

Project Whirlwind
Servomechanisms Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

SUBJECT: BI-WEEKLY REPORT, PART II, APRIL 30, 1948

To: 6345 Engineers

From: Jay W. Forrester

6.0 MATHEMATICS

(P. Franklin)

Study of the Seidel method was continued. The coding of numerical integration has been started for simple systems of differential equations. Some calculations of fields in storage tubes by means of elliptic integrals have been made.

(C.W. Adams)

Coding of numerical methods of integrating nth order linear systems of differential equations continues. The Runge-Kutta method has been coded for the general case and some special cases and estimates of time and storage requirements have been obtained. These requirements, while not small, seem entirely reasonable.

(Edgar Reich)

At one time it was thought that a way of breaking off the Seidel process would be to stop when the sum of the absolute values of the residues stopped decreasing. Attempts to prove that positive definiteness of the coefficient matrix was sufficient to insure success of this method failed, and now a numerical example has been found which definitely proves that the sum of the absolute values of the residues need not decrease monotonically during the iteration process.

(M. Daniloff)

1. Memorandum M-370 "Electronic Devices with a High Emission of Secondary Electrons (A Translation from Russian) has been prepared and distributed to the Storage Tube Group.
2. Preparation of Memorandum on Simulation of Empirical Functions by Polynomials is continued.
3. Attention given to problem (proposed by Storage Tube Group) of the thickness of oxide deposited on a plate by evaporation from a toroidal cup. Since the exact analytical solution leads to complete elliptic integrals of the third kind, the numerical evaluation of which is not

6.0 MATHEMATICS (Continued)

very convenient, an approximate solution in series form is being attempted. This will give the effect of all the design parameters with an accuracy which is expected to be sufficient for practical purpose and for apparatus of the same proportions, generally, as the one in use at the present time.

(D.W. Batteau)

Given a data table having r rows and c columns, investigation of methods for conveniently checking the possibility of a linear relationship, or dependence, between columns (or rows) suggests considering the ratios of the c dimensional volume to the $c-1$ dimensional volume obtained by deleting a given column c_1 . To obtain a criterion, the ratio must be divided by the length of c_1 . In terms of matrices

$$P = \frac{\sqrt{DD'}}{\sqrt{D_1D_1}} \times |c_1|$$

where D is the data table as a matrix.

7.0 INPUT AND OUTPUT

7.4 Magnetic Recording

(E.S.Rich)

Work on the thesis report covering the investigation of pulse recording on magnetic tape has been continued. Photographs of the equipment have been taken, all drawings have been submitted to the drafting room, and a draft of about two thirds of the report has been typed.

7.6 Output Printers

(F.A.Poss)

The use of the transmitter distributor in controlling the transfer and switching of digits through the use of the relay selector circuits has been studied. Timing pulses have been obtained from the control circuits through the use of successively closing relay contacts. After the printing registers are cleared of one number, the control circuits have been used to pulse in a new number in order to produce another printing cycle.

The thesis report on the investigation of output printing systems is being written.

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8.0 STORAGE TUBES

8.1 Tube Construction and Testing

8.11 Tube Construction and Processing

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

Nine tubes were processed during this period and complete components for several more tubes were prepared.

The second and third five-inch storage tubes were constructed and processed. The storage surfaces in these tubes were calcium tungstate on Al_2O_3 . The envelope of the second tube had a very slow leak which could not be located. This tube processed well on the pumps and the beam currents in both guns were excellent. The current in the holding gun was more satisfactory than in previous tubes. Just as we expected from the behavior of the tube on the pumps, enough air leaked in overnight to prevent further testing. However the third tube pumped satisfactorily and is ready to be tested.

A storage tube ST 28 was constructed and processed with a 3/4 inch storage surface having a beryllium mosaic with 85% conducting area. This tube is undergoing a series of tests. A research tube RT 22 was constructed and processed to study the secondary emission characteristics of this type of mosaic. Two more research tubes RT 20 and RT 21 with beryllium surfaces having thick layers of oxide were constructed and processed.

Several beryllium surfaces and one caesium-silver surface were prepared in evaporation tubes. One attempt was made to prepare a large surface with a beryllium mosaic. The evaporation was performed at a pressure of 10^{-4} mm of Hg. This evaporation was unsatisfactory. The resistance across the surface was approximately 500 K. Two large size evaporation tubes to prepare beryllium mosaics are under construction. The evaporation will be performed at a pressure of 10^{-6} mm of Hg. Previous results indicate this should give a satisfactory mosaic. If these surfaces are adequate they will be put in the fourth and fifth large size storage tubes.

Also under consideration are a series of research tubes to study the secondary emission characteristics and life of caesium-silver surfaces.

One tube will be constructed to study the secondary

8.11 Tube Construction and Processing (Continued)

emission characteristics of beryllium oxide power settled on Al_2O_3 . The objective of this tube is to obtain a storage surface which is a smooth uniform dielectric with SE characteristics close to those of the Be mosaic so that comparison between mosaic and smooth surfaces can be made.

Preliminary considerations have been given to the preparation of magnesium oxide surfaces.

R. Shaw has been assigned to make a preliminary design of an exhaust system to evaporate material, vacuum fire and braze in an atmosphere of hydrogen.

(R. Shaw)

One signal plate assembly was completed during this period and was assembled into ST-27. Parts for three more will be available during the week of May 3. Signal plate assemblies for ST-26 and ST-27 are described in memoranda M-392 and M-393 respectively.

Sketches are being made of a basically new screen and plate assembly.

A five-inch evaporation tube was made, working from rough sketches. Calculations were made on the variation of deposited film thickness in this tube, assuming an annular source of evaporating material. Results indicate that film deposited on a 4-3/16 dia. plate will be 10% thinner at the edge than at the center. This problem has been referred to the mathematics group for further study.

Some sketches have been made of parts for a new holding gun, but the design is not yet complete.

(F.H. Caswell)

Five evaporation tubes, one research tube, and two storage tubes (including one 5") were fabricated and assembled during the past two weeks with their particular envelopes and electron gun modifications. Parts for the next two 5" storage assemblies are on hand.

The "Dag" machine has been completed and will be installed in the tube construction room.

Several more experiments were carried out to improve our Calcium Tungstate settling process.

8.11 Tube Construction and Processing (Continued)

The Tube Construction Room (room 020 in the basement) will be ready for occupancy Monday, May 3. This is a filtered air room in which all vacuum tube elements will be fabricated and assembled. For utmost cleanliness, the room and all equipment are painted white, all seams are caulked and filtered air is forced in through a Raytheon Precipitron.

This room will be kept locked at all times and permission to enter can be obtained from F.H. Caswell.

8.12 Tube Testing

(S.H. Dodd)

ST 26, the second 5-inch tube, was tested but a leak resulted in too much gas so no operation tests could be made. Current measurements on the pumps indicated satisfactory holding gun operation with about 600 μ a beam current at 1000 V on g2 and quite uniform coverage.

A beryllium mosaic research tube for studying storage characteristics (ST 28) is now being tested. Measurements of leakage across the mosaic surface and through the Al_2O_3 dielectric indicate high leakage R. Adjustments were made to run with low holding beam accelerating voltage and preliminary tests indicated an optimum holding beam accelerating potential of about 85 volts.

(W.J. Nolan)

Considerable work has been done in studying the characteristics of the storage surfaces of Mod 14A and 15A when bombarded by low velocity electrons. The most significant results are the evidence that the willemite surface of Mod 14A has a much lower first crossover voltage than had been expected. Some doubt still exists, however, as to the interpretation of some of the data.

8.13 Storage Tube Demonstration

(J.S. Rochefort)

The first draft of the report on the E.S.T. Demonstrator has been completed. Copies have been made available to members of the Storage Tube Group for criticism and suggestions.

8.2 Storage Tube Research

8.21 Surface Material Characteristics

(H.L. Heydt)

The secondary emission characteristics of three research tubes RT-18, RT-19, RT-21, each having a storage surface composed of beryllium on Al_2O_3 , have been studied in detail. The surfaces have been continuously bombarded by 300-volt primary electrons in the life-test rack, except for brief intervals during which secondary emission tests were made on the surfaces. Results to date are summarized as follows:

<u>RESEARCH TUBE</u>	<u>APPROX. HRS. OF BOMBARD- MENT</u>	<u>APPROX. 1ST CROSSOVER POTENTIAL</u>	<u>MAX. S.E. RATIO</u>	<u>S.E. RATIO AT 1500V</u>
RT-18	0	30V	3.9 @ 600V	3.1
	200	25V	5.0 @ 500V	2.8
RT-19	0	25V	3.0 @ 500V	1.8
	200	25V	3.6 @ 400V	2.0
RT-21	0	30V	3.7 @ 500V	2.0
	20	30V	3.6 @ 450V	2.0

The surfaces in these tubes have been prepared in various manners and it is expected that their secondary emission properties should differ. Further life-testing of these surfaces will be performed. In addition, two other beryllium surfaces will be studied. One will be a mosaic surface, while the second will be used to observe the effect of cathode contamination on the secondary emission properties of the surface.

8.23 Output System Circuits

(C.H.R. Campling)

In the last week more work has been done on the direct-coupled clamp circuit with results which are somewhat better than those which were obtained previously. A simple method has been found to simulate the complete input to this circuit, that is, to couple simultaneously to the input both the signal-plate switching-gate and the signal pulse.

More than half of the thesis report has been drafted and typed. The drawings for this portion of the report are in the drafting room now and it is likely that they will be completed on time. Some or all of the remaining drawings probably will be done by myself.

8.23 Output System Circuits (Continued)

Some additional time is being spent now on the remaining two output circuits to obtain better organized data on their performance.

8.3 Unclassified

(M.I. Florencourt)

Work has been kept up to date on tube files, photographs and anodizing. No new holding-gun tubes have been processed for testing.

8.4 Deflection Circuits

(J.O. Ely)

The experimental 32-position deflection-voltage generator has been set up with a restricted control sequence and suitable synchroscopes and tests have been started. These tests will be continued, as indicated below, during the next two weeks.

Initial operation, after correcting minor wiring errors, was satisfactory except for the rise-time of the output signal, which was between 5 and 6 microseconds. The following steps were taken to correct this deficiency:

1. Decoupling circuits were changed from individual filters at each buffer amplifier and switch cathode-follower to balanced circuits.
2. Plate supply voltage of the output amplifier was raised from +250 volts to +350 volts and the necessary changes made in the feed-back voltage-divider resistors in order to secure more nearly linear amplifier operation.
3. Phase correction capacitances in the feed-back loop were reduced.

After making these changes, rise-time of the output signal is approximately $1\frac{1}{2}$ microseconds. Stability and linearity of the output cannot be checked sufficiently closely by visual observation of the waveforms on an oscilloscope, but appear satisfactory. More accurate checks will be made by means of an instantaneous voltmeter of some sort.

A circuit for one type of instantaneous voltmeter has

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8.4 Deflection Circuits (Continued)

been devised. This circuit will be bread-boarded and tested next week. If operation is satisfactory, the deflection-voltage generator will be placed on continuous operation with daily checks of linearity and amplitude of the output voltages in order to evaluate stability.

Construction of the second panel (horizontal coordinate) of the deflection-voltage generator was begun last week and is progressing rapidly. Unless material shortages interfere, this panel may be completed by May 19 or 20.

Electrical modifications have been made on a P-4 synchroscope to allow its use as a display 'scope for demonstrations with the two deflection-voltage generator panels. A 26" rack-mounting panel for this synchroscope will be made during the next two weeks.

Assembly of power supplies, test equipment, etc., needed for demonstration purposes will be begun as soon as possible.

9.0 SERVOS AND SIMULATION

9.1 Cockpit

9.11 Structure:

(E.S. Prohaska)

The hydraulic piston has been detailed and is about ready to be checked.

Some difficulty is being experienced with the tachometer drive since the tachometer inertia is large. However, this should be cleared up by next week.

9.13 Control Force Loading:

(C.G. Eaton)

Transient and steady-state runs have been made on the Control Force Demonstrator.

The demonstrator has been operated as a simulated spring-mass system and also with strain-gage feed back. The system is sensitive enough so that backlash, noise, friction, etc. are now the limitations.

At present, time is being spent in trying to reduce the above-mentioned non-linearities.

9.2 Sampling Servo Stability Study:

(W. Linvill)

A new book, "The Dynamics of Automatic Controls" by Oldenbourg and Sartorius translated from German by H.L. Mason treats sampling servos in a fashion similar to Hurewicz' method. It is being studied. The difficult problem still rests in simplifying the analysis to a point where it may be used in setting up a design procedure. Considerable time was spent in attempting to apply step-by-step analysis in terms of time functions only. The process, though it can be carried out, is too cumbersome to use in design. Since the system is superposable, the use of transforms and transfer functions still seems to be the most convenient approach.

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10.0 TRAINING

10.1 Seminar Series

(R.P.Mayer)

Work on the series writeup has been resumed after a slight delay caused by more urgent matters.

(R.R.Everett)

The seminar was resumed on Monday April 26. April 26 and 28 were spent in discussing as an example the coding of a linear interpolation problem.

Seminars for the next month will be given by Professor Franklin.

A less formal seminar on computer block diagrams will be started in the near future. This seminar will be made a part of the regular Friday afternoon electronics meetings. It will cover the details of the block diagrams and will be coordinated with the electronics discussions.

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 Draws.</u>	<u>Date</u>	<u>Author</u>
R-135	History of Secondary Emission	76	11	3-30-48	H. L. Heydt
E-110	Life Data - 6AG7 Tubes of D. C. Flip-Flop Rack	2	2	4-14-48	J. J. O'Brien
E-111	History of Secondary Emission (Abstract of Report R-135, An Electrical Engineering 6-502 Seminar Paper)	2	-	3-30-48	H. L. Heydt
E-112	Tube Failures	2	2	4-23-48	J. J. O'Brien
E-113	Block Diagram of Master Clock for Whirlwind I	2	1	4-27-48	D. R. Brown
M-352	WWI Control Desk Proposal No. 1	7	4	4-13-48	J. W. Norrester
M-361	Vacuum-Tube Life-Tests Proposal	3	11	4-15-48	J. J. O'Brien
M-365	Accumulator, Zero Digit	1	-	4-16-48	H. Fahnestock
M-366	Layout of Panels to Permit Proper Cooling of Tubes and Components	1	1	4-20-48	C. W. Watt
M-367	Progress Report: A Storage Tube Output System	3	-	4-17-48	C. Campling
M-368	Control Pulse Output Prototype Authorization	2	-	4-21-48	H. Fahnestock
M-369	Program Register Prototype Drawing Authorization	1	-	4-21-48	H. Fahnestock
M-370	Electronic Devices with a High Emission of Secondary Electrons	8	-	4-21-48	M. Danilooff
M-371	Flip-Flop Register Prototype Drawing Approval	2	-	4-22-48	H. Fahnestock
M-372	Time Pulse Distributor - Output Panel Layout Authorization	1	-	4-23-48	H. Fahnestock
M-373	Meeting of the Electronics Group, April 9 and April 16, 1948	1	-	4-23-48	E. S. Rich
M-374	Test Procedures for WWI Tubes	2	4	4-23-48	N. H. Taylor
M-375	Construction of a Second Tube Tester	1	-	4-26-48	D. R. Brown
M-376	Rack Ground Bus	1	-	4-27-48	H. S. Lee
M-377	Project Whirlwind Seminar Schedule April 26 - May 26	1	-	4-27-48	R. R. Everett
M-378	Temporary Sylvania Numbers for WWI	3	-	4-28-48	A. M. Falcione

No.	Title	No. of Pages	No. of Drwgs.	Date	Author
M-379	Voltage Regulation Proposal	4	2	4-27-48	G. R. Wieser
M-380	WWI Dynamic Analysis of D.C. Load	3	1	4-26-48	R. P. Mayer
M-381	Time Pulse Distributor, Counter Panel Layout Authorization	1	-	4-28-48	H. Fahnestock
M-382	Accumulator Schedule	1	-	4-28-48	H. Fahnestock
M-383	Video Layouts and Mechanical Drawings for Accumulator	2	-	4-28-48	C. W. Watt
M-387	WWI Video Cabling	1	-	4-29-48	H. Fahnestock
A-57	Requests for Test Equipment	8	2	4-23-48	R. R. Everett
A-56	Internal Handling & Mailing of Classified Correspondence and Documents	4	1	4-22-48	J. W. Forrester

Library Files

65	Trans-Blacks - Project 6295 and 6345	6-24-47	
66	Report on the ENIAC - Operating Manual, June 1, 1946		Univ. of Penna., Moore School of Engineering
67	Some Fundamental Aspects of Telemetering - Engineering Report No. E-1007		Signal Corps Engineering Lab., Bradley Beach, N. J.
69	Microfilm M-784-47 Rechenplangesteuerte Rechengerate for technische und wissenschaftliche Rechnungen - Dr. Ing. Zuse (Calculating Machine Controlled by Computing Plans for Solution of Technical and Scientific Problems a Resume)		ONR, Boston 4-29-48 M. Danilooff

Books

Radar Electronic Fundamentals	Bureau of Ships, Navy Department
Radar System Fundamentals	Bureau of Ships, Navy Department

Report On Loan from Library of Congress Until May 25, 1948

U 257	On the Interpretation of Combined Torsion and Tension Tests of Thin-Wall Tubes - W. Prager, Brown University
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11.2 Standards Committee

(S. Abbott)

Discussions have been initiated pertaining to a possible revision of the present coding system used in the Standards Book.

When a decision is reached, the present temporary index will be replaced by a detailed index. Revisions will be issued as necessary reflecting this change.

A number of other revisions based on additions and changes, held up pending a change in coding system, will also be issued.

(C. W. Watt)

A standard finish for WWI panels was decided on and will be formalized in specification S7.507. It is a "Hammertone" finish, silver gray. It is smooth, hard, easy to clean, and easy to letter on with the silk screen process. It is also cheaper than wrinkle (see M-391).

Several items were passed on by the standards committee and will receive specifications in the next two weeks.

11.3 Purchasing - Stock

(H. B. Morley)

A conference was held with New England Transformer Company regarding quality of pulse transformers, at which time inspection standards and tolerances by N.E.T. were agreed upon. Principal difficulty appeared to be non-uniformity of Hipersil cores, and steps are being taken to achieve better quality control of this item.

Representatives of Western Electric Company met with laboratory engineers and Mr. Morley to discuss the application of certain items of telephone equipment to our needs.

Panel finishes have been investigated and tested. A smooth finish known as "Hammertone" or Mottletone" has received favorable comment.

Revision of the Kardex file is progressing rapidly with the addition of Mrs. Shay to the office force. Standard items are complete, and non-standard classifications are being revised for easier location of items. Closer coordination with the stockroom is aiding in the anticipation of requirements, enabling orders to be placed for better scheduling of material.

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11.4 Electronic Construction

(A. J. Taylor)

A tube tester has been ordered and the drawings are being modified. Construction is expected to begin May 4, 1948. Delivery will be May 28, 1948.

A prototype of a Variable Frequency Clock Pulse Generator has been ordered and will be delivered May 11, 1948.

(Robert H. Murch)

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

1. 4 d-c Bench Outlet Boxes
A sample relay has been received for use in controlling +500 V, and found satisfactory. 10 more relays of this type have been ordered. Boxes are being modified for this relay and will be completed when the relays arrive.
2. Rack Power Control Unit-Mod 2 Proto-Type
This unit is completed except for filament transformers which are due May 12, 1948.
3. Horizontal Coordinate of Deflection Voltage Generator
This unit is under construction and should be completed by May 21, 1948.
4. Breadboard of Basic Circuit GG-1
This is completed except for 5:1 pulse transformers.
5. D-c Power Strip-Proto-Type.
6. 2 Capacitor Panels for Deflection Voltage Generators.
7. Arithmetic Control for WWI
Construction of Divide Control is due to start May 3, 1948.

The work load in the Electronic Laboratory is as follows:

2 WWI prototype technicians have work scheduled for 14 weeks.
The other 8 men have an immediate work load of 1 week.

(F. H. Caswell)

Adapter cables for use with the E.S.T. demonstrator have been

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11.4 Electronic Construction (Continued)

assembled. Component changes in the 931-A test set were made and tests continue. Hookup of the portable annealing oven for 220V plug-in operation has been made.

A failure in the 220V supply system to the oven of #1 vacuum system necessitated brazing the Nichrome bus feeders. The failure occurred where the bus was joined by screws.

The electrolytic tank is now in operation and an attempt is being made to reproduce the data as plotted in curves contained in report R-130.

11.5 Drafting

(A. M. Falcione)

A memo was written to all 6345 Engineers requesting their anticipated drafting requirements for the coming 6 months. The response to this request has been poor to date. However, Mr. Osborne is contacting all Engineers personally to obtain this information and incorporate it into the various schedule forms. It is expected that by the next report, some form will have been worked out to show the future work load for drafting.

Three additional draftsmen will commence work on Monday, May 3. The acquisition of the present standards room (157) will greatly assist our drafting area problem.

11.6 Unclassified

(H. R. Boyd)

The continued expansion of the project has made the need for additional space a very acute problem. The only solution within the building is to use the basement more effectively. The following changes are proposed to accomplish this objective:

1. Room 157 is being eliminated and the area added to the present drafting room. This move provides room for 7 additional draftsmen.
2. The former occupants of 157, Mercer, Abbott, and Miss Leighton, are moving to 136.
3. Best has moved from 136 to 132 and Massard from 136 to 128.
4. Ellis and Grinnell will move to the basement and

11.6 Unclassified (Continued)

establish with Miss Aghajanian a combined component and tube test and record group.

5. The large room next to the basement conference room will be used as an engineering office.
6. Stockrooms 024 and 014 will be eliminated. Stock will be stored elsewhere.
7. 014 and 012 will be combined and used for the sheet metal shop and building maintenance group headquarters.
8. Room 026 formerly used by these groups will become an engineering laboratory.

(A. J. Taylor)

The machine shop now has a backlog of 15 man-hours of work. 30% of it is for storage tube parts.

The sheetmetal shop is now making chassis and punching panels for the Rack power control units and doing other routine work. The backlog contains about 12 man-hours work.

12.0 GENERAL

(H. Fahnestock)

In accordance with the definitions of E-113 make the following changes in headings of section 1.1:

- 101 Pulse Generator
- 109 Clock Pulse Control
- 110 Frequency Divider
- 111 Synchronizer
- 112 Restorer Pulse Generator
- 113 Delay Counter

Delete 108

(J. W. Forrester)

All reports, engineering notes, and memos which report or summarize experimental results should be complete with notebook references to the pages where data and calculations may be found. The standard reference form is 7PQR62 giving notebook number, initials and page number. Arabic numerals are used.

New Non-Staff Personnel

(H.R. Boyd)

ANGUS, Robert Brownell, Jr., is a graduate student working for Mr. Youtz. He graduated from Northeastern University in 1947 and for the past year has been an instructor at Northeastern.

BILLE, Anthony M., is an electronic technician working for Al Taylor. He studied radio at Boston Trade School and was last with the Gillette Safety Razor Company.

GOLDBERG, Jacob, is an electronic technician working with Bob March. He attended the University of California and studied radio while in the Navy.

GRAVES, Allen William, is a technical detailer working with George Graff. He attended school at the Massachusetts Trades Shops after spending three years in the U.S.Navy.

LEFKOVICH, Wilfred, is a student at Northeastern University, and is working with Walter Rogers on wiring. He also served in the U.S.Navy.

SHULMAN, Joseph, is a student at Northeastern University and is working with Walter Rogers on wiring. He also attended Lehigh University and served in the U.S.Army.

SHAY, Colia T., attended Northeastern University in the evenings, where she studied electricity. She worked last at the Raytheon Mfg. Company and is now running the Kardex file for Mr. Morley.

12.0 GENERAL (continued)

New Non-Staff Personnel (cont.)

TURNER, Frank C., is a Senior Electromechanical Technician working with Al Taylor. He previously worked for several large concerns, including Bethlehem Steel Company and Pneumatic Drop Hammer Company.

Terminated

Elizabeth Ladner
Helen Sorrentino