Project Whirlwind
Servomechanisms Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

SUBJECT: BI-WEEKLY REPORT, PART I, APRIL 29, 1949

To: 6345 Engineers

From: Jay W. Forrester

1.0 WHIRLWIND I COMPUTER ELEMENTS

1.01 Production Report

(H. F. Mercer)

Since April 15 we have received the following panels (Production Units) from Sylvania:

13 Flip-flop storage registers (total received 29).

The following units have been completed here since April 15:

29 Voltage variation panels.
11 Indicator panels.
12 Mixers - operation matrix.
Synchronizer.

1.02 Whirlwind I System Tests

(G. C. Sumner)

System testing for the last two-week period has mainly been in making pulse measurements of arithmetic control to complete the maintenance file. Measurements on point-off control, divide error and sign control, overflow and special add memory and the step counter have been completed. Two different types of operation-maintenance diagrams have been made. A decision will be made as to which of these should be adopted.

Two connector failures were observed. The power connector of PR-0 had a loose pin due to faulty manufacture. A video T-connector was found with an internal short.

1.1 Listed by System Number

104 Control Switch / 201 Storage Switch.

(C. W. Watt)

Matrix Panels: Final assembly of the matrices is complete. Panel assembly is about 20% done.

Output Panels: Work has been suspended temporarily on these due to the need for producing voltage variation panels.

104 Control Switch.

(J. A. O'Brien)

A test set-up has been made up for preliminary tests on the control-switch switching panel. Observations made to date indicate that the unit is operating as was expected.

Final tests on this switch will be performed in the computer room where more space is available and all of the operation control racks can be tested as a complete unit.

106 Time Pulse Distributor.

(K. McVicar)

The time pulse distributor tests have been finished and results approved. Test specifications have been written and are being typed.

109 Clock Pulse Control.

(R. H. Gould)

The design of clock pulse control has reached a quiescent state. No further changes are being contemplated at the moment.

The spare flip-flop and gate tubes have been utilized to control the low frequency pulses to the time pulse distributor and the electrostatic storage control, and the 62.5 kc pulses to the single-pulse synchronizer and the restorer pulse generator during the operation of electrostatic storage control. Two extra buffer amplifier tubes and eleven new coaxial cable jacks have been

109 Clock Pulse Control (Continued)

added to the panel to provide for the new inputs and outputs and leave some spare cable jacks for possible future use.

The revisions in the drawings and the work on the panel are still under way. In order that the panel may be put in the computer next week, the work on the panel relevant to in-out control and electrostatic control will not be done at this time. It will probably be held until the computer is shut down in May.

111 Synchronizer

(A. K. Susskind)

The synchronizer has been tested and found to operate satisfactorily. Minor design changes have been made to obtain proper delay limits and to adjust the amplitude of the output pulses to the desired level. Test specifications are now being drawn up and will be available early next week.

202 Toggle Switch Storage Switch Panel

(C. W. Watt)

Assembly is about 30% complete.

404 Comparison Register Check

(H. S. Lee)

The aluminum panel has been painted and sent to the engravers. The terminal board has been fabricated and the wiring is 75% completed.

601 Check Register

(C. W. Watt)

All parts are finished and on hand. Final assembly will start at once.

602 Alarm Indicator Control

(H. S. Lee)

The video layout has been completed and checked. The mechanical details are 95% complete and the cable drawing has been started.

1.2 System Engineering

Installation

(H. S. Lee)

Racks C-12 and C-13 were turned over to the systems group as ready for operation on April 25. The installation of internal power wiring in rack C-8 has been completed. Plans are being formulated for effecting the installation of all wiring that can be installed prior to the two-week power shutdown scheduled for May 14.

1.21 Power Control and Distribution

(H. S. Lee)

Voltage Variation Panels. The production of these panels is progressing satisfactorily. A total of 44 panels has been completed to date out of the entire lot of 73.

1.22 Power Cabling.

(H. S. Lee)

The fabrication of power cables for Rack C8 is completed and fabrication of cables for Racks C9-C10-C11 is 80% completed. Drafting of cables for Rack C7 has been completed and a construction requisition forwarded to the shop. Except for checking, drafting of cables for racks C5 and C6 is completed. Drafting on rack C4 will start Monday, May 2.

A requisition has been forwarded to Gavitt Manufacturing Company for 15 additional external power cables for voltage variation panels as it has recently developed that the use of 71 panels will be required. This quantity includes five spare cables.

1.23 Video Cabling.

(R. H. Murch)

Flip-flop storage register No. 1 video cables have been received from Sylvania and are approximately 50% installed.

All central control cables that are measured have been received from Sylvania. This completes the central control cabling that Sylvania will build. All remaining cables for Whirlwind I that are not designed will be

1.23 Video Cabling (Continued)

constructed here. Approximately 10% of central control cables, all of electrostatic storage cables and in-out equipment cables, remain to be designed.

A video cabling block schematic for flip-flop storage has been nearly completed.

1.25 Time Schedules

(R. A. Osborne)

The detailed schedules are being posted for April. The Summary Schedule and prints of the detailed schedules will be distributed the latter part of next week.

1.3 Auxiliary Equipment

1.31 Power Supplies

(J. J. Gano)

Synchronous Motor Regulator: Commercial grade transformers for the output voltage rectifier have been received and are being assembled on a breadboard set-up for testing. The transformers presently used are too bulky and not high quality.

A permanent power supply for the amplifier is now under construction. It will be identical to that constructed for the filament alternator regulator.

When the filament load of WWI is transferred to the filament alternator, the amplifier of the regulator will be revised to correspond to that of the filament alternator. At present the first two stages float below ground. With the revision, all stages will be at ground potential.

(C. R. Wieser)

Filament Alternator Regulator: Tests have continued on the breadboard regulator, which is now working satisfactorily. A glow-tube reference has been built into the breadboard. The reference is regulated in two stages, two VR-150 in series followed by two 5651 reference tubes in series. (The 5651 tubes are supposed to have a stability of ±0.1 volt in 87 volts if operated at constant current.) The regulator power-supply is complete except for front

1.31 Power Supplies (Continued)

panel and has been tested. The over-voltage relay was tested and found to be sticking because of dirt on the stops. This condition has been corrected and the relay pick-up voltage set at 118 volts.

The breadboard regulator and WWI filament alternator will probably be connected to the computer Monday, May 2.

Tests on the regulated alternator do not show any observable change in terminal voltage following a 100-ampere change in load.

Work will be started at once on the layout of a permanent regulator to replace the breadboard.

1.32 Air Conditioning.
(J. C. Proctor)

The refrigeration system has been changed and is now in operation. Final adjustment of the controls will probably have to wait until hot weather, but the present approximate adjustments will give reasonably satisfactory operation.

WWI Drawing List	Block Diagram	Block Schematic	Circuit Schematic
System	B-37071-5		
Control	B-37098-4		
Master Clock	B-37159-2		
101 Pulse Generator	B-37155-3	B-32385	B-32333-4
102 Program Counter	B-37062-4	B-32213-1	D-31516-6
103 Program Register	B-37067-3	B-39289-2	D-33836
104 Control-Switch Matrix Panel	B-37066-3	C-33843	R-32722-3
104 Control-Switch Switch Panel	B-37066-3		Z60CS00-2-D
104 Control-Switch Output Panel	B-37066-3		Z60CS00-B
105 Operation Matrix Driver Panel		S600M00	Z600M00-1-E
105 Control-Pulse Output		R60CP00	S60CP00-1-B
106 Time-Pulse Distributor	B-37068-4	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-31729-2
111 Synchronizer	B-37172	C-33485	R-33486-1
112 Restorer-Pulse Generator	B-37160-1	B-32209-4	D-31909-8
200 Test Storage	B-37156-2		
201 Test-Storage Amplifiers	B-37121-2	C-32855-2 C-33768	D-33706-1
201 Storage-Switch Matrix Panel	B-37121-2	C-32855-2	R-32722-3 D-33706-1
201 Storage-Switch Switch Panel	B-37121-2		Z60CS00-2-D
201 Storage-Switch Output Panel	B-37121-2		Z60CS00-B

WWI Drawing List	Block Diagram	Block Schematic	Circuit Schematic
202 Toggle-Switch Storage Switch Panel	B-37122-3	C-33768	D-33706-1 C-33707
202 Toggle-Switch-Storage Output Panel	B-37122-3		E-32721-4
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-32106-3	
301 A-Register, Digit 0	B-37056-3 B-37072-7	B-31574-1	D-31573-7
301 A-Register, Digits 1-15	B-37056-3	B-31211-3	D-31276-12
302 Accumulator, Digit 0	B-37173-1	D-32851	R-32850-3
302 Accumulator, Digit 0, Aux. Panel	B-37173-1	B-32492-2	D-32602-1
302 Accumulator, Digits 1-14	B-37173-1	D-31213-3	R-31275-10
303 B-Register	B-37097-5	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-37074-7	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 & Overflow	B-37072-7	C-31575-5	E-31632-5
310 Point-Off Control	B-37072-7	C-31600-6	E-31717-6
403 In-Out Register	B-37119-2	E-32434-2	D-31277-6
404 Comparison Register	B-37120-2	B-32578-2	E-32576-6
404 Comparison-Register Check		B-33488-1	E-33515-2
601 Check Register	B-39816-3	B-32577-1	E-32576-6
601 Check-Register Check	B-39816-3	B-32018-1	E-32023-2

WWI Drawing List (continued)	Block Diagram	Block Schematic	Circuit Schematic
Alarm-Indicator Control	B-37175	B-33603	E-33651-1
Standardizer Amplifier		A-33881	C-33880
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-32261-7
Register Driver, Type II		B-32691-2	D-32690-2
Bus Connections	B-37124-3	C-37123-3	
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-B
Fixed-Voltage Switching Panel			T-60PP00-11-B
Power-Interlock & Indication Panel			Z-60PP00-12-B

2.0 WHIRLWIND I RESEARCH

2.1 Circuits

2.11 Flip-Flop Design and Stability

(R. L. Best)

A d-c flip-flop has been built which is d-c coupled to its load. Using two 6AN5's, this circuit develops 18 volts across 680 ohms, and, with proper peaking, will drive a 100 mmf load at 4 mc with less than 5 volts trigger. The rise time, so loaded, is 1/8 microsecond; unloaded, it is about 1/10 microsecond. Minimum set and reset pulse amplitudes are also under 5 volts.

2.2 Components

2.23 Vacuum Tube Studies

(H. B. Frost)

The model 2 tube tester has been received from Sylvania. Some switches have been changed to correct faulty operation, and this tester is now in use.

An engineering note on the current status of tube studies, with emphasis on life test data, has been prepared.

Life test data on five 5687 tubes of lot 3229-13 was so bad that a repeat life test is being run. No tubes of this lot will be issued until the completion of the repeat life test, which will run 500 hours. The first five tubes of this lot life-tested were unusable after 500 hours, while tubes of lot 3228-52 were still usable after operation for the same length of time under the same conditions.

(John Olivieri)

The tube complement for the Comparison Register Check was delivered:

2.23 Vacuum Tube Studies (Continued)

Ninety 7AD7, ninety 7AK7 and forty-five 6SN7's were tested for 100 hours.

The model 2 tube tester has been received from Sylvania. Several additions involving meter switching were made. Some of the adapters need servicing. This tester will be useful in that tubes can be tested more rapidly due to a presetting arrangement of voltages.

Approximately 200 needed cards were completed by additional secretaries. This proved very helpful. Pending retests of burned tubes, 200 more will be done.

2.3 Systems

2.31 Five-Digit Multiplier

(R. W. Read)

The operation of the five-digit multiplier during the past two weeks has been so unreliable that extensive investigation has been necessary to remove causes of intermittent errors. Marginal checking failed to indicate in any way cause for the random type of errors.

The multiplier panels have been subjected to shock and vibration while in operation in order to locate failures. A set of relays controlling d-c on each panel was removed from the circuit because of extreme sensitivity to shock. A fuse holder which was mechanically faulty, causing arcing, was replaced. A coaxial line including two T connectors was removed; the precise location of the failure in it has not been determined because of its intermittent nature. About a dozen adapters (6AG7 to 7AD7) have been removed. Others are suspected, so much trouble has been encountered that a more rugged type is to be installed when assembled. In addition to such failures, four poor solder joints were discovered. Three were unsoldered, and one was a broken solder joint.

2.31 Five-Digit Multiplier (Continued)

An Esterline-Angus Recorder is being used to determine if the failures are peculiar to a certain time of day or night.

4.0 BLOCK DIAGRAMS

(J. M. Salzer)

A decision was reached on the orders which will be included in the present cabling of WWI. An Engineering Note will be prepared to explain additions and changes. All codes, not specifically used for checking, should employ only the accepted orders.

(R. P. Mayer)

The investigation of codes in connection with the AE-ES overlap problem indicates that the maximum saving in time, by using overlap, is likely to be from about 4 to 6 percent. This saving occurs when the ES read time is about 10 microseconds, and is considerably less for other values of read time.

The investigation also indicates that the average time for an operation is practically independent of the code being worked on.

An Engineering Note will give further details.

Norm Taylor has worked out a simplified version of the previously suggested ES-TS Selection block diagram. The saving in equipment seems to outweight the few slight disadvantages to the plan.

5.0 CHECKING METHODS

(G. Cooper)

Investigation of test operation zero which contains program timing only is continuing. Thus far, three different modifications of this operation have been found useful for checking purposes:

1. Operation zero with all storage cleared
2. Operation zero with a one stored in the address section of a register
3. Operation zero with a one stored in one of the middle six digits of a register

These three routines will check a considerable portion of control under the assumption of single faults, but, as yet, I have not discovered everything that will be checked, nor the effect of multiple faults.

As an example of what will be checked, malfunctions of the TPD have been studied. In particular, attention was given to the failure of crystals in the matrix. Out of 24 matrix crystals, if any one of 15 should become open (or have its forward resistance sufficiently increased to cause a malfunction), these routines will indicate it. If any of the 24 should become shorted (or have its back resistance decreased), it will be detected.

In addition, many functions of the various registers (storage switch, control switch, Program Register, Check Register, and Test Storage) and the Program Counter and Step Counter will be checked. The functioning of transfer check is also checked. The arithmetic element is not checked.

It appears as though this particular scheme will be quite useful in that it will indicate many faults.

5.0 CHECKING METHODS (Continued)

(C. W. Adams)

A likely approach to the problem of developing a test sequence which will check the entire computer is that of producing separate subsequences for use with the individual voltage variation lines used in marginal checking. Such subsequences would be intended to check the function of every circuit affected by the particular line being varied. As a necessary preliminary to this undertaking, a survey of the voltage variation circuits is being carried out and a list of all tubes affected by each of the 202 variable lines so far assigned is being prepared.