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Memorandum M-1139

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Project Whirlwind  
Servomechanisms Laboratory  
Massachusetts Institute of Technology  
Cambridge, Massachusetts

SUBJECT: BI-WEEKLY REPORT, Project 6345, December 22, 1950

To: Jay W. Forrester

From: Project Whirlwind Staff

1.0 SYSTEMS TESTS

1.1 Whirlwind I System Test

(S. H. Dodd)

Efforts to increase system reliability have been quite successful. ES row has operated without error on several different types of programs for three hours. The two worst storage row problems are deflection shifts probably caused by glass charging and reduction of high velocity gun current with age. Good progress is being made toward solution of both of these problems. No further trouble with surface deterioration has been experienced. New methods of marginal checking and new routine maintenance schedules are improving central control reliability.

(R. Read)

The efforts toward improving operation in ES row have been centered around studies of the transfer characteristics of the high velocity guns. The study was precipitated by the increasing frequency of errors in a few digit columns. Measurements taken last week show that the present beam current is from 30% to 90% of that available when the tubes were installed in September. The tube with the lowest current was the most frequent source of errors. An attempt (started December 20) to extend the life of the tube by increasing its filament voltage to 7 volts has been successful so far. The decreased emission in 5 other digits was combated by increasing the writing time and adjusting the gates to produce somewhat larger spots than those used initially. The trouble in those digit columns has been reduced significantly. Studies of

1.0 SYSTEMS TESTS (continued)

1.1 Whirlwind I Systems Test (continued)

the tubes to correlate reduced emission with other conditions are continuing.

The type of failures experienced in testing routines, as well as programs used by the applications group, support the presence of deflection shifts in some tubes, probably due to glass charging. It is difficult to conclusively relate any failures to deflection, since it is quite probable that use of the TV display aggravates the glass charging. The effects of this trouble have possibly been reduced by the increase in spot size.

(N. Daggett)

Tests made on the Test Storage Switch and the Control Switch and Matrix Drivers during the last two weeks have yielded rather interesting results. It appears that a relatively simple series of d-c voltage measurements at critical points in these units will give an accurate measure of the condition of all critical tubes. As a result, routine maintenance procedures will be set up to be performed at relatively infrequent intervals much as the flip-flop complement tests are done now. These tests will be used to obtain more accurate and more specific information on gradual deterioration in the units than is provided by marginal checking; the marginal checking data will be used to spot rapid deterioration.

(H. F. Mercer)

Component Failures in WWI: The following failures of electrical components have been reported since December 8, 1950:

<u>Component</u>	<u>No. of Failures</u>	<u>Hours of Operation</u>	<u>Reason for Failure</u>
<u>Crystals</u>			
D-357	2	1725	Low $R_b$
	6	4289	Low $R_b$
	1	4462	Low $R_b$
D-358	2	3600	1 Drift 1 Low $R_b$
	4	4000-5000	2 Drift 2 Low $R_b$

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1.1 Whirlwind I System Test (continued)

<u>Component</u>	<u>No. of Failures</u>	<u>Hours of Operation</u>	<u>Reason for Failure</u>
<u>Tubes</u>			
3E29	1	4276	Low $I_b$
	8	4646	6 Low $I_b$ 2 mechanical
6AG7	1	3312	Low $I_b$
	1	3296	
	1	4624	
6V6	2	3136	Low $I_b$
6Y6G	6	4000-5000	4 Low $I_b$ 1 High cut-off 1 Screen leakage
7AD7	5	0-1000	3 Low $I_b$ 2 Mechanical
	17	4000-5000	15 Low $I_b$ 1 Mechanical 1 Cassy
	1	5228	Mechanical
7AK7	1	4525	Mechanical

1.2 Five Digit Multiplier

(C. N. Paskauskas)

At about 1425 on December 8, 1950 the multiplier began making errors and continued for a period of about 5 minutes. The trouble cleared up by itself before the cause could be determined.

During the period of this report one IN34 clamp crystal was replaced as a result of marginal checking.

One 6AS6 check gate tube was removed for test due to failure in the check gate test.

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## 2.0 CIRCUITS AND COMPONENTS

### 2.1 Circuits and Components

(J. A. O'Brien)

#### 400 Input-Output Element

The mechanical drawings for the In-Out Switch-Panel have been completed, and the drawings for the D-position, and typewriter equipment, matrix panels have been completed.

(C. W. Watt)

#### 403 I-O Register

The prototype of the new in-out register is well under way, and should be completed during the next two weeks.

(W. J. Nolan)

#### 835 ES Drivers

Work on the R-F Pulser breadboard is progressing at a satisfactory fraction of the estimated rate. The layout has been completed except for the location of a few decoupling resistors for which I cannot find room. Sketches of the sheet metal work are being made and the schematic is started.

### 2.5 Tubes and Components

(H. B. Frost)

The first few days of this period were spent at the Conference on Electron Tubes for Computers at Atlantic City. Three observations may be mentioned -- first, other people's tube problems are at least as bad if not worse than ours; second, vacuum tube life can probably be improved very considerably in two ways -- proper operation of existing tubes and design of special tubes; third, our crystal problems are not unique.

With two technicians in the vacuum tube test shop, the work load is under much better control. Necessary reserves of tested tubes are being brought up to par as quickly as possible.

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2.5 Tubes and Components (continued)

The vacuum tube pulse current tester is now being debugged. It appears that this operation will be completed during the next period. Owing to the large number of functions of this equipment, some rather unorthodox circuits are being used, which adds to the complexity of servicing this 15 tube equipment.

(F. E. Irish)

An engineering note is being prepared on the progress of the germanium diode life test. Included in this report will be a short discussion about the behavior of the back resistance of a 1N34 germanium diode as a function of time and duty factor of the voltage applied to the diode.

2.7 Three-Dimensional Magnetic Storage

(W. N. Papiian)

A temporary arrangement has been made whereby the Glenco Corp. of New Jersey supplies us and the Insulation Lab with magnetic-ferrite and ferroelectric samples under purchase orders from the Cambridge Field Station. Specs and technical direction are to come from the Insulation Lab and ourselves. A more permanent contractual arrangement is expected to grow out of the experience and results of the next months.

Mr. Upham of the Glenco Corp. visited us for a first discussion of the problem. Further visits are expected as soon as production gets under way.

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### 3.0 STORAGE TUBES

#### 3.1 Construction

(R. Youtz)

During the past six weeks we constructed a series of six research tubes, RT-187, RT-188, RT-190, RT-191, RT-193 and RT-194, which were designed to minimize the drift of the high velocity beam resulting from charged glass surfaces. In almost all these tubes the glass was completely dagged and the holding gun had a 1-1/2" diameter metal  $A_2^0$  cylinder. These tubes are still being evaluated by the test group and during the next bi-weekly period, one of them will be put in a storage tube mount and tested in the storage tube reliability tester. Preliminary tests indicate that this type of tube can be used in Whirlwind. We have built up a supply of components so that a series of these tubes can be constructed as replacement tubes for any storage tube that might fail in the computer. We have constructed ST-305, the first tube of this series.

Another problem is the life of the cathodes. We have started a program to reprocess to a new all-day specification the storage tubes with paralyzed cathodes. These tubes will also have the new holding gun. We have also built a research tube, RT-195-1, with a deflecting electrode in the  $G_2$  anode to provide a means for interrupting the high velocity beam without interrupting cathode current.

We are continuing the experiments to settle a uniform layer of powdered 707 glass on a metal backing plate and sinter it to the backing plate. This is one of the approaches to the problem of finding a suitable thin dielectric surface with as low a dielectric content as possible.

(R. Shaw)

A considerable part of the past fortnight has been spent on the design of a number of simple jigs to facilitate assembly of the holding gun. A thorough dimensional inspection was made of representative samples of steatite tube. In the future, a systematic check will be made of

### 3.1 Construction (continued)

other gun components. This will provide a rational basis for future tool and fixture design.

An envelope inspection fixture has been completed which will determine whether there is a possibility of the HV beam hitting the side of the envelope. Envelopes in which this possibility exists will not be used for WW tubes.

### 3.2 Test

(A. R. Tanguay)

The following Research tubes have been tested for restoring currents on the Restoring-Current Tester: RT-194, RT-126-2 and RT-145.

The restoring currents of RT-194 compare favorably with those of RT-193, tested 2 weeks ago. Both tubes have a metal cylinder for  $A_2'$ , and a separate dag in the holding gun neck, designated  $A_3'$ . For reasons yet undetermined, this particular configuration of electrodes results in a maximum negative restoring current larger than found in most ST's and RT's. The only known exceptions are RT-150, and RT-145.

RT-150 has the extra screen in front of the collector; RT-145 has 4 holding guns and 1 HV gun in one neck.

The restoring current curves of RT-126-2 (1 HG, 1 HV gun in one neck) and RT-145 were compared to determine the effect of cathode current on restoring currents. The ratio of cathode currents was approximately 4, while the ratio of restoring currents was 2 to 2.5. A restoring current increase of approximately 2 was achieved by partially biasing off the holding guns of RT-145, thereby decreasing the total cathode current from 13.95 ma to 2.63 ma. No definite explanation for this phenomenon is available; perhaps the convergence of the holding beam and the reduction of secondaries from  $A_3$  or the reduction of space charge are partially responsible.

A smaller increase in restoring current was obtained in RT-126-2 by reducing its cathode current from 3.27 ma to 1 ma. Such an effect was also observed in standard

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### 3.2 Test (continued)

storage tubes.

Next week the Restoring-Current Tester will be modified to include T.V. monitoring of the storage surface.

(A. Stein)

Pretests as outlined in M-1077-3, sections B, C and K were carried out on the television demonstration unit.

RT-193, RT-194 were pretested and passed.

ST-300-1 was rejected due to high surface leakage. With a negative surface, positive array and holding beam off for more than 15 seconds, many spots of the array begin to fuse. With a positive surface, negative array and holding beam off for more than one second, many spots of the array fade away.

Special tests were conducted to investigate possible variation of  $I_k$  as a result of varying  $V_{A3}$ . It was found that no such variation occurred if the potential of  $V_{A1}$  remained constant.

(H. Platt and C. L. Corderman)

Two tubes were checked out on the STRT. ST-192 and ST-193 both proved to be satisfactory. While performing these tests it was found that by moving the lead to the HV gun grid, close to the base of the gun, it was possible to obtain transient change in read-out intensity and in some cases to even cause the entire surface to switch positive. Careful cleaning of the base jack eliminated this trouble. There was an indication that this same phenomenon was present in another tube mount. Therefore the HV gun base jack was carefully cleaned in this mount, too. The trouble has not as yet reappeared.

RT-150 was placed in the STRT and given the initial tests. The tube proved to be very satisfactory. Further tests on spot interaction and spot size are planned.

A large part of the period was spent in making timing diagrams of the STRT and in helping to get the life test rack in shape for new tests.

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3.2 Test (continued)

(C. L. Corderman)

The Storage Tube Life Tester has been reactivated for the purpose of observing high-velocity gun cathode deterioration under several test conditions. Seven new tubes, rejected because of surface imperfections, will be placed in operation on Friday, December 22. All high-velocity guns will be normally biased off and at selected intervals the pulsed target currents will be monitored using a 32 microsecond pulse at 1% duty factor. The tests will determine the effects of the holding gun, the high-velocity gun heater voltage, and the  $A_2-G_2$  voltage upon the reduction in HV gun current with life. RT-195, a second tube having a split  $G_2$  section, will be added to the Life Tester as soon as initial checks are made.

Following a series of tests on RT-150, the STRT will be used for checking an all dagged research tube in a WWI Mount. In addition to the tests required for passing the tubes to WWI, every effort will be made to obtain the characteristic failure attributed to glass charging.

Block diagrams and timing sketches have been made to facilitate the addition of an r-f television read-out system to the restoring current tester.

(M. F. Mann)

The cathode inspection reports of J. O. Ely on cathodes from dissected tubes are being compiled with information considered pertinent to the destruction of their surfaces, e.g. gas in the tube, positive grid drive, etc. Note is also being made of cathodes which were not harmed by such presumably injurious factors.

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4.0 INPUT-OUTPUT EQUIPMENT

4.3 Typewriter and Tape Punching Equipment

(R. E. Hunt)

An auxiliary control unit for the Tape Preparation Room has been designed and will be built in the next two weeks.

This control will greatly facilitate the following procedures:

1. Library tape insertion into a checked tape.
2. Tape reproduction.
3. Tape printing and reproduction.
4. Tape printing either every line or alternate lines.

(C. W. Watt)

Operation of the tape Input and Output equipment has shown up several points at which the whole system is weak. Some analysis of the trouble has been made so far, but no computer time has been available for systematic experimental investigation. Starting next week some evening time will be reserved for this work. A thorough analysis will be made and the troubles will be eliminated or minimized.

(J. S. Hanson)

Analysis of tape output equipment timing charts has been completed and a timing diagram for the "Words Only" mode of operation has been prepared. Timing measurements have been consistent, and accuracy of measurement with a Brush oscillograph is within  $\pm$  one millisecond. Timing diagrams for the other modes of operation will be prepared during the next period.

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4.0 INPUT-OUTPUT EQUIPMENT

4.4 Input-Output Planning

(J. A. O'Brien)

Some thought is being given to the problem of electronically switching the heads on the magnetic tape unit in an effort to save time and tape over relay controlled operation.

(E. S. Rich)

In working out the details of a block diagram of presently planned terminal equipment, attention has been focused on the magnetic tape control. Some doubt has arisen as to whether relay control of the units will be fast enough to prevent excessive waste of space on tape and also whether the amount of time used up may be excessive for some future applications. Quantitative information on three alternatives is being worked out so a decision can be made by the input-output committee.

Some consideration has been given as to where magnetic drums and IBM punched-card equipments might fit into our terminal equipment program. In conferences of interested parties, it was decided that these units are not of sufficient value to our immediate work with the computer to warrant diversion of manpower to them. In the future, when more ES storage is available and some of the present terminal-equipment projects have been completed, work on drums and IBM equipment should be undertaken since they have distinct advantages in many applications and would add to the flexibility of the whole system.

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5.0 INSTALLATION AND POWER

5.1 Power Distribution

(C. W. Watt)

Four more voltage variation circuits will be needed for the Gun Driver in ES row. Wiring for the extra circuits has begun and will continue on Saturdays. Sixteen more D-C filter panels are being built to accommodate the added circuits.

Installation of the new In-Out register will require a number of extra voltage variation circuits. A new analysis of the existing installation is being made to see how many, if any, new voltage variation panels need be constructed.

5.2 Power Supplies and Control

(J. J. Gano)

D-C Plate Supply Alternator: Instability in the system seems to be due to the high internal impedance of the Regulator Power Supply, aggravated by the feedback of the 120-208 regulated laboratory voltage as the source for the regulator power supply. This same disturbance also occurs at the 120-208 Regulated Laboratory Power System and is coupled to the Alternator. At present the regulators are using 250 volt d-c laboratory power. The protective circuit on the alternator protects the WWI D-C Supplies. On the first available Saturday, we will try 1) connecting the power supplies to an unregulated source and 2) connecting the screens of the output stage of the regulator amplifiers to a regulated voltage.

5.3 Video Cabling

(T. Leary)

Several video cables must be made for the new shift roundoff control in AC15, as well as a number of cables to make temporary cabling changes permanent.

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5.3 Video Cabling (continued)

(T. Leary) (continued)

CPO units with temporary uses have been identified by labels typed on adhesive tape. A set of engraved labels has been ordered to bring the identification of all CPO units with permanent uses up to date.

The connections between the synchronizers and the push-buttons in Test Control are to be made by means of video cabling to eliminate crosstalk. Video jack panels to mount over the Jones strips behind the two synchronizers are being manufactured, and a jack panel to mount behind the synchronizer switch panel in Test Control will be made shortly. Since making all twenty of the long cables required for this purpose would practically use up our stock of RG-62/U cable, only six of them are being built pending the procurement of more cable.

6.0 BLOCK DIAGRAMS

(J. M. Salzer)

In collaboration with Ben Morriss the input-output block diagrams and operations have been re-examined with respect to each contemplated external unit. Several mistakes were corrected, improvements made, and a better insight into the whole philosophy of communicating with the computer was gained. The changes do not affect any equipment now under construction.

As far as a generalization of the operations of various external units is concerned, there seems to be little hope in grouping them in such a manner that a new unit would definitely fit one of the groups; rather each operating feature of a new unit considered must be individually fitted into the whole. On the other hand, the pattern of adopting new units is clear and no difficulty is expected.

(R. P. Mayer)

"Shift Roundoff Control" (SRC), for control of shifting left or right without roundoff by adding 800 to number of shifts required, is now incorporated in WWI and is shown on the up-to-the-minute drawings.

(G. Cooper)

Work has continued on the Test Sequences for checking the entire Arithmetic Element. It now appears that three such sequences fitting into TS will be required. Two of them, TSQ VII and VIII are complete. TSQ IX is about half complete.

Work has also been done on several ES Test Programs, including a modification of the "Bootstrap" program designed to erase ES. This program has been assigned Tape No. T-29. It has been tried out with the computer but the results were inconclusive because of difficulties encountered in the operation of ES. Modifications have been made of other ES Test Programs.

8.0 MATHEMATICS

(C. W. Adams)

Much of the time of the members of the scientific and engineering applications group is being devoted to writing and trying various exploratory programs on the computer. Three evenings a week are theoretically available for the use of the computer by this group, although it seems likely that in practice two evenings is about all that can be hoped for. At present, a considerable portion of that time will be devoted to allowing the members of the group to become familiar with operating the machine.

Work is being done on using the computer to read in tapes prepared in a standard decimal form, convert, and punch a new tape in some binary form. It will also be possible to use the computer to prepare octal copies (which are useful in operating the computer on a program). Use of the computer to perform the latter clerical job is probably not economically justifiable, but the former can be justified and will appreciably ease the tape preparation work load.

A program has been written to yield interesting, if useless, results while providing a good test of computer and Flexowriter equipment. This program, which has been run successfully, will tabulate, in any arbitrary printing layout, exact values of numbers of the form  $k^n$ , or  $(n!)^k$  for given values of  $k$  as a function of  $n$ . The program as written requires both  $n$  and  $k$  to be less than 8000 and the result to be less than  $10^{457}$ .

(J. M. Frankovich)

A tape for a Runge-Kutta solution of the Schrodinger equation was prepared and tried in the computer. This program would permit an estimation of the round-off error of the extrapolation process. However, difficulties were encountered in getting the solution started, and no results were obtained. The program has been suitably modified and will be tried again when the computer is available.

Work has also begun on a program for an inter-industrial production-consumption problem suggested by a Harvard economist, Mr. Alan Manne, and will continue during the next bi-weekly period.

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8.0 MATHEMATICS (continued)

(F. Helwig and J. Porter)

The two programs that were prepared for our solution of the magnetic tape problem were both run on Whirlwind and valuable results were obtained. The two methods involved in these programs both replace the partial differential equations by difference equations. However, they differ in their choice by the differences -- in the simpler method functional values at just four points are involved and the method is basically one of extrapolation. The other method, described previously in M-1071, involves functional values at six points and employs an iterative procedure.

The simpler method was found to be unstable. This is in agreement with our theoretical prediction based on a linear approximation. This theoretical analysis investigates the stability of a solution of the difference equation and indicates thereby the possibility of making this solution approximate the continuous case (i.e. the differential equation). It was found that the computed results indicated a relationship between time and space intervals necessary for physically significant results that corresponded with the predicted stability criterion. However, the required time intervals become so small as to render this method impractical because of the growth of round off errors. Nevertheless this method will not be completely abandoned - we will investigate the possibility of changing our time intervals as required to keep the stability condition satisfied approximately as we move along different portions of the hysteresis curve.

This difficulty is not encountered in our second method. In fact a theoretical analysis indicates that the stability of this method is independent of the relationship between the intervals. The results we obtained on Whirlwind for this method indicated that our correction program was not covering a sufficiently wide range of values. This will be corrected by increasing the size of the initial correction and the program will be run again.

9.0 FACILITIES AND CENTRAL SERVICES

9.1 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>Date</u>	<u>Author</u>
E-362	Storage Devices in Computing Systems, Text of an M. I. T. E. E. Department Colloquium Talk	9	5-3-50	R. R. Everett
E-364	Construction of a Beryllium Evaporation Boiler	5	11-29-50	(T. R. Parkins R. Shaw)
M-1124	Vacuum Tube Failures During the Month of October, 1950	5	11-1-50	H. B. Frost
M-1135	Vacuum Tube Failures During the Month of November, 1950	7	12-1-50	H. B. Frost
M-1136	Bi-Weekly Report, Project 6345, December 8, 1950	20	12-8-50	

Library Files

.004	Proceedings of the IRE: December, 1950			I. R. E.
47	European Scientific Notes: November 15, 1950			ONR/London
	Technical Information Pilot: November 14, November 24, 1950			(ONR/Library of Congress RLE/MIT American Insti- tute Physics Int'n'l Tele- phone, Telegraph Ntl. Bur. St'ds. Servo Lab., M. I. T.)
180	Document Office Bulletin: December 15, 1950			
232	Physics Today: November, 1950			
361	Electrical Communication: December, 1950			
559	Technical News Bulletin: December, 1950			
884	Supplement to Progress Report 13, Project 6694. December 13, 1950			
1056	The Use of the EDSAC for Mathematical Computation. February 20, 1950			M. V. Wilkes
1057	Public Health Nursing Statistics. Use of Marginal Punched Cards. February, 1947			C. L. Crown
1058	Reviews of Modern Physics: October, 1947. Least Squares Fitting of Data by Means of Polynomials, with Mathematical Appendix			(R. T. Birge J. W. Weinberg)
1059	Investigation of the Response Time of Magnetic Fluid Clutches. National Bureau of Standards 12.3-3R. September 26, 1950			W. A. Notz

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9.1 Publications (Continued)

Library Files (Continued)

<u>No.</u>	<u>Title</u>	<u>Author</u>
1060	Les Machines a Calculer et la Pensee Humaine: Colloque International Programme Provisoire. Paris: January 8 to 13, 1951. November 30, 1950	(C. N. R. S., Institut Blaise Pascal, Lab. de Calcul Mecanique
1061	The Pulse Response and Testing of Wide Band Networks: S. M. Thesis. M. I. T. 1950	R. L. Massard
1062	Kodak Digital Reader-Recorder, Model A. Final Report. June, 1950	Eastman Kodak Co.
1063	A Digital Electronic Correlator. Technical Report No. 152. February 21, 1950	(H. E. Singleton (RLE/MIT
1064	Programming in a Linear Structure. 17 February, 1948	G. B. Dantzig
1065	Storage Devices for Communications. Reprint from <u>Electronics</u> , December, 1950	A. J. Lephakis

Books

Magnetic Recording. Copyright 1949.

S. J. Begun

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9.2 Standards, Purchasing and Stock

(H. B. Morley)

Standards

The following standards are now in the process of publication and will be issued soon:

6.192-4	PLATE TRANSFORMER
6.192-5	HIGH VOLTAGE TRANSFORMER
6.192-6	LOW VOLTAGE TRANSFORMER
6.192-7	HIGH VOLTAGE TRANSFORMER
6.195-4	FILAMENT TRANSFORMERS
6.195-6	FILAMENT TRANSFORMERS
6.198-1	INTER-PHASE REACTOR

Procurement and Stock

Due to the present procurement situation, it will become increasingly necessary to accept substitutes. This applies particularly to non-standard items, but may also become necessary with some standard items. Engineers should make allowances for this whenever possible in placing their requests for procurement.

9.3 Construction

(R. A. Osborne)

Production Report

The following items have been completed and inspected since December 8, 1950:

6	98' Video Cables
1	TV Control Panel for WWI
3	Oven Switch Signal Circuits
3	Rack Power Plug Strip
1	Vacuum Tube Pulse Current Tester

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9.4 Drafting

(A. M. Falcione)

1. New Drawings 420 Input-Output Switch
  - A. Bus Driver drawings are all complete.
  - B. Switch Panel Drawings are all complete.
  - C. 8-Position Matrix drawings are all complete.
  - D. Flexowriter Matrix: Circuit completed, Assembly and Al. panel drawings are now being done.
2. DC Input-Output Register: Circuit Schematic is complete. Prototype Assembly drawing and Parts List are complete.
3. Display Unit 16" Scope drawings are now under way.
4. Block Diagrams: All the Block Diagrams are now under revision.
5. Thesis Drawings: All engineers are reminded that all thesis drawings are due in the drafting room as soon as possible in order to meet the January 13th due date.

10.0 GENERAL

(J. C. Proctor)

New Non-Staff

Edward Arthurs is a new part-time student mathematician in the 6673 Group. He is a senior majoring in mathematics at MIT.

Terminated Non-Staff

James L. Stockard