Project Whirlwind
Servomechanisms Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

SUBJECT: BI-WEEKLY REPORT, PART I, APRIL 16, 1948

To: 6345 Engineers

From: Jay W. Forrester

1.0 WHIRLWIND I COMPUTER ELEMENTS

1.1 Listed by Block Diagram Number

101 Master Clock

The master clock has been changed to include a variable frequency oscillator instead of a crystal-controlled oscillator. A delay line has been inserted in the 2 megacycle channel so that 1 and 2 megacycle time pulses are exactly coincident.

104, 105, 106 Control

(H. Fahnestock)

Drawings have been received from Sylvania (memo 60-4) showing the physical arrangement of the major elements of the main control. These have been approved by M.I.T. (M-354) as a basis for detailed layouts. Completion of construction of the time pulse distributor is desired Sept. 2. The remaining units can be later than the scheduled Oct. 2.

106 Time Pulse Distributor

(H. Fahnestock)

Circuit schematic of the counter panel of the time pulse distributor has been received from Sylvania and a list of corrections returned. After correction, layout will commence. Circuit schematic of the remainder of the TPD has not been received. Both circuit schematics are scheduled for approval May 1.

106 Time Pulse Distributor Control

(H. Kenosian)

The control circuits for the time pulse distributor have been revised. A breadboard including the restorer pulse generator and push-button circuits is being constructed.

106 Time Pulse Distributor Control

(J. A. O'Brien)

A preliminary circuit schematic of the matrix type TPD control has been drawn and is now being drawn up in the drafting room.

The layout for a breadboard has been almost completed and actual construction of a breadboard is well under way.

It is expected that the unit will be ready for test in about a week.

107 Operation Timing Matrix, Control Pulse Output Unit.

(J. A. O'Brien)

A preliminary model of the control pulse output unit has been received from Slavin of Sylvania.

Except for a few changes that have been agreed upon, the unit seems to be quite satisfactory. The unit will use the same style of power plug as the rest of the computer, except that a few of the pins will be removed.

300 Arithmetic Control

(H. Fahnestock)

A decision has been made on the construction of the accumulator zero digit. Sylvania will supply an additional standard digit which will be modified at M.I.T. The overflow of a few tubes will go on another panel in arithmetic control.

(G. C. Sumner)

Panel layout design continues on schedule on the AC-0 Carry and Special Add Memory panel and the Divide Control panel. Final checking and changes are being made on the schematics of the other panels of the arithmetic control in preparation to grading the drawings. Late trends in register-driving methods necessitate some redesign in the Divide Error and Sign Control Panel.

302 Accumulator

(C. W. Watt)

The construction of the prototype accumulator is about one week behind schedule. It is expected to be complete not later than April 23. Provision is being made in the prototype to install the standard power connector when the first sample is received in about three weeks.

302 Accumulator (Cont'd)

(N. H. Taylor)

Test equipment is being set up to make necessary prototype tests on the accumulator panel now under construction. This test equipment will include the variable frequency clock and restorer pulse source which H. Kenosian is now finishing. A new impedance matching panel will also be built to provide termination for outgoing lines from this accumulator. Such termination will simulate WWI conditions. This test set up is being planned in such a way that it will be adequate for subsequent work on the A-register, B-register, program counter, program register, and check register panels.

It is thought that the amount of time allowed for testing of the prototype accumulator is not adequate, and some arrangement should be made to allow rigorous testing on this panel for approximately a three week period. Test specifications for almost all the repetitive elements will depend on the work done on this panel.

305 Step Counter

(N. Daggett)

A block schematic for the step counter is in the drafting room.

The circuit schematic, which has been held up pending preliminary breadboard studies, will be ready for the drafting room about April 22nd.

1.2 System Engineering

1.21 Power Control & Distribution

(C. W. Watt)

Good design progress has been made during the past two weeks on the physical arrangements of racks, fuses, terminal strips, etc.; and revised proposals for the marginal checking circuits, rack and cabinet wiring, and voltage variation panels have been prepared. A new proposal, on system grounding, has been issued, M-362.

(W. S. Rogers)

Power duct system from power room to computer room is being drawn. Resistance measurements are being made on grounds including smoke stack lightning ground.

1.22 Power Cabling

(H. R. Boyd)

Walter Rogers is directing the work of a recently organized installation group. It includes electricians Emerson, Adams, and Lawton who formerly worked with Proctor and Wierzinski, and will include Lynch and Stebbins as well as temporary employees who are being hired.

This group is now working on the ceiling lighting for the computer room, and will soon start installation of the vertical power feeder ducts to the computer room.

(H. S. Lee)

The power cabling has been redesigned in accordance with the decisions made at the conference of 1 April 1948. Wire sizes and requirements have been recalculated to conform to the new design. The sizes and requirements are as follows:

1 1/2" x 1/8" Bus Bar	-	1700 ft.
#10 Wire	-	14,000 ft.
#20 Wire	-	52,000 ft.

These figures include the requirements for:

a. The Ground Grid.
b. All relay leads from computer racks to power racks.
c. All indicator leads for same.
d. Filament transformer primary leads for same.
e. D-C power wiring for the arithmetic elements and flip-flop storage.

It is estimated that additional requirements will not exceed a total of 6,000 feet.

Drawings are being made illustrating the new design. These will be included in a memorandum outlining the design which will be published and submitted for approval not later than 23 April.

1.23 Video Cabling

(C. W. Watt)

A schedule for video cabling was prepared. Drafting time in May will be needed for a cabling diagram. Procurement of cable and connectors should start at once, both here and at Sylvania.

Due to the apparent need for RG-58/U cable (52 ohm) in addition to RG-62/U (93 ohm) an additional type of cable

1.23 Video Cabling (Cont'd)

connector will be required, the UG-88/U. This will be added to the WWI standards.

(H. Fahnestock)

A proposal for production inspection of video cabling has been received from Sylvania (memo 60-2). It will be returned with a few minor suggestions for improvement.

(N. H. Taylor)

In the development of the register drivers it has become necessary to use RG-58/U coaxial cable in certain lines. A separate connector is needed, and some form of coding to avoid confusion with the standard cables. The improved performance obtained by using this lower impedance cable justifies the addition of an additional type of video cable. This RG-58/U, 52 ohm, cable will be used in the run from the register drivers across the aisle to the first digit on the other side of the aisle. At this point RG-62/U will continue the run to the end of the register with a few possible exceptions.

1.24 Driver Panels

(H. Fahnestock)

Layout of bus driver panels has been received from Sylvania, approved, and returned for completion of production drawings for prototype.

(G. C. Sumner)

A survey has been made of the driver requirements of all registers with regard to designing a common register-driver panel. This information has been transmitted to Sylvania. The engineer in charge there will submit a proposal as to physical arrangement of such a panel.

1.25 Time Schedules

(R. A. Osborne)

Below is a revised list of time schedules, showing all changes* and additions[1] to date.

Schedule Title	Number	Person Responsible	Coordinator
Repetitive Elements (Sylvania)			
A-Register (AR 1-15)*	C-31638	N. Taylor	
B-Register	C-31639	"	
Accumulator (AC 1-15)*	C-31640	Watt	N. Taylor

1.25 Time Schedules (Cont'd)

Schedule Title	Number	Person Responsible	Coordinator
Repetitive Elements (Cont'd)			
Flip-Flop Storage Register	C-31641	D. Brown	
Flip-Flop Storage Output	C-31642	"	
Bus Drivers	C-31643	Rowland	N. Taylor
Program Register	C-31644	D. Brown	
Program Counter	C-31645	"	
Check Register	C-31646	"	
Input-Output Register	C-31647	"	
Comparison Register	C-31648	"	
Non-Repetitive Elements (Sylvania)			
Control Switch	C-31649	J. A. O'Brien	D. Brown
Operation Timing Control*	C-31650	"	"
Time Pulse Distributor	C-31652	Flaherty*	"
Time Pulse Distributor Control	C-31653	J. A. O'Brien*	"
Master Clock	C-31655	Kenosian	"
Delay Counter[1]	C-31804	"	"
Push Button Pulse Generator [1]	C-31805	Kenosian	"
Restorer Pulse Generator [1]	C-31806	"	"
Frequency Divider [1]	C-31807	"	"
Flip-Flop Storage Register Driver*	C-31656	Rowland	"
Arithmetic Register Driver *	C-31657	"	N. Taylor
Input-Output Register Driver *	C-31658	"	"
Toggle Switch Storage	C-31662	J.A.O'Brien	D. Brown
Storage Switch	C-31663	"	"
Trouble Location Racks (and TSS Control)	C-31664	Watt	
Operator's Console	C-31665	Watt	Everett
Input-Output Register Control	C-31666	D. Brown	
A-Register End Digit (AR-0) *	C-31667	N. Taylor	
Accumulator End Digit (AC-0) *	C-31668	Sumner	N. Taylor
Others			
Arithmetic Control	C-31654	(Sumner) (Daggett)	N. Taylor
AC-0 Carry & Special Add Memory [1]	C-31659	Sumner	"
Divide Control [1]	C-31660	Daggett	"
Step Counter [1]	C-31689	"	"
Divide Error and Sign Control [1]	C-31661	Sumner	"
Multiply and Shift Control [1]	C-31673	Daggett	"
Point Off Control [1]	C-31686	Sumner	"
Add AC-0 Functions on Panel Control Rack [1]	C-31687	Sumner	"
Storage Tube Construction - Full Size 5"	C-31669	Dodd	Forrester
Storage Tube Research	C-31688	Dodd	Forrester

1.25 Time Schedules (Cont'd)

Schedule Title	Number	Person Responsible	Coordinator
Others (Cont'd)			
Storage Tube Deflection Circuits	C-31683	Ely	Forrester
Storage Tube Output Circuits	C-31670	Campling	Forrester
Summary Power Installation	C-31688	Watt	
Power Distribution Panels	C-31671	Anderson	Watt
Power Supplies (sub-contract)	C-31672	Boyd	"
Power Cabling (inter-cabinet)	C-31674	Watt	
Stepping Relays (marginal checking)	C-31675	Rich	Watt
Video Cabling	C-31676	Watt	
Racks (cabinets)	C-31677	Wainwright	Watt
Film Reader-Recorder (Eastman)*	C-31678	Boyd	Forrester
Air Conditioning of Computer Room	C-31681	Proctor	"
Preparation of Computer Room	C-31682	"	"
Test Equipment	C-31679	Everett	"
Trouble Location Methods	C-31684	Hoberg	Everett
Servo & Simulation Research	C-31680	Wieser	Forrester
Summary Whirlwind I Schedules 1	C-31690	Osborne	"
Summary Whirlwind I Schedules 1 cont.	C-31691	"	"

1.3 Auxiliary Equipment

1.31 Power Supplies

(C. R. Wieser)

The 75 HP synchronous motor delivery has been delayed in order to fabricate a base for connecting the 31 kw alternator for WWI heater power. Delivery of the complete motor-generator set is scheduled for next week. This set will include base, coupling, exciters for both machines, and associated meters and protective devices.

A scheme for automatic cycling and manual control of the marginal-checking supply has been worked out. A memorandum describing this proposal will be issued soon.

Power Distribution Racks

(R. E. Hunt)

Layout work on these racks has been proceeding for the past week. These racks have presented quite a problem as the internal wiring is heavy and they will be accessable from only one side.

Practically all of the major problems have been worked out and the preliminary sketches of these racks should be ready for approval in the next few days.

1.31 Power Supplies (Cont'd)

(R. P. Mayer)

An analysis of intermittent power requirements is nearing completion. No definite information is available yet, but the actual intermittent power required may be many times smaller than earlier estimates have indicated.

Panel Selection - Marginal Checking

(R. E. Hunt)

Some work has been done to locate suitable manual selector switches for the panel selection circuits. These switches will have to be modified to be mechanically interlocking so that selection can only be made at the end of a complete cycle.

The most suitable switches found to date are manufactured by Shallcross Mfg. Co. Detailed prints on these switches will be forthcoming in the next few days.

Layout of the panel selection components will be started within one week.

1.33 Cabinets

Rack Power & Fusing Panels

(R. E. Hunt)

A mockup of a 31½ inch section of this panel has been constructed here in our shop.

This panel has been turned over to Sylvania to be included in their rack mockup. The complete mockup should be ready for inspection at Sylvania in the next few days.

(C. W. Watt)

Design of the racks is progressing well.

1) A mockup of a rack with all the necessary brackets, terminal strips, etc., is almost finished at Sylvania. This will be a most instructive piece of work, for it will bring out many points that cannot be well checked on paper.

2) Racks for the power distribution panels have been in process of design and a good layout has been obtained with only slight modifications to the basic rack.

1.4 Unclassified

(W. S. Rogers)

Approval is being requested of five underwriters for permission to remove Sprinkler System from power room.

Overhead lighting in computer room is being rushed. Completion expected by April 23rd.

Fire Protection

(J. C. Proctor)

An order has been placed with the Rockwood Sprinkler Co. for the alterations on the sprinkler system in the computer room. Actual work should start next week.

Elevating Test Trucks

(R. E. Hunt)

Specifications on these test trucks as outlined in memo M-313 have been submitted to the Lewis-Shepard Co., and the Langley Co.

Proposals on these trucks should be available for approval in about one week.

2.0 WHIRLWIND I RESEARCH

2.1 Circuits

(D. R. Brown)

Circuit research not directly connected with Whirlwind I production is to be carried by a smaller but more closely coordinated group than in the past. I will coordinate the group's activities and provide tie-in with the Whirlwind I system. For the time being, the efforts of the group will be directed to provide more reliable circuits for Whirlwind I. We will attempt to discover where trouble will arise in Whirlwind I and develop remedies for the trouble. Best will continue work on a more reliable flip-flop. Hayes will work on gate circuits, starting with a study of the characteristics of our present gate circuits. J. Hunt will work on clipping circuits, starting with a study of pulse amplitudes in Whirlwind I.

(H. Kenosian)

An experimental binary counter has been constructed in accordance with Whirlwind I layout standards. This two stage counter was built to determine the cause of alternate large and small pulses which occur when one stage of a counter is followed by another stage.

2.11 Flip-Flop Design and Stability

(W. P. Horton)

The a-c flip-flop life test has been conducted for 318 hours to date and is continuing. Two errors, both by the same flip-flop, have been recorded. At 300 hours the rack was shut down and all tubes retested. It is planned that this will again be done at 600 hours.

Investigation of the effect of flip-flop parameter changes has continued. The present stage is concerned with the effect of changes in the grid-leak resistance, Rg. results indicate that switching time is only slightly affected, and that the free-running period is increased with increasing Rg. The amplitude of the plate pulse increases with Rg. to a certain point.

2.11 Flip-Flop Design and Stability (Continued)

(R. L. Best)

The new d-c flip-flop, which has 20 volts bias on the "off" tube, 3 volts bias on the "on" tube, and 250 volt plate and screen supplies, is undergoing tests. Two "bad" 6AG7's were borrowed from J. J. O'Brien, and put into the circuit; these showed 15 volts bias on the "off" tube, and no bias on the "on" tube. This seems to be more than an adequate factor of safety. The large amount of bias on the "off" tube makes the flip-flop more difficult to trigger than the old one; therefore the circuit may be redesigned to decrease this bias slightly.

2.13 Drivers

(C. A. Rowland)

Of the six types of register drivers, four have been determined. Work is progressing on the register driver for restoring eight flip-flops on their cathodes from a common bus. Work on the register driver for supplying restorer pulses to trigger tubes is being postponed for the present; a trigger tube with a higher input impedance is desirable.

2.14 Mixing Circuits

(J. A. O'Brien)

A small packaged mixer for the inputs to the control-pulse-output units has been made up in an aluminum cylinder.

The unit has been tested and it appears to satisfy all concerned in performance and appearance.

2.16 Basic Circuits

(J. M. Hunt)

Tests have been conducted to determine the magnitude of the supply voltage variation which can be tolerated without erratic flip-flop operation, a standard flip-flop circuit being used. Slow variations of the plate or screen supply voltage of plus or minus 10 volts have negligible effect on flip-flop operation although output voltage is affected slightly.

2.16 Basic Circuits (Continued)

(J. M. Hunt)

A plate supply voltage step function having a magnitude of 20 volts and a rise time of 0.2 microseconds was sufficient to trigger the flip-flop. A screen supply voltage step function of approximately fifty volts magnitude was required to trigger the flip-flop. The observed results were difficult to duplicate and were somewhat unpredictable in nature, restorer pulse repetition rate having a pronounced effect on sensitivity to supply voltage variations, with sensitivity to power supply transients apparently being high at low restorer pulse repetition frequency.

Further investigation of the factors affecting flip-flop tolerance to power supply voltage variations is planned.

(R. L. Massard)

It has been found that the output of a gate tube (which has its suppressor a-c coupled to the plate of a flip-flop being fed restorer pulses through the cathode) is materially reduced with an increase in the amplitude of the first restorer pulse. This is due to the fact that the restorer pulse is coupled through to the output of the flip-flop and the a-c coupling circuit clamps so effectively that it tends to clamp the top of the pulse to zero instead of clamping the top of the flip-flop wave. Thus the suppressor of the gate tube is held three or four volts negative with respect to ground when it should be at zero. Due to the high suppressor-plate transconductance the output of the gate tube is decreased.

(R. H. Gould)

Testing of the basic bus driver panel, BA-1, has been nearly completed except for photographing the waveforms. A detailed report will appear as soon as possible. In general the circuit is not at all prf sensitive up to a prf of 500 kc, the expected maximum prf to be applied to circuit, and only slightly prf sensitive at a prf of 1 megacycle. A pulse amplitude of between 10 and 50 volts on the input line gives output pulses between 36 and 38 volts into 47 ohms. An input amplitude between 5 and 10 volts gives an output between 10 and 36 volts.

2.2 Components

(D. R. Brown)

The 7AK7 is now in production. Delivery is promised May 1. We have requested 50 tubes to be shipped as soon as possible without waiting for life tests.

2.23 Vacuum Tube Studies

(J. J. O'Brien)

Engineering Note E-109 describing the effects of 1500 hours of operation of 6AS6 gate tubes in the five digit multiplier has been issued.

2000 hours have been reached in the operation of the d-c flip-flop Life Test Rack. The effects on its tubes have been presented in E-110.

The proposals for the first group of vacuum tube end-of-life tests have been presented in M-361. 99 tubes will be used in conditions simulating WWI.

(M. Hayes)

Additional pulsed tests have been made under normal operating conditions on 6AG7 tubes, indicating that the effective parallel R-C combination present in the 1500 hour bad tubes has a resistance of approximately 40 ohms, and a capacity of 0.007 mfd.

All the data that has been taken to date will be presented in an Engineering Note shortly.

(N. H. Taylor)

Arrangements have been made with the storage tube group to aid in the analysis of specific tube failures as they occur in the five digit multiplier and other equipment running on a life basis.

(Ray L. Ellis)

The new supply of 6AG7 tubes have higher output than the previous stock. The average of the present stock, marked $\frac{H}{5}$ on standard test #1 is:
$I_b = 39.7$ ma$_1$ $I_{c_2} = 9.0$ ma while on the previous stock, marked $\frac{E}{5}$ it was $I_b = 36.0$ ma and $I_{c_2} = 8.6$ ma.

2.23 Vacuum Tube Studies (Continued)

(Ray L. Ellis)

The cumulative histories on tubes are well organized. Periodic tests are now being made as requested and recorded.

The greatest problem here is the lack of space to operate.

2.3 Systems

2.31 Five Digit Multiplier

(N. H. Taylor)

Some recent failures in the 6AS6 gate tube indicates a new kind of trouble with tube reliability. These failures after 2500 hours have been gassy tubes, open filaments, and internal shorts.

(H. L. Ziegler)

The multiplier has been returned to continuous operation for accumulation of life data on the various components.

At the same time, the circuit-improvement program is being continued and considerable progress has been made. Three more Whiffle-Tree switches have been constructed and will be installed as soon as a sufficient number of 7AK7 tubes are available.

Recent additions to the multiplier are the completed add control, and a trouble-location control. The add control provides stable operation on either automatic or step-by-step operation. The trouble-location control, in conjunction with the periodic program control, makes possible repetitive partial solutions of any selected problem. This greatly speeds up the trouble-location operations.

(H. Kenosian)

Installation of the timing pulse sources for the five digit multiplier has been completed. Stability has been achieved by use of a crystal controlled clock pulse generator which receives its power from the rotary equipment.

3.0 SPECIAL CIRCUITS

3.2 Test Equipment

(W. H. Taylor)

The Sylvania test program demands careful regulation of power supplies which run the test equipment. It has been decided to furnish Sylvania with adequate power supplies so that each test position will have its own bank of regulated power supplies. It has also been decided that voltage variation could be easily affected by bucking and boosting these regulated voltages by the use of an ordinary "B" battery and inserted in series with the line in question. The details of the program are being worked out and will soon be issued in memorandum form.

(R. R. Everett

A memorandum A-57 will be issued shortly describing a new system for requesting and obtaining test equipment. The system uses a request form which will be filled out by anyone desiring equipment and submitted to the test equipment committee. The committee will use this form for giving approvals, follow-up, and scheduling.

3.21 Standard (Gate and Delay Units)

(H. Kenosian)

The prototype of the gate and delay unit is under construction. These units will be made on 5-inch standard rack panels with 2 units on each panel.

3.22 Special (Variable Frequency Clock - Restorer Pulse Source)

(H. Kenosian)

This unit is now undergoing test. One of the chief difficulties was that of getting sufficient output from 7AK7 gate tubes.

It is expected that the unit will be completed as soon as the new delay lines are delivered.

4.0 BLOCK DIAGRAMS

(R.P. Mayer)

Eight of the diagrams in the recent R-127 revision have been classified as confidential. They are:

D-57071-4	System block diagram
D-57072-6	Arithmetic element
B-57098-3	Main control
B-57001-3	Parallel digit computer codes
C-57135	Operation Matrix I
C-57136	Operation Matrix II
C-57137	Operation Matrix III
C-57138	Operation Matrix IV

5.0 CHECKING

(G. G. Hoberg)

Preparation of a thesis report on the evaluation of various automatic systems for utilizing trouble location problems is progressing.

(E. Blumenthal)

It has been found that trouble-location problems provide an efficient means of fault-localization for tube failures, when these failures are of more common variety; filaments or cathodes open, or low emission to such an extent that the tube is effectively out of the circuit.

However, there are certain tube failures whose occurrence may, at best, complicate the trouble-location sequence by providing non-unique responses to problems, and, at worst, make the responses utterly unpredictable. Such a failure is a control-grid-to-cathode short in a gate-tube.

Two reasons exist for the ambiguity this failure produces:

1. Whenever the controlling flip-flop switches, a transient output pulse is fed from the gate-tube to a succeeding flip-flop and is of such waveshape that flip-flop triggering cannot be relied upon.

2. Restorer action therefore results in the continual transmission of these transient pulses, causing continual changes in register contents.