock.
11. Multiplier Test Rack. Layout of frequency divider 32:1 and 16:1 has been completed. Construction was started but had to be stopped for lack of parts.
12. Modifications to multiplier control panel. Dan Mach is making the layouts for this.
13. 2 Variable delay pulse and gate generators. Layouts are being made.
14. 30 93-ohm cable terminators. Will be made as soon as technicians are available.

There is about five weeks work in the lab at present. This does not include the machine work on jobs number 2, 3, 4 and 7.

11.5 Drafting.

(H. R. Boyd)

Some changes in drafting room arrangements are being worked on to improve the quality and facility for making mechanical tracings.

Mr. Lovett is going to follow the WWI air-conditioning program as a part-time activity.

A-34 and A-43 have been issued and prescribe many of the de-

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tailed procedures that are necessary for control and manufacture of drawings. These should be read carefully.

(A. M. Falcione)

Work Load Status. An additional draftsman has been obtained which will assist in decreasing the work load. The contemplated change in the cockpit program will make drafting manhours available for other work. Progress on the present load is progressing at a satisfactory rate.

(C. W. Watt)

Administrative memoranda A-46 "Circuit Schematic Standardization for WWI," and A-34, "Drawing and Print Procedure for DIC 6345" have been issued. All personnel are urged to read these memorandums carefully since a knowledge of procedures simplifies the use of any system.

11.6 Unclassified.

(E. Mercer)

Have received copies of new parts list forms and am in process of bringing previous parts lists up to date to conform to new procedures as set forth in Administrative Memo A-34. The vellum masters for the parts lists are to be ordered this week.

(A. Taylor)

The mechanical lab is now working on the construction of an electric oven for the storage tube lab and building electronic equipment for the testing of storage tubes. The machine shop is still manufacturing special parts for use in electronic equipment.

The backlog contains about three days work. All of it is low priority except a tube element for the ST lab.

The electric annealing oven will not be ready until January 19 because of material arriving late.

The machine shop is short one man.

(J. C. Proctor)

The problems of building and office equipment maintenance have been carried along as usual.

A new procedure for numbering equipment and keeping equipment records is being put into effect which should be of considerable help in future inventories, etc.

12.0 GENERAL.

(J.W.Forrester)

Please note the following changes in decimal classification of material for the bi-weekly reports:

1. Delete Section 311 Five Digit Multiplier
2. Add Section 2.31 Five Digit Multiplier.