Project Whirlwind
Servomechanisms Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

SUBJECT: BI-WEEKLY REPORT, PART I, MARCH 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
- Time Pulse Distributor
- Pulse Generator
- Bus Drivers, Flip-Flop Storage (complete)
- Register Driver, Type 1 (complete)
- Digit Interlock Panels (complete)
- Flip-Flop Storage Output Panels (complete)
- Frequency Divider
- Operation Matrix
- 16 In-Out Registers
- 13 Fuse Panels
- 130 Control Pulse Output Units

1.02 WWI Systems Tests

(H. L. Ziegler)

During the past two weeks the operation of the computer for arithmetic check and for special add was checked and found satisfactory. Correct and stable performance of all arithmetic-element operations provided for by the present Test Control setup has now been obtained.

Attention has been shifted to a study of timing within the various AE operations, particularly to those operations believed to be critical in timing. Multiplication, division, and scale

1.02 WWI Systems Tests (continued)

factor operations were checked at each step of the operation with critical points in timing being recorded by drawings of scope waveforms. An important point that has been brought out by these studies, is the appreciable delays caused by RG-62/U coaxial cables used for transmission of pulses. Delays of as much as 0.1 μsec have been observed, usually when widely separated control panels are involved in the operation. These timing studies will be continued when the computer is returned to operation.

Pulse-amplitude tests to determine minimum levels, and the source of the first error resulting, were continued during this period. Due to the nature of the induced marginal operation, it has been difficult to make measurements and progress has been slow.

All systems testing has been temporarily discontinued because of the present shut down for power equipment installation.

1.1 Listed by System Number

102 Program Counter

(C. W. Watt)

Mechanical drawings are complete and construction requisition for 13 will be issued next week.

104 Control Switch & Storage Switch

(R. E. Hunt)

CS&SS Switch Panel - M.I.T. drafting on this panel is about 80% complete, and should be complete by 3-7. This conforms almost exactly to the scheduled drafting time.

CS&SS Matrix & Output Panels - Status reports and drawings on these panels should be received from Sylvania by 3-7.

105 Operation Matrix

(R. E. Hunt)

Operation Matrix Drivers - Construction of three of these panels is now about 30% complete.

The scheduled completion date is April 17. This date should be bettered by approximately two weeks.

109 Clock Pulse Control

(C. W. Watt)

The sheet metal work on this panel is finished. Wiring is proceeding. The scheduled completion date should be bettered by at least a week.

(R. H. Gould)

Tests on the experimental breadboard model of clock pulse control show that the uneven amplitude of the 2 mc output pulses is due to interaction between the 1 mc and 2 mc pulses through the control grid to suppressor capacitor of the gate tube controlling the 2 mc pulses. A reduction in the size of this capacitor gives satisfactory operation. During testing of the Whirlwind panel the optimum value will be determined.

Changes have been made in the design of clock pulse control to prevent time pulse 5 from initiating restorer pulses during push button operation. Time pulse 5 is fed to a gate tube and buffer amplifier that were spares, and the gate tube is held closed by the matrix when the flip-flops are in push-button operation position. This has necessitated the addition of a few components and a length of coaxial cable to the phenolic panel but will have negligible effect on production time. The shop is working from a marked-up print while the drafting room is changing the drawings.

111 Synchronizer

(H. S. Lee)

The video layout is approximately two-thirds complete and the aluminum panel detail has been started. Progress is satisfactory.

112 Toggle Switch Storage Switch Panel

(C. W. Watt)

Video layout is nearly finished, and mechanical drawings have begun.

202 Toggle Switch Storage Output

(C. W. Watt)

Drawings are complete, and sheet metal work has begun. The scheduled completion date of May 1 should easily be met.

204 Electrostatic Storage Control

(K. E. McVicar)

A breadboard consisting of five d-c coupled flip-flops and five buffer amplifiers with associated crystal gates has been built and is ready for testing. Also constructed as part of the breadboard for electrostatic storage control was a matrix and fourteen buffer amplifiers and their associated crystal gates.

302 Accumulator

(W. N. Papian)

Imperfect isolation resulting in an objectionable amount of signal feed-through from inputs "from AR" and "Comp. & Restore" to the "H.S. Carry from Right" circuit is being corrected by replacing the present mixing circuit by the type described in E-155 (21 Oct. 48). The change should be completed on all digits during this week.

404 Comparison Register Check

(H. S. Lee)

The circuit and block schematics have been completed. The video layout is scheduled to start March 13.

601 Check Register Check

(H. S. Lee)

The aluminum panel has been received from the engravers and several minor fabrication modifications have been made upon it by our sheet metal shop. The quality of the engraving was quite satisfactory and, based thereon, a tentative decision has been made to have all panels of unit quantity engraved by the same concern.

The phenolic panel has been fabricated and the wiring operation has started. The cable harness has been completed. All work is on schedule and progress is satisfactory.

(C. W. Watt)

Mechanical drawings are complete. A construction requisition will be issued next week.

700 Operator's Console

(A. K. Susskind)

The basic alarm indicator circuit has been shown to be satisfactory and consequently it became the basic building-block of the WWI alarm control-unit now being drawn up. The block schematic is already available and the circuit schematic will be completed by the drafting room in a few days.

The control unit is set up to handle alarms from ten separate sources. Each source will have its own indicator lamp and there is a master indicator which is operated by all sources. The control unit also contains a BA which sends a pulse to the alarm input in CPC upon receipt of any one of the alarms.

1.2 System Engineering

(C. W. Watt)

Installation - Wiring of flip-flop storage racks is nearly complete. Wiring from voltage-variation racks to panel selection equipment, rack P-9, is nearly complete. During the power shut-down, March 7-21, the wiring in the power row will be changed to permit use of the voltage variation panels, and the power supply controls in test control will be connected to the relay panel in the power supply room. Most of the wiring to be installed will be permanent.

(H. S. Lee)

The bracket for the interphone and sync pulse jacks has been designed and has been approved. The cabling layout has been started and will continue.

1.21 Power Control and Distribution

(H. S. Lee)

Auxiliary Relay and Bias Interlock Panel - Assembly of this panel has been completed and it has passed mechanical and electrical inspection. Several minor engraving errors were noticed and will be corrected this week before the panel is installed in the rack.

Voltage Variation Panels - The original ten panels have been completed, passed inspection and have been installed in the racks.

1.21 Power Control and Distribution (continued)

An additional assembly requisition has been given to the shop for assembly of the remaining 63 panels. With the exception of two panels required by March 4, this order was to be completed as a fill in job for slack periods. The two panels have been completed and are now being inspected.

(R. E. Hunt)

Marginal Checking - The marginal checking supply and control is about 85% installed and checked.

The panel selection rack and control has been installed and checked for manual operation. The output signals have been wired to racks P-10 thru P-14 and checked.

The marginal checking temporary supply has been installed, and checked. Operation is satisfactory but a little further work remains to be done on voltage variation sensitivity.

1.22 Power Cabling

(H. S. Lee)

On March 2nd and 3rd a conference was convened to reconsider the grouping of panels in control in connection with marginal checking and power cabling. Present were N. Taylor, Rich, Lee, O'Brien and Sumner. A memo will be issued in the near future describing the decisions made at the conference.

As a result of this conference it will be necessary to redesign the power cabling for the control racks. Therefore, drafting revisions will be necessitated on racks C12 and C13 which had been completed. This will delay drafting, fabrication and installation of control power cabling. It will not be possible to complete racks C12 and C13 during the two-week power shutdown.

The external power cables for the check register and program counter have been removed from the racks and sent to the shop for modification. The shop is also engaged in fabricating the power cables for the PP storage register drivers. Within the next week the external power cables for the arithmetic register drivers will be sent to the shop for modification.

1.22 Power Cabling (continued)

The temporary wiring in C15 will be replaced with permanent wiring as soon as the latter cables can be fabricated in the shop. It is hoped that this can be effected in the next two weeks but no definite commitment can be made at this date.

1.23 Video Cabling

(R. H. March)

Approximately 75% of all video cables for the control row have been measured. This information is being added to cable detailed drawings by the drafting room so that it may be sent to Sylvania for construction of these cables. Approximately 234 cables have to be constructed.

1.24 Register Driver Type II

(R. E. Hunt)

Four of these panels are now in the construction shop and are about 90% complete.

The scheduled completion date of March 13 should be bettered by about one week.

1.25 Time Schedules

(R. A. Osborne)

The new time schedules are nearly finished and the summary should be ready early next week.

Sylvania's schedules have been posted through February.

1.3 Auxiliary Equipment

1.31 Power Supplies

(J. J. Gano)

WWI D.C. Power - By experiment, the optimum value of the R.F. chokes for the -15 and -30 volt supplies was found to be about 150 microhenries. Permanent chokes will be designed and installed during the computer shut down period.

1.31 Power Supplies (continued)

Synchronous Motor Regulator - Protective Circuit. In testing the overvoltage and undervoltage relay, the seal-in coil operated unsatisfactorily with a-c power because of a lack of shading pole in the design. This necessitated the introduction of an intermediate d-c relay which has been ordered. Due to overcrowding of components, the panel has been redesigned.

(C. R. Wieser)

WWI Filament Power - The 100 H.P. motor showed some vibration due to unbalance. Compensating weights have been attached, and the vibration has been reduced to a satisfactory level. The 1.5 kw exciter has also been rebalanced for smoother operation.

WWI D-C Power - R-F chokes have been wound and will be installed during the shut-down period (March 7-26).

Power-supply control wiring will be installed in the existing wireways during this period. If time permits, the supplies will be tested under load to set the compounding adjustments.

WWI Drawing List	Block Diagram	Block Schematic	Circuit Schematic
System	B-37071-5		
Control	B-37098-4		
Master Clock	B-37159-1		
101 Pulse Generator	B-37155-3	B-32885	E-32333-3
102 Program Counter	B-37062-4	B-32213-1	D-31516-6
103 Program Register	B-37067-2	B-39289-1	D-31276-10
104 Control Switch	B-37066-3	T60CS00-4-C	Z60CS00-A R-32722 Z60CS00-2-A
105 Operation Matrix Driver Panel		S60C100	Z60C100-1-E
Control-Pulse Output		R60CP00	S60CP00-1-B
106 Time-Pulse Distributor	B-37068-3	T60PD00-3-A T60PD00-4-B	
106 Time-Pulse Distributor Counter		T60PD00-3-A	Y60PD00-C
106 Time-Pulse Distributor Output		T60PD00-4-B	Z60PD00-1-D
109 Clock-Pulse Control	B-39817-2	C-32642-4	R-31916-7
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-31909-8
200 Storage	B-37156-2		
201 Storage Switch	B-37121-2	B-32855-1 T60CS00-4-C	Z60CS00-A Z60CS00-2-A E-32830-2 R-32722-1
202 Toggle-Switch Storage	B-37122-3		E-32711
202 Toggle-Switch Storage Output		C-32080	E-32721-3
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	

WWI Drawing List	Block Diagram	Block Schematic	Circuit Schematic
301 A-Register, Digits 1-15	B-37056-3	B-31211-3	D-31276-10
301 A-Register, Digit 0	B-37056-3 B-37072-7	B-31574-1	D-31573-6
302 Accumulator, Digits 1-14	B-37173	D-31213-3	R-31275-9
302 Accumulator, Digit 0	B-37173	D-32851	R-32850-2
302 Accumulator, Digit 0, Aux. Panel	B-37173	B-32492-2	D-32602-1
303 B-Register	B-37097-4	B-31212-5	D-31277-6
304 Sign Control & 308 Divide-Error Control	B-37072-7	C-31576-3	E-31619-2
305 Step Counter 305 Step Counter Output	B-37074-5	D-31828-1 A-32723-1	D-39764-3 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-31632-4
310 Point-Off Control	B-37072-7	C-31600-6	E-31717-6
403 In-Out Register	B-37119-2	B-32434-2	D-31277-6
404 Comparison Register	B-37120-2	B-32578-1	E-32576-5
404 Comparison Register Check		B-33488-1	E-33515
601 Check Register	B-39816-3	B-32577-1	E-32576-5
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-32261-6
Register Driver, Type II		B-32691-2	D-32690-2

WWI Drawing List (continued)	Block Diagram	Block Schematic	Circuit Schematic
Fuse Indication Panel			W60PP00-7-D
Voltage Variation Panel			W60PP00-6-C
WWI Power-Connector Pin Connections			B-31955-6

2.0 WHIRLWIND I RESEARCH

2.2 Components

2.23 Vacuum Tube Studies

(R. L. Ellis)

Two burning racks have been adapted to fit Laboratory conditions. Burning will be completed this week on forty-five 7AD7 and forty-five 7AK7 tubes. It is planned to continue burning more of these tubes and build up a reserve of WWI type tubes.

Tube complements for Check Register Check and four Register Driver Panels II are about completed.

Transfer characteristic curves for the average of four 5687 tubes in the 0 to 0.1 ma plate current region have been completed. The drawing number is A-40487.

Plate family curves for average 3E29 with screen voltage at 150 and 100 volts are about complete. This will likewise have a drawing number.

All tubes in the Multiplier have been retested. A report will soon be out giving the plate current and control-grid cut-off on the initial test and on the re-test. The report will also give the number of hours operated, the manufacturer's production number, the type of circuit use, and the percentage of change for each tube.

(H. B. Frost)

A life-test rack of 10 7AD7 tubes of F8B production is being operated with a filament voltage of 8 v. Five of these tubes are biased off, and five have 90 volts plate and screen with zero bias. These tubes will be compared with 10 other tubes of the same production operated under the same conditions except at normal filament voltage of 6.3 v. A clock has been installed in the life-test racks for more accurate timing of life tests.

Twenty multiplier-deteriorated 7AD7 tubes of B8B production were pulse-tested to determine interface

resistances and delivered to John Weymouth, Physics Department, for spectrochemical analysis. These tubes were used as flip-flops and flip-flop cathode followers only. The interface resistances as calculated from pulse data varied between forty and two hundred ohms. A study of the correlation between flip-flop behavior on marginal test and interface resistance will be made.

A study is being made to evaluate the results of pre-burning all tubes as part of the test schedule. Information concerning the rejection of early failures and the effect of pre-burning on ultimate life is being gathered.

Four 5687 tubes used in multiplier standard-test-equipment were pulse-tested. These circuits have operated slightly over 1000 hrs., and all these tubes showed well-developed interfaces. These tubes were from production lot 3228-52; tubes from production lot 3228-26 previously were known to develop interfaces. Unless future tests on new lots show better results, application of 5687 tubes in flip-flops and multivibrators for continuous operation is not recommended. Pulse amplifier operation is apparently satisfactory.

2.3 Systems

2.31 Five-Digit Multiplier

(C. R. Wieser)

The power supply motor generator sets have been rewired for more reliable operation and easier maintenance. In the past, the -15, -100, and ±250-volt generators have been operated self-excited at voltages well below saturation. This makes them quite sensitive to hysteresis and temperature changes. The machines will be reconnected so that the ±150 volt supply (which is more stable) is used to excite the -100 and ±250 volt generators.

A simple regulator will be built for control of the -15 volt generator. While this is being done, the -15 volt regulator formerly used on WWI will be used as a temporary supply to the multiplier.

3.0 SPECIAL CIRCUITS

3.2 Test Equipment

3.22 Special Test Equipment

(H. Kenosian)

A booster amplifier is under design to work with the Mega-Sweep generator for testing r-f components.

4.0 BLOCK DIAGRAMS

(J. M. Salzer)

Several problems relating to systems operation have arisen:

1. On selective pushbutton operation the selection is proposed to be done from the Operator's Console by grounding the suppressors of the chosen output GT's of the control matrix. It is necessary then to apply a pulse (called CONTROL SIGNAL) to all eight TP lines. TP5 would thus appear every time and start restoration resulting in almost unpredictable action. It was decided to gate out TP5 going to the Restorer Pulse Generator on pushbutton operation. One of the spare gate tubes, GTO5, of the Clock Pulse Control will be used for this purpose. An additional advantage of this scheme is the elimination of restoration following TP5 on single-pulse operation. This was an undesirable, though tolerable, feature.

2. The Computer Complement pushbutton puts a pulse on all restorer lines to complement most FF's of the computer. However, complementing of the Clock Pulse Control must be avoided in order not to interfere with the state of operation. Since the Computer Complement pulse is amplified in the Restorer Pulse Generator, modification of this unit would be necessary for the non-complementing of the CPC. Another solution would be a delayed re-complementing of the CPC to re-establish its initial state. Though the former solution is slightly more desirable, practical considerations by the Electronics Group will decide the issue.

3. A difficulty with the "shift zero" operations was investigated. In these cases TP1 is used both for STOP CLOCK and for STEP COUNTER END CARRY. For unambiguous operation of the Clock Pulse Control the latter command must be delayed. An appropriate DE will be inserted either in the ADD TO SC line coming from the Control Matrix or in the SC END CARRY line going to the CPC. Either solution poses questions on timing which will have to be resolved by testing.

(C. W. Adams)

I have started work on a block schematic of the arithmetic element. It is hoped that this will lead eventually to a complete system block schematic which many people concerned with the WWI system feel would be quite useful. At present much of the information needed for system circuit tracing in trouble shooting, in checking, and in timing studies is scattered through a number of separate drawings and some seems not to be on paper at all.

4.0 BLOCK DIAGRAMS (continued)

(R. P. Mayer)

A new operation has been proposed. The proposal is that it will be called "at", "add and transfer", and that it will 1) add the contents of AC to the number in the selected register of storage, returning the sum to storage, and 2) leave the original contents of AC in AC, so that the same number may be added to the contents of other storage registers.

The at order could be used to restore many addresses at the end of a cycle. (In this respect, notice that at is similar to ao except that 1) ao can add only "1", while at can be instructed to add any number and 2) ao leaves the AC containing minus the sum, while at leaves it containing its original contents). The at order could also be used in purely arithmetic operations when a number must be added into a given register, as when the terms of a series are to be accumulated in a given register, or when the independent variable is to be increased to a new value.

Also, the limited size of test storage can be effectively increased slightly by the adoption of the at order.

Any comments on this proposal will be welcomed.

5.0 CHECKING METHODS

(J. A. O'Brien)

Marginal checking of Control Elements - The distribution of power wiring to voltage variation panels as it concerns the marginal checking of units in the main computer control racks was decided upon. The engineers present at the discussion were N. H. Taylor, E. S. Rich, H. S. Lee and J. A. O'Brien.