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Memorandum M-775

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Project Whirlwind  
Servomechanisms Laboratory  
Massachusetts Institute of Technology  
Cambridge, Massachusetts

SUBJECT: BI-WEEKLY REPORT, PART I, FEBRUARY 4, 1949

To: 6345 Engineers

From: Jay W. Forrester

1.0 WHIRLWIND I COMPUTER ELEMENTS

1.01 Production Report

(H. F. Mercer)

The following WWI panels (production units) have been received from Sylvania to date:

Arithmetic Element (complete)  
Bus Driver, Arithmetic Element (complete)  
Program Register (complete)  
Fixed Voltage Switching Panels (complete)  
Fuse Indication Panels (complete)  
Restorer Pulse Generator (complete)  
Time Pulse Distributor Output  
Bus Driver, Flip-Flop Storage (complete)  
87 Control Pulse Output Units  
2 Digit Interlock Panels  
17 Register Driver, Type I  
9 Fuse Panels

1.02 WWI System Tests

(G. C. Sumner)

As far as we know, the fastest digital multiplication ever performed by a man-made device on numbers as large as 15 digits was accomplished by the WWI arithmetic element on 26 January. A high-speed multiplication was made less than one day after it was determined that the temporary console was operating properly and it was decided to use the console for further system testing. That no difficulties were encountered in obtaining multiplication is evidence of the value of the production testing and preliminary system testing which had already been done. It was only necessary to verify video

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1.02 WVI System Tests (continued)

cabling and to set the amplitudes of signals throughout the system.

Multiplication was first performed at a push-button rate. When proper operation was obtained at that speed, a rate of 1 megacycle was tried and eventually the normal speed of 2 megacycles. This idea of starting testing at a slow speed and building up to normal high speeds seems particularly appropriate for computer testing. It is being used to develop the division operation of WVI.

Push-button operation of divide was attained 27 January. It is not yet possible to divide at a slow automatic rate. One trouble, only recently discovered, was failure to provide for clearing of the ACO carry FF. A mistake which left this FF holding 1 caused incorrect results of subsequent divisions. This situation has been discussed in E-176. It now seems that division can be done as soon as amplitude sensitivity in the carry function is corrected.

The operation of round-off and sign control permitting the use of negative numbers has been found to be satisfactory.

System testing was interrupted from 28 January to 7 February to allow installation of permanent bias supplies. Multiplication worked well after the shut-down, but some trouble was experienced with instability of the temporary console. Operation was improved by prudent adjustment of signal amplitudes within the console, but further work remains to be done.

(N. H. Taylor)

Testing on the arithmetic element has proceeded very satisfactorily and is somewhat ahead of the schedule that was anticipated. In view of this, it has been decided to transfer two engineers from Systems Engineering Group to Storage Tube activity. This transfer will slow up the remaining work to be done on the arithmetic element and its associated control, but should aid materially in the over-all plan of obtaining the WVI computer at the earliest possible date.

During the next two-month period, the present systems work will be concerned mainly in studying the margin of operation available in the present design, that is, installation of marginal checking equipment, a study of pulse amplitudes throughout the system, and a study of the effect of aging tubes on system operation.

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**1.02 WWI System Tests (continued)**

(N. H. Taylor)

From time to time during this period, new elements of central control will be installed as they are constructed and tested. According to present schedules, this activity will continue throughout the summer.

(H. Palmestock)

Power will be off the computer, and tests will be suspended, from Friday morning, March 4, to Monday morning, March 21. All concerned are requested to check memo M-773 describing installation to be done during shut down. Advise Palmestock of additional work which could or should be done during this period so that it can be scheduled in advance.

**1.1 Listed by Block Diagram Number****111 Synchronizer**

(H. S. Lee)

Progress on the circuit schematic has been temporarily suspended pending further circuit investigation necessitated by replacing the type 5687 tubes with 2C51's. Kenosian is conducting the investigation.

The block schematic has been completed.

**112 Restorer Pulse Generator**

(J. A. O'Brien)

The restorer pulse generator panel has been reviewed to conform to the latest changes. The panel is back in service in the computer room, and the final balancing adjustments will be made on the unit as soon as it can be done without interrupting the arithmetic element testing.

**204 Electrostatic Storage Control**

(J. A. O'Brien)

A study is being made of the electrostatic storage control problem in an effort to produce a block diagram that can be used as a basis for the electronic design of the unit for WWI.

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404 Comparison-Register-Check

(J. A. O'Brien)

The circuit schematic, and block schematic for the comparison register-check panel have been drawn and turned over to the drafting department for finishing.

601 Check Register Check

(H. S. Lee)

All necessary drawings have been completed and the aluminum panel has been fabricated and painted. It is planned to have the panel engraved by an outside contractor. As of this date we are waiting receipt of quotations from several bidders, as the first quotation received was considered to be somewhat high. Having this panel engraved by an outside firm is a trial, the results of which will influence our decision as to the advisability of having all future panels of unit quantity engraved by an outside concern.

1.2 System Engineering

(G. W. Watt)

Installation - During the period from Jan. 24 to Feb. 4, power was off 3 working days, during which time filament transformers in arithmetic element were adjusted, d-c outlets in surfaceduct were connected to WWI power, relays were adjusted in relay switching panels, and some video cabling was installed. After power was turned on again three men continued assembly and installation of fuse and terminal strips in flip-flop storage racks.

It is planned to turn power off each Friday and Saturday for the next three weeks to permit completion of flip-flop storage installation.

(R. E. Hunt)

Installation Drawings - Installation drawings for the flip-flop storage bay are now nearly complete. PD cabling remains to be included in the installation drawings and this should be complete in less than one week.

Installation drawings for control are now being worked out. Panel locations, video trough, and transformer brackets have been worked out for C-9 thru C-15. Installation drawings for

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1.2 System Engineering (continued)

rack C-12 have been given to the cabling installation group for their information in designing cabling here.

The Master Installation Drawing R-32129 references all installation drawings done to date, and all rack allocations. This drawing will be kept up to date.

1.21 Power Control & Distribution

(R. E. Hunt)

Power supply control drawings are now complete and graded.

The power supply control panel is now in the shop and will be complete in a day or two.

During the two-week power shutdown beginning Mar. 4, power control cabling will be run in and wired in, insofar as possible. Remote control of WTI d-c voltages will be available at this time. Remote control of all power will not be available until May 1st or later.

The filament voltage control panel is now in the shop for manufacture. This panel is required for the remote control of WTI filament power.

(H. S. Lee)

Auxiliary Relay and Bias Interlock Panel - The aluminum panel has been fabricated, painted and lettered. All the component parts are available. Assembly is being deferred pending receipt of drawings from the Drafting Dept. This panel is scheduled for completion by March 4.

Voltage Variation Panels - All drawings pertaining to this panel that were listed on the Sylvania Status Report of January 31, 1949 have been received. A. Brusila, Sylvania, has verbally informed us that all the necessary parts and components required for assembly, excepting the power cable, would be delivered on or before February 7. The aluminum panels will be delivered painted and lettered.

The Parts List PL-60P08 has been compared with the stock inventory furnished to R. Fairbrother by A. Brusila and several discrepancies have been noted. Some discrepancies are being rectified by utilizing the same or other items

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1.21 Power Control & Distribution (continued)

available in our stock. Coordination is being effected with Sylvania in procurement of the other deficient items.

Insofar as the first order of ten (10) panels is concerned, it is planned to schedule the lot for assembly in our shop on or before February 11. Assembly should be completed and the wiring and cabling started by February 18. The shop should complete the order by February 27 allowing approximately one week for testing prior to installation during the two-week power shutdown of March 4.

Sylvania is furnishing the electrical test jig that is to be employed in the production testing and inspection of these panels.

1.22 Power Cabling

(H. S. Lee)

(a) Gavitt Mfg. Co. is fabricating all the power cables for flip-flop storage. It is anticipated that these cables will be completed and ready for installation by February 15. Also Gavitt is fabricating the rack power cables and the panel cables for the voltage variation racks. These latter cables should be completed and ready for installation by February 28.

(b) The power cables for the flip-flop register driver rack are in the drafting stage. These cables will be fabricated in our shop as will the "Reset" cables for the flip-flop storage racks.

(c) For the information of all concerned, it should be noted that the d-c power for test equipment in the computer room has recently been transferred from the laboratory power system to the WWI power system. Thus d-c power is now available throughout the computer room at the following voltages: 250, 150, 120, 90, -30, -15, -150. This power is obtainable from the Jones receptacles which are mounted on the 7" channel at the bottom of the racks. In addition both 115 volt a-c, regulated and unregulated are obtainable from the twist lock receptacle mounted in close proximity to the Jones receptacle.

(d) The design and detailing of cables for rack C12 is progressing satisfactorily.

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1.23 Video Cabling

(R. H. Muroh)

Installation of arithmetic control video cabling has been completed. Vertical bus video cables from the bus drivers to the AR, BR, AC and PR have been received from Sylvania and installed.

The following video cables have been installed for the program register: clear, restorer, read-in and read-out.

1.25 Time Schedules

(R. A. Osborne)

All of the old series of time schedules have been posted through January and the summary prepared for inclusion in SR-16.

New time schedules are still in the process of being drawn up by the various groups concerned. It is hoped they will be ready in another week.

1.3 Auxiliary Equipment1.31 Power Supplies

(J.J. Gano)

WTI Filament Power - A temperature rise test was made on the stator of the motor operating at rated current and with the fan blades removed. The rise was 40°C. The permissible rise is 50°C. Since the field current was zero, there were no losses from the field to contribute to the heating of the air stream. The most severe conditions will occur when both the field and stator are operating at rated current. After the generator is coupled to the motor and a load can be applied, another test will be made with both field and stator at rated currents.

Test Power for Computer - Reduction of transients in the +250 and +150 volt supplies were checked with only two tubes operating as full wave rectifiers. Before chokes were applied the center to peak values were 13 and 9 volts respectively. R.F. chokes (90 microhenries) reduced the values to 2.5 and 1.5 volts. Mica condensers (.008 microfarads) at the input to the filters provided a further reduction factor of about two. A series L-C circuit tuned to about one mc and connected from the +output to ground cut the peaks about twenty-five per cent

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1.31 Power Supplies (continued)

more. The total reduction was then about 15 to one. Choke coils to carry the load of these supplies are now being designed.

(H. R. Boyd)

The -15 and -30 volt bias supplies have arrived and been installed.

This completes the delivery and installation of the Power Equipment Company supplies. The filament alternator will be running soon. The regulator and protective relays will require several weeks for design, construction, and test. In the meantime, manual voltage control of the filament power will be available. Wieser will continue to be in complete charge of all power room work until the installation is completed. J. Lynch, attached to Murch's operating group, but working with Wieser, will start and stop the power equipment with Murch or Wieser as alternates.

(C. R. Wieser)

WVI Filament Power - The filament alternator coupling hub was found to run out too much to be used as a reference for aligning the generator with the motor. A face plate is being made for use as a reference.

The plate alternator (now in use as temporary filament supply) will have to be shut down for maintenance work on the motor slip rings. This will be done Saturday, February 4, and completed then if possible.

WVI Plate Power

The -15 and -30 volt supplies are installed. This completes delivery from the Power Equipment Co. The timers on these two supplies are of the wrong voltage rating, and have been disconnected until replacements arrive.

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<u>W/I Drawing List</u>	<u>Block Diagram</u>	<u>Block Schematic</u>	<u>Circuit Schematic</u>
System	B-37071-5		
Control	B-37098-4		
Master Clock	B-37159-1		
101 Pulse Generator	B-37155-3	B-32385	E-52333-3
102 Program Counter	B-37062-4	B-32213-1	D-31516-4
103 Program Register	B-37067-2	B-39289-1	D-31276-9
104 Control Switch	B-37066-3	T60CS00-4-C	Z60CS00-A W60CS00-1-A Z60CS00-2-A
105 Operation Matrix		S600M00	Z600M00-1-C
Control-Pulse Output		R60CP00	S60CP00-1-B
106 Time-Pulse Distributor	B-37068-3	T60PD00-8-B	
106 Time-Pulse Distributor Counter		T60PD00-3-A	Y60PD00-C
106 Time-Pulse Distributor Output		T60PD00-4-B	Z60PD00-1-B
109 Clock-Pulse Control	B-39817-2	C-32642-3	R-31916-5
110 Frequency Divider	B-37154-3	B-32264-1	R-31729-1
111 Synchronizer	B-37172	C-33485	R-33486
112 Restorer-Pulse Generator	B-37160-1	B-32209-4	D-31909-7
200 Storage	B-37156-2		
201 Storage Switch	B-37121-1	B-32855 T60CS00-4-C	Z60CS00-A Z60CS00-2-A E-32830-1 R-32722-1
202 Toggle-Switch Storage	B-37122-3		E-32711
202 Toggle-Switch Storage Output		C-32080	E-32721-2
203 Flip-Flop Storage Output	B-37060-5	B-32269-1	E-31635-4
203 Flip-Flop Storage Register	B-37057-4	B-32268-1	E-31621-4
203 Flip-Flop Storage Control	B-37061-7	D-32106-2	

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<u>WWI Drawing List</u>	<u>Block Diagram</u>	<u>Block Schematic</u>	<u>Circuit Schematic</u>
301 A-Register, Digits 1-15	B-37056-3	B-31211-3	D-31276-9
301 A-Register, Digit 0	B-37056-3 B-37072-7	B-31574-1	D-31573-5
302 Accumulator, Digits 1-14	B-37063-5	D-31213-3	R-31275-7
302 Accumulator, Digit 0	B-37096-5	D-32851	R-32850-1
302 Accumulator, Digit 0, Aux. Panel	B-37096-5	B-32492-2	D-32602-1
303 B-Register	B-37097-3	B-31212-4	D-31277-6
304 Sign Control & 308 Divide-Error Control	B-37072-7	C-31576-3	E-31619-2
305 Step Counter	B-37074-5	D-31828-1	D-39764-3
305 Step Counter Output		A-32723-1	D-32735-2
306 Multiply & 307 Shift Control	B-37072-7	C-31532-3	E-31588-5
308 Divide Control	B-37072-7	C-31552-3	R-31718-5
309 Special Add Memory & ACO Carry	B-37072-7	C-31575-4	E-31632-3
310 Point-Off Control	B-37072-7	C-31600-6	E-31717-6
403 In-Out Register	B-37119-2	B-32434-1	D-31277-6
404 Comparison Register	B-37120-2	B-32578-1	E-32576-3
601 Check Register	B-39816-2	B-32577-1	E-32576-3
601 Check Register Check		B-32018	E-32023-2
Bus Connections	B-37124-3	C-37123-3	
Bus Driver, Arithmetic Element		A-32297-1	D-31727-7
Bus Driver, Flip-Flop Storage		A-32296-1	D-31726-7
Register Driver, Type I		B-32207-1	E-32261-5
Register Driver, Type II		B-32691-2	D-32690-2
Fuse Indication Panel			W60PP00-7-D
Voltage Variation Panel			W60PP00-6-C
WWI Power-Connector Pin Connections			B-31955-5

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2.0 WHIRLWIND I RESEARCH2.1 Circuits2.11 Flip-Flop Design and Stability

(K. E. McVicar)

A breadboard panel with three d-c coupled flip-flops was installed in the temporary clock-pulse control for WWI for tests regarding their adaptability to that purpose. However, operation was unsatisfactory due to what seemed to be a change in some voltage level which rendered the flip-flops unstable. Attempts to locate a voltage drift in the flip-flop circuits themselves were unsuccessful and rather than tie up the entire Whirlwind test program further, the panel was disconnected and clock pulse control returned to its original condition. When the permanent clock pulse control has been received and installed, the d-c flip-flops can be reconnected to the temporary unit for further tests to determine the exact nature of the difficulty.

2.2 Components2.24 Crystal Rectifiers

(H. Kenosian)

Test equipment has been sent to Sylvania to expedite studies of bus driver crystals. It has been noticed that many D359 crystals exhibit a decrease of forward resistance after a 0.1 microsecond pulse has been passed through it. The test setup sent to Sylvania shows the effect of these crystals on pulse chains.

2.3 Systems2.31 Five-Digit Multiplier

(E. S. Rich and R. W. Read)

The initial life test on the Multiplier commenced on January 24. The Multiplier is solving the problem  $31 \times 31$ ; at the end of each period between problem solution a check pulse is sent to a gate tube associated with each flip-flop. An error, due to any flip-flop being in the wrong position, allows

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**2.31 Five-Digit Multiplier (Continued)**

the check pulse to go to a counter. The counter is capable of recording single errors; a chain of errors can be counted by means of another circuit, and its duration indicated on a time clock.

Since January 24, the Multiplier has approximately 250 hours operating time, with nine recorded errors. Approximately one hour a day was used for checks and maintenance.

On January 25, one error was counted. It was noticed that an indicator light on the 150 volt d-c line on Panel I was burned out.

On January 31, after a weekend operation, eight errors had been counted; an indicator light in the 150 volt d-c line on Panel 2 had burned out.

The initial life test will continue until about February 21, when life test will commence.

(R. W. Read)

Investigation into the errors due to pilot light failure in the Multiplier revealed that they could be introduced at will by completing the circuit in the 150 volt indicator light circuits; when the circuit was broken, an occasional error was noted. The lamps draw about 30 ma. at 120 volts.

The transient at the load side of the 150 volt line appeared to be about 70 volts peak amplitude, and had a duration of less than a microsecond. Fast ringing, estimated to be about 40 megacycles, was observed following the first transient.

The effect was produced by the distributed capacity, to ground and to the panel supply leads, on the indicator supply line. The capacity would discharge into the cold lamp, when contact was made; the transient would be coupled into the supply leads, and would oscillate with the lead inductance. Flip-flop error was noted at the time of the transient.

To reduce the transient, the supply leads to the indicator lights were moved to the supply side of an R.F. filter section, and an extra 1000 ohm dropping resistor, located at the light, was inserted.

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### 3.0 SPECIAL CIRCUITS

#### 3.2 Test Equipment

##### 3.21 Standard

(E. Kenosian)

Cathode-Follower Probe - The cathode follower probe is being modified to permit shielding the attenuator. The modified unit will be slightly larger in diameter, and will have an input capacitance of about 7  $\mu$ farads.

(R.L. Massard)

Video Amplifier - The power supplies for the amplifiers have been modified so as to make them interchangeable. Changing supplies entails two voltage adjustments.

Peaking component values have been standardized. It has been found that all amplifiers may be peaked the same with fairly good results.

One amplifier has been mounted in a single-beam 'scope, access to the top vertical deflection plate being provided. The side of the output stage of the amplifier which drives this top plate may thus be disconnected at the expense of adding 4  $\mu$  wiring capacity when the amplifier is in use. The fact that the lower vertical deflection plate always has 400 ohms to grid (amplifier plate load resistor) did not seem to have an appreciable effect on the use of the top plate directly.

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4.0 BLOCK DIAGRAMS

(C. W. Adams)

Detailed step-by-step binary divisions have been written out for use in checking WVI in division. Several different problems have been tried in an attempt to find problems which are at the same time easy to check step by step with the computer indicator lights and are rigorous in their demands on elements of the computer.

In working out problems, a need was found for rapid conversion between binary and decimal numbers and a short table which greatly facilitates this conversion has been prepared. It may be obtained by anyone on request.

(R. P. Mayer &amp; J. M. Salzer)

The Multiply operation of WVI has been investigated in an effort to find a test problem that will check the proper operation of all digit columns. Three problems are required, one of which checks nearly everything - the other two being required to check miscellaneous omissions from the first problem. An Engineering note will be issued explaining the check in detail. WVI was checked, with the temporary console, at high-speed operation and showed correct results.

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