Project Whirlwind
Servomechanisms Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

SUBJECT: BI-WEEKLY REPORT, PART I, MARCH 18, 1949

To: 6345 Engineers

From: Jay W. Forrester

1.0 WHIRLWIND I COMPUTER ELEMENTS

1.01 Production Report

(H. F. Mercer)

No additional panels (production units) have been received from Sylvania during the past two weeks.

In addition to the panels previously reported as completed by Sylvania the following have been completed here:

4 Register Drivers, Type II (complete)
Check Register Check
3 Operation Matrix Drivers (complete)
12 Voltage Variation Panels

1.1 Listed by System Number

101 Pulse Generator

(H. Kenosian)

The pulse generator has been tested and modified. It is now ready for the system.

102 Program Counter

(C. W. Watt)

Production requisition modified to include 18 units, 5 to be unmarked except for jack designations and schematic number, per memo M-803. These will be used in electrostatic storage control.

104 Control Switch/Storage Switch

(C. W. Watt)

Switch panel: Drafting complete, panels complete and marked, assembly work begun. Schedule pushed ahead to take place of matrix panel which is not ready.

Matrix panel: More drafting than expected is needed on this panel, requiring a shift in schedule. Drafting proceeding.

Output panels: Drawings just received from Sylvania.

Schematics are being simplified and brought up to date.

105 Operation Matrix Drivers

(C. W. Watt)

All three assemblies are complete and ready for test. Preliminary test specs are complete three weeks ahead of schedule.

106 Time Pulse Distributor

(K. E. McVicar)

The time pulse distributor counter panel has been received from Sylvania and it is being tested in conjunction with the time pulse distributor output panel. Alterations have been made on both panels to obtain more uniform pulse amplitude with variation in input level, and to reduce the formerly excessive output voltage.

109 Clock Pulse Control

(R. H. Gould)

The problem of the operation of clock pulse control in the case of "computer complement" has been solved by recomplementing CPC with a delayed complement pulse. The RPC output consisting of restorers and the complement pulse is fed to one input of RD1 of Register Driver Panel, Type I in C7. The output of RD1 goes to the "restore" input of CPC. A complement pulse from the synchronizer goes also to

109 Clock Pulse Control (continued)

to the other input of RD1 which has been modified by the addition of a 0.5 microsecond delay line between this input and the amplifier tube. Thus CPC is recomplemented 0.5 microsecond after being complemented and the operation is the same as during restoration.

(C. W. Watt)

Shop work is almost complete. Scheduled date will be bettered by three days. Preliminary test specs have been written.

110 Frequency Divider

(H. Kenosian)

The frequency divider has been tested and modified. It is now ready for the system.

111 Synchronizer

(H. S. Lee)

All drafting has been completed.

The aluminum panel has been fabricated, painted and will be engraved within the next week. The terminal board has been fabricated. Progress is satisfactory.

112 Toggle Switch Storage Switch Panels

(C. W. Watt)

Drafting is finished and construction requisition is issued. Three weeks ahead of schedule.

202 Toggle Switch Storage Output

(C. W. Watt)

Sheet metal work is complete, and electrical assembly is about 20% done. Two weeks ahead of schedule.

204 Electrostatic Storage Control

(H. Fahnestock)

Further decisions on electrostatic storage control were made at a meeting on March 14. Present were Forrester,

204 Electrostatic Storage Control (continued)

Boyd, Everett as well as those at the meeting reported in the bi-weekly of February 18, namely Fahnestock, Taylor, O'Brien and Rich.

In view of the time element and the uncertainty of new design, the matrix type of control will not at present be pursued. Electrostatic storage control will be made up from panels which have already been designed or built. Existing spares will be used in the following quantities: 2 accumulators, 3 B-registers, 2 A-registers, 2 register drivers type I. These spares will be later replaced. We will construct 5 additional program counters, making a total of 18. An 8 channel 7AD7 amplifier is also required and will probably be designed instead of the inefficient use of 2 control switch output panels.

404 Comparison Register Check

(H. S. Lee)

The video layout is approximately 33% completed. Progress is satisfactory.

500 Input-Output Control

(J. A. O'Brien)

A block diagram of in-out control has been drawn in sketch form and it is now being studied in detail by Everett, Salzer, Rich and O'Brien. The equipment includes comparison register check, an extra digit on the IO register, an interlock flip-flop, a shift control flip-flop and circuit for synchronization and restorer pulse control. The equipment does not include any output selection or switching facilities.

601 Check Register

(C. A. Rowland)

Check Register Check - Testing of this panel has just been completed, and it is ready for installation in WWI.

(C. W. Watt)

Construction requisition issued to shop, and sheet metal work has begun. Three weeks ahead of schedule.

1.2 System Engineering

Installation

(H. S. Lee)

Since March 7 the computer has been inactive and the installation group has been modifying the power distribution system and effecting new rack installations.

The modified power distribution system consists of the permanent system and an interim temporary system. Voltage variation has been provided for all flip-flop screen circuits and gate tube screen circuits in the arithmetic elements, flip-flop storage, arithmetic control and register drivers. This is a permanent installation. In addition the following permanent circuits have been installed:

Flip-Flop Plates - Non Variable

Gate Tube Plates - Non Variable

Gate Tube Control and Suppressor Grounds - (Temporarily these circuits have been connected to the common ground.)

Permanent installations have been made in the following racks:

P12 - 90 volts variable
P11 - 120 volts variable
P4), P3) - Fuse indication
P2 - Digit interlock
P5 - Power junction and switching
P1 - (Part permanent, part temporary) Fixed Voltage Switching

The permanent wiring for control and indication between the above racks and between the above racks and the computer racks has been installed.

When the present phase of the work is completed the only temporary wiring will be that between P1 and the computer racks and between P1 and P2. This temporary wiring constitutes 40% of the total wiring between these racks.

All circuits to repetitive elements, both temporary and permanent, are connected according to the permanent system plan, by digit pairs. Thus all d-c power to any pair of digits of eight digit separation (0-8, 1-9 etc.) can be independently

1.2 System Engineering (continued)

controlled by either the automatic interlock system or the master digit interlock switches in rack P5. The arithmetic control excluding the step-counter and step counter output, which are a separate digit, is wired as one digit as is the register driver column of racks.

The installation has progressed on schedule and it is expected that all work, except testing, will be completed by March 19. It is believed that testing and rectification of possible minor errors will expend Monday and Tuesday, 21 and 22 March.

Sync Pulse and Interphone Distribution - A construction requisition has been forwarded to our shop for fabrication and assembly of 15 brackets on which will mount the video and telephone type jacks for the sync pulse and interphone respectively. At present it is planned to install one such bracket centrally located per each eight racks. The bracket will be installed on the rear side of all rows excepting C row.

It has been decided that a video cable system and possibly an auxiliary power system should be installed to provide for the employment of video probes in the computer room and synchroscopes in the control room. Engineering of this system will start at the earliest practicable date consistent with present engineering schedules.

1.21 Power Control and Distribution

(H. S. Lee)

The modification of the remaining 61 aluminum panels has been completed by our shop. Some consideration has been given to having Sylvania complete the assembly of these panels during their remaining contractural time. To date no decision has been made. Further work by our shop will be temporarily suspended pending such decision.

1.22 Power Cabling

(H. S. Lee)

Drafting of cabling for rack C12 has been completed and that for rack C13 95% completed, the latter requiring checking only. Layout and detailing of cabling for rack C8 has started. Rack C8 and the group of racks C9-C10-C11 were reversed on the drafting schedule inasmuch as complete information was not available on C9-C10-C11 at the scheduled starting date. With the completion of C13, power cables drafting will return to schedule.

1.22 Power Cabling (continued)

All cable modifications referred to in the report of March 4 have been completed and the cables are ready for installation. It is not believed that time will be available for installation prior to the next Friday power shut down. This stated belief is also applicable to the replacement of the temporary wiring in C15.

Cavitt has made partial delivery on all outstanding orders for preformed cables in quantities adequate for the satisfactory prosecution of the cabling installation. Complete delivery will be made before March 31.

1.23 Video Cabling

(R. H. Murch)

The flip-flop storage vertical video cables, flip-flop storage output horizontal video cables and flip-flop storage register II horizontal video cables have been received from Sylvania.

Information for construction of approximately 75% of all video cabling for central control has been sent to Sylvania. Cables should be received in about two weeks.

The video cabling block schematic (SR40182-4) for the arithmetic element and central control, has been re-drawn in a much clearer form. At present it shows all arithmetic control cabling and approximately 80% of central control cabling. Arithmetic element cabling will be added as soon as time is available. Balance of central control video cabling will be added as soon as decisions have been made on the method of connecting the clear circuits, alarm circuits and time pulses to the operation matrix.

Video cable master schedules and panel schedules are being completed for cables measured by M.I.T. Some revision of schedules made by Sylvania will be necessary due to video cabling changes resulting from block diagram and system changes.

During the past two week shut-down period, all video cabling for test control has been completely reconnected. All cables are being marked with their terminations, to eliminate the confusion which resulted from cables not having these markings.

1.23 Video Cabling (continued)

Most of the video cabling for flip-flop storage, arithmetic element, arithmetic control and central control has either been constructed or designed. Any changes in block diagrams, block schematics location and marking of video jacks, or location of panels in the racks, may result in changes in video cabling. An exception to this is comparison register check which has had no video cabling designed for it at present. I would appreciate being informed of any such changes as soon as they occur.

1.25 Time Schedules

(R. A. Osborne)

The new summary schedule for inclusion in the monthly summary report has been completed. This schedule has been reduced from three sheets to a single sheet. It is felt a single sheet will be of more use to the reader and more quickly give him an over-all picture of project activities.

A more detailed three sheet summary has been drawn up for use in the lab.

The individual schedules have been posted through February.

1.3 Auxiliary Equipment

1.31 Power Supplies

(J. J. Cano)

WWI D-C Power - Permanent R.F. chokes have been installed in all the d-c power supplies except the -15 and -30. Since these latter two supplies will require only two chokes each instead of six as was required by the others, they can be installed on a Saturday morning or during a brief shut down period.

Synchronous Motor Regulator - Protective Circuit - The circuit has been rewired using final components except for push-button stations which have not been delivered yet.

(C. R. Wieser)

The power-supply control panel has been installed and tested satisfactorily. This leaves filament voltage control yet to be installed.

1.31 Power Supplies (continued)

Work will be started immediately on design of the filament-voltage regulator.

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-32385	E-32333-4
102 Program Counter	B-37062-4	B-32213-1	D-31516-6
103 Program Register	B-37067-2	B-39289-1	D-31276-10
105 Operation Matrix Driver Panel		S60OM00	Z60OM00-1-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-39817-3	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-33486-1
112 Restorer-Pulse Generator	B-37160-1	B-32209-4	D-31909-8
200 Storage	B-37156-2		
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	
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-31573-7
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

WWI Drawing List (continued)	Block Diagram	Block Schematic	Circuit Schematic
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	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-31632-4
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
Fuse Indication Panel			W60PP00-7-D
Voltage Variation Panel			W60PP00-6-C
WWI Power-Connector Pin Connections			B-31955-6
Digit Interlock Panel			W60PP00-8
Fixed Voltage Switching Panel			C-60PP00-11
Power Interlock & Indication Panel			Z-60PP00-12

2.0 WHIRLWIND I RESEARCH

2.2 Components

2.23 Vacuum Tube Studies

(H. B. Frost)

Nine 7AD7 tubes made to L7P specifications, which have operated on life test with only filament voltage applied, were tested this week after 1500 hours of operation. Deterioration was slight, with no interface formation.

Eighteen 6AG7 tubes made by RCA, which have been operated 1200 hours on life test were also tested. Deterioration was quite pronounced, with more deterioration being observed in tubes operated on 10 percent duty cycle than in tubes operated on 90 percent duty cycle. All 6AG7's showed some interface during warm-up; the highest interface resistance was 60 ohms at normal temperature.

A life test panel for 5687 tubes has been designed and built. This will be placed in operation in the near future.

(R. L. Ellis)

The report on the multiplier tube tests will be ready on Monday next.

Nearly 700 tubes have been tested in the past two weeks and most of the test data has been recorded on cards.

The burning racks have been kept running continuously. Ninety 7AK7 and 180 7AD7 tubes have been burned for 100 hours. This stack of burned tubes has been reduced, however, by increased assignments. 325 tubes, all types, have been assigned to circuits during these periods. This leaves about 75 each of 7AK7 and 7AD7 tubes burned and ready for WWI circuits.

More curves have been completed on 5687. Plate current characteristics from the average of four average tubes with grid bias from 0 to -12 volts are now available with number A40490.

2.23 Vacuum Tube Studies (Continued)

The 6J6 tubes have showed a very wide range of variation in plate current. They are from four different productions. The Sylvania B&P production shows a much better balance. Since our stock is not of JAN specifications, some of these variations can be expected.

3.0 SPECIAL CIRCUITS

3.2 Test Equipment

3.22 Special Test Equipment

(H. Kenosian)

The Megasweep Booster Amplifier is now undergoing tests. This amplifier will facilitate testing of R.F. circuits and amplifiers in the storage tube R.F. readout program.

4.0 BLOCK DIAGRAMS

(R.R.Everett)

Considerable effort is being put on completing the block diagrams for Electrostatic Storage Control and In-Out Control. Wherever possible these controls will be made up of standard panels such as accumulators and B-registers.

The following people are working on Electrostatic Storage Control:

N. H. Taylor
S. H. Dodd
J. A. O'Brien
R. P. Mayer
R. R. Everett

The following people are working on In-Out Control.

J. A. O'Brien
E. S. Rich
J. M. Salzer
R. R. Everett

Preliminary memorandums on these controls should be available next week.

(J. M. Salzer)

A new block diagram has been made out for the Alarm Indicator.

(R.P.Mayer)

At a recent conference several decisions were made concerning WWI operations. Other decisions will be made in several weeks, at which time a note will be issued describing the status of the operations.

An operation has been investigated which can be used for starting the computer automatically. The steps involved in starting WWI with this operation are: 1) Place film in reader. 2) Clear WWI. 3) Select the reader (containing the film) with a manual switch. 4) Restart WWI. 5) Start the film reader running forward.

4.0 BLOCK DIAGRAMS

The same operation can be used to read sections of film into storage automatically during a program. Other In-Out control operations are under consideration.

(C. W. Adams)

Consideration of check problems for WWI was considerably clarified by a meeting of the trouble location group on March 14. We are now aiming at problems for use with test storage only, and perhaps using special purpose test orders, intended for use primarily in preliminary checking and reliability testing.

I am still giving much of my attention to piecing together a system block schematic. The size and complexity of such a drawing will preclude its use as a handy guide to Whirlwind operation, but it may be useful for reference.

5.0 CHECKING METHODS

(G. Cooper)

Final decision on the nature of the special display unit has made possible a wider variety of demonstration problems which will fit into test storage than first thought possible. The problems which had been previously coded have been recoded in accordance with the modified display unit.

Among those problems which have thus far been found feasible for test storage are:

1. The evaluation of $y = \sqrt{x}$ by Newton's method displaying all the approximations. (The display will give a very good indication of the rate at which this method converges.)

2. The plotting of a family of parabolas $y = ax^2$, it is possible to do this for 26 values of a, provided they are properly chosen.

3. The plotting of a polynomial $y = \sum_{i=0}^{n} a_i x^i$. It is possible to obtain values for polynomials of degree 17 with the restriction that $|a_i| < 1/2$.

4. The evaluation of sin x from the series, for x ranging between $A - 2\pi$ and 2π. This requires the use of terms up to the 23rd power.

5. The evaluation of sin x and cos x as the solution to $\frac{d^2y}{dx^2} = -y$ with appropriate initial conditions by the method of linear extrapolation and integration.

Among those problems being investigated are:

1. The solution of the general second order linear differential equation,

$$\frac{d^2y}{dx^2} + 2sw\frac{dy}{dx} + w^2y = 0$$

by an extrapolation method.

2. The solution of first and second order linear differential equations by the Runge Kutta method.

3. The plotting of two or more polynomials simultaneously.