Project Whirlwind
Servomechanisms Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

SUBJECT: BI-WEEKLY REPORT, PART I, SEPTEMBER 3, 1948

To: 6345 Engineers

From: Jay W. Forrester

## 1.0 WHIRLWIND I COMPUTER ELEMENTS

### 1.1 Listed by Block Diagram Number

#### 102 Program Counter

(J. A. O'Brien)

Work has started at Sylvania on the production drawings and the prototype of the program counter under the direction of J. Connors. The time schedule calls for delivery of the prototype on September 12th.

#### 104 Control Switch

(J. A. O'Brien)

The block schematic of the control switch, T60CS00-4-C, is being revised by Sylvania so that it can be used as a drawing for both the control and the storage switches. See M-601.

#### 111 Synchronizer

(J. A. O'Brien)

The plan to use relays to perform the switching of pulses in the gas-tube section of the synchronizer has met with trouble in that large transients appear on the output lines when the relays operate. The exact source and mode of transmission of these transients has not been determined, nor has a remedy been found.

#### 112 Restorer Pulse Generator

(J. A. O'Brien)

At the suggestion of G. Summer provision has been made in the drawings of the restorer pulse generator to allow a

112 Restorer Pulse Generator (continued)

single pulse to be applied to all restorer lines and thus, when the computer is on push-button operation, all of the flip-flops in the computer will be complemented. This new input, called computer complement, will enable the operator to quickly check all flip-flops by observing the neon lights on the console as he depresses the push button initiating the computer complement pulse.

205 Flip-Flop Storage

(R. H. Gould)

Tests on the flip-flop storage register have recommenced with the flip-flop storage output panel connected with it and tested at the same time. It has been observed that switching the reset switch of the register on the output panel causes the flip-flop to switch before a reset pulse is fed to the panel. Investigation has not yet revealed whether the fault is in the circuit design or in the construction of the panel.

300 Arithmetic Control

(G. G. Hoberg)

Testing has started on the multiply-shift control panel.

The ACO carry and special add memory panel has been returned to the electronics shop for permanent rewiring of the several modifications. The arithmetic check and special add pulses have been delayed 0.25 μsec to avoid interference with high-speed carry.

305 Step Counter

(J. A. O'Brien)

The layout of the step-counter output panel has been started in the drafting room. It is hoped that this work will be facilitated by use of the Sylvania drawings of the layout control switch output panel.

601 Check Register

(J. A. O'Brien)

The breadboard model of the check register check unit has been tested and found to function satisfactorily. The

601 Check Register (continued)

circuit schematic is ready to be given to the drafting room, but awaits a decision on the proposal to add a gate tube in the end carry line to the clear register driver.

700 Operator's Console

(C. W. Watt)

Studies are continuing on the equipment and facilities needed in the operator's room. For the temporary testing period, enough coaxial cable will be brought into the control room to permit connection of simulated central control to the arithmetic element. This amounts to about 30 RG-62/U control lines, and 16 RG-62/U bus lines. WWI standard test equipment will be interconnected to provide proper pulse sequencing. A design has been made for an indicator panel to house 32 neon indicators, and a prototype will be made next week. It will be part of the standard test equipment series.

(R. E. Hunt)

A temporary operator's console consisting of 8 standard 19 inch relay racks is in the process of being designed.

The temporary console racks will be wired thru power rack P-9 (Panel Selection Rack), and thru an existing doorway behind the power bay.

A special wireway will be designed to carry from the overhead wireway in the power bay to an overhead wireway above the console racks.

Design & construction on this job will probably require two more weeks.

1.2 System Engineering

1.21 Power Control & Distribution

(C. W. Watt)

WWI Installation. All of the 7" base channel in the computer room has been laid. Most of the rack uprights for the racks have been installed. Installation of mounting brackets, terminal strips, and remaining hardware for the 14 power bay racks will proceed during the next two weeks; completion of the other racks and installation of wireways will proceed at the same time.

1.21 Power Control & Distribution (continued)

Power Control. A schematic of the power control system is almost completed in the drafting room. All parts are either ordered or on hand. Design of a panel for the power supply room is proceeding.

(H. S. Lee)

Power Connectors. Memorandum, M-602, subject: "Standard Power Connectors, WWI" has been published and distributed to all engineers, draftsmen and technicians concerned with the design, layout and fabrication of panels for the computer. This memo supersedes Engineering Note E-119 and Memo M-450.

D-C Filter Panel. J. Forrester has approved the location of the d-c filter panel in the racks. Fabrication of seventy-five of these units will begin Tuesday, 7 September.

Rack Filament Power Panel. Of the seventy-five basic panels received from the painters approximately 50% have been rejected and returned to the painters for repainting. The surface texture was rough and not equal to the standard previously established.

(R. E. Hunt)

Power Junction Rack. The status of panels for the power junction rack are as follows:

1. Shut (meter) panel - design and drafting complete.
2. Common tie and ground disconnect panel - design and drafting almost completed.
3. Lab power panel - design complete - drafting 80% complete.
4. Digit master switch panel; WWI test jack panel -will be designed in the near future.

Distribution Busses. Design is about 90% complete - manufacture will commence immediately.

Meter Panel for Console Room. Design is complete- drafting will commence immediately.

1.22 Power Cabling

(H. S. Lee)

Gavitt Manufacturing Co. is presently engaged in fabricating all the preformed power cables designed to date. As of this

1.22 Power Cabling (continued)

date it is believed that deliveries can be scheduled so as to meet the deadline date of 3 October. Gavitt will submit prototype cables to us for approval by 10 September.

Design of the ground grid has been completed and installation should commence when wireway installation is completed.

Drafting on power cabling has been delayed one week by the illness of V. Savio.

1.25 Time Schedules

(R. A. Osborne)

The task of making up revised time schedules has been completed.

Prints of all schedules posted through July 31st have been distributed.

Prints of all schedules posted through August 31st will be distributed early next week.

Following is a list of the Revised Whirlwind I Time Schedules, together with their number, the name of the person responsible for the schedule, and the name of the coordinator.

Revised Schedule List

| Schedule Title | Number | Person Responsible | Cocrdinator |
|---|---|---|---|
| Racks (Cabinets) | C-31671-1 | Wainwright | Watt |
| Overhead Wireways | C-32699 | Wainwright Hunt | Watt |
| Video Cabling | C-31676-1 | Anderson | Watt |
| Cabling Troughs | C-32700 | Anderson | Watt |
| Power Cabling | C-31674-1 | Watt | |
| Panel Selection Rack | C-31675-1 | R. Hunt | Watt |
| Power Panels (Summary) | C-31859-1 | Anderson | Watt |
| Fixed Voltage Switching Panels | C-32645 | Anderson | Watt |
| Fuse Indication Panels | C-31832-1 | Anderson | Watt |
| Digit Interlock Panels | C-31671-1 | Anderson | Watt |
| Voltage Variation Panels | C-31831-1 | Anderson | Watt |
| Power Supplies | C-31672-1 | Boyd-Wieser | Forrester |
| A-Register-Program Register | C-31638-1 | N. Taylor | |
| A-Register ero Digit | C-31667-1 | N. Taylor | |
| B-Register-In-Out Register | C-31639-1 | N. Taylor | |
| Accumulator | C-31640-1 | Connors | N. Taylor |
| Accumulator ero Digit | C-31668-1 | Sumner | N. Taylor |
| Restorer Pulse Generator | C-31806-1 | Kenosian | J. A. O'Brien |
| Register Drivers - Type I | C-31657-1 | Rowland | N. Taylor |
| Bus Drivers | C-31643-1 | Rowland | N. Taylor |
| Arithmetic Control | C-31654-1 | N. Taylor | |
| Divide Control | C-31660-1 | Daggett | N. Taylor |
| AC-O Carry & Special Add Memory | C-31659-1 | Hoberg | N. Taylor |
| Point Off Control | C-31686-1 | Daggett | N. Taylor |
| Divide Error & Sign Control | C-31661-1 | Sumner | N. Taylor |
| Multiply & Shift Control | C-31673-1 | Daggett | N. Taylor |
| AC-O Auxiliary | C-31687-1 | Sumner | N. Taylor |
| Step Counter | C-31689-1 | Daggett | N. Taylor |

1.25 Time Schedules (Cont'd)

| Schedule Title | Number | Person Responsible | Coordinator |
|---|---|---|---|
| Step Counter Output | C-32701 | J.A.O'Brien | |
| Time Pulse Distributor | C-31652-1 | Flaherty | J.A.O'Brien |
| Time Pulse Dist. Counter | C-32696 | Flaherty | J.A.O'Brien |
| Time Pulse Dist. Output | C-32697 | Flaherty | J.A.O'Brien |
| Operation Matrix | C-31809-1 | Anderson | J.A.O'Brien |
| Control Pulse Outputs | C-31810-1 | Anderson | J.A.O'Brien |
| Operation Matrix Drivers | C-31830-1 | Anderson | J.A.O'Brien |
| Control Switch | C-31649-1 | Anderson | J.A.O'Brien |
| Clock Pulse Control | C-31653-1 | J.A.O'Brien | |
| Pulse Generator | C-31655-1 | Kenosian | J.A.O'Brien |
| Frequency Divider | C-31807-1 | Kenosian | J.A.O'Brien |
| Synchronizer | C-31805-1 | Kenosian | J.A.O'Brien |
| Flip-Flop Storage Output | C-31642-1 | J.A.O'Brien | |
| Program Counter | C-31645-1 | J.A.O'Brien | |
| Storage Switch | C-31663-1 | Hayes | J.A.O'Brien |
| Flip-Flop Storage Register | C-31641-1 | J.A.O'Brien | |
| Register Drivers - Type II | C-31656-1 | Rowland | J.A.O'Brien |
| Toggle Switch Storage | C-31662-1 | Hayes | J.A.O'Brien |
| Toggle Switch Storage Output | C-32698 | Hayes | J.A.O'Brien |
| Check Register Check | C-32643 | J.A.O'Brien | |
| Check Register - Comparison Reg | C-31646-1 | J.A.O'Brien | |
| Control Desk | C-31665-1 | | Watt |
| Control Room Equipment | C-31664-1 | | Watt |
| Temporary Control Equipment | C-32646 | | Watt |
| Film Reader - Recorder | C-31678-1 | Boyd | |
| Input-Output Control | C-31666-1 | | Everett |
| Keyboard & Printing Control | C-32647 | | Everett |
| Test Equipment | C-31679-1 | | Everett |
| Trouble Location Methods | C-31684-1 | Sumner | Everett |
| Air Conditioning | C-31681-1 | Proctor | Forrester |
| Preparation of Computer Room | C-31682-1 | Proctor | Forrester |
| Storage Tube Summary | C-32702 | Dodd | |
| Storage Tube Output Circuits | C-31670-1 | Campling | Dodd |
| Storage Tube Deflection Circuits | C-31683-1 | Ely | Dodd |
| Storage Tube Control Circuits | C-32695 | | Dodd |
| Storage Tube - 5 inch Tube | C-32703 | Dodd-Youtz | Dodd |
| Storage Tube - Expand Vacuum Lab. Facilities I | C-32704 | Prohaska | Dodd |
| Storage Tube - Expand Vacuum Lab. Facilities II | C-32705 | Nolan-Youtz | Dodd |
| Storage Tube - Expand Test Lab. Facilities | C-32706 | Klemperer-Dodd | Dodd |
| Storage Tube - Storage Phenomena Research | C-32707 | Dodd | |
| Storage Tube - Stability Research Tubes & Studies | C-32708 | Klemperer-Nolan-Youtz | Dodd |

1.25 Time Schedules (Cont'd)

| Schedule Title | Number | Person Responsible | Coordinator |
|---|---|---|---|
| Storage Tube - Electrostatic Guns | C-32709 | Youtz<br>Klemperer | Dodd |
| Storage Tube - Life & Reliability Tests | C-32751 | Dodd | |
| Storage Tube - Equipment for Pilot Quant. Tube Const. | C-32752 | Youtz | Dodd |
| Storage Tube - Final Design WWI Tubes | C-32753 | Youtz | Dodd |
| Storage Tube - Const. WWI Tubes | C-32754 | Youtz | Dodd |
| Installation - WWI | C-32644 | Watt | |

## 1.3 Auxiliary Equipment

### 1.31 Power Supplies

(C. R. Wieser)

Barta Building Power. A new 2300-volt service from the Cambridge Electric Light Co. has been installed. The 2300-volt power is stepped down to 550 volts by two 100-KVA transformers in the court yard. The 115-volt lighting service near the Mass. Ave. entrance has been cut and removed. Lighting is now supplied from three new 37½-KVA transformers located in the transformer room. The installation of new conduit, wiring, switches, meters, etc.associated with conversion to the new service is complete. The change has resulted in better voltage regulation and simplification of the electrical distribution system in the building.

WWI Filament Power. The bed for the filament supply motor-generator set is being installed. The generator has been delivered. The motor is being rewound and should be delivered by Sept. 9. Conduit installation to supply motor power is almost complete.

WWI Plate Power. The plate supply alternator control-board wiring is complete except for the emergency supply contactor, which is on order. The alternator regulator has been operated satisfactorily. The reactors for the drive motor have been connected. With these reactors in the circuit, the 110-volt, a-c lab supply may be varied from 110 to 125 volts by manual variation of the motor field current. Tests for design of an automatic regulator are under way.

(L. J. Nardone)

Variable Voltage. A curve was obtained to determine the noise level vs. output filter capacitance for the amplidyne of the variable-voltage supply. At an output of 100 volts d-c, 2000 μf are needed to reduce the noise to 0.1 volt rms.

Tests on the variable voltage supply will continue for the closed-loop system. All previous tests were on an open loop system.

(J. J. Cano)

Synchronous Motor Regulator. The frequency response curves and the time constants of the exciter-amplifier with feedback have been secured. The time constant of the synchronous motor will now have to be measured.

1.31 Power Supplies (continued)

(R. E. Hunt)

Power Supply Room. Design of racks and component location in the power supply room is now pretty well up to date.

The power supply racks and wireways have been designed and installed.

Location of the filament M.G. set has finally been fixed and installation started. The side doorway will be moved one foot to accomodate a larger motor starter than anticipated.

The grill work and grill doorways have been laid out, and will be ordered when final dimensions have been received from the manufacturer.

1.32 Air Conditioning

(R. A. Osborne)

Assembly of the air conditioning equipment has not begun due to revisions by Carrier in their drawings.

Final drawings will be submitted for our approval next week.

1.4 Unclassified

(M. Hayes)

Simulation of Control Pulse Outputs. By simulating the pulse generator, clock pulse control, the time pulse distributor, and the clock pulse output unit, the amplitude and width of the pulses appearing on the control line may be determined. The equipment necessary for this is being set up at the present time to ensure that the pulses on these lines are of proper amplitude and width.

| 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 | A-37155-1 | B-32385 | E-32333-3 |
| 102 | Program Counter | B-37062-4 | B-32213-1 | D-31516-4 |
| 103 | Program Register | B-37067-2 | B-39289-1 | D-31276-7 |
| 104 | Control Switch | B-37066-3 | T60CS00-4-C | Z60CS00-A<br>W60CS00-1-A<br>Z60CS00-2 |
| 105 | Operation Matrix | | S60OM00 | Z60OM00-1-B |
| | Control Pulse Output | | R60CP00 | S60CP00-1-B |
| 106 | Time Pulse Distributor | B-37068-3 | T60PD00-8-B | |
| 106 | Time Pulse Distributer Counter | | T60PD00-3-A | Y60PD00-B |
| 106 | Time Pulse Distributer Output | | T60PD00-4-A | Z60PD00-1-A |
| 109 | Clock Pulse Control | B-39817-1 | C-32642 | R-31916 |
| 110 | Frequency Divider | A-37154-1 | B-32264-1 | R-31729-1 |
| 111 | Synchronizer | - - - | - - - | - - - |
| 112 | Restorer Pulse Generator | A-37160 | B-32209-3 | D-31909-6 |
| 200 | Storage | C-37156-1 | B-31150 | |
| 201 | Storage Switch | B-37121-1 | C-31152 | R-32722 |
| 202 | Toggle Switch Storage | B-37122-2 | | E-32711<br>E-32721 |
| 203 | Flip-Flop Storage Output | B-37060-4 | B-32269 | E-31635-3 |
| 203 | Flip-Flop Storage Register | B-37057-3 | B-32268 | E-31621-3 |
| 203 | Flip-Flop Storage Control | A-37061-5 | | |
| 301 | A-Register | B-37056-2 | B-31211-3 | D-31276-7 |

| WWI Drawing List (continued) | Block Diagram | Block Schematic | Circuit Schematic |
|---|---|---|---|
| 301 A-Register Zero Digit | B-37056-2<br>B-37072-7 | B-31574 | D-31573-2 |
| 302 Accumulator | B-37063-5 | D-31213-2 | E-31275-3 |
| 302 ACC Zero Digit | B-37096-5 | | |
| 302 ACC Zero Aux. | B-37096-5 | B-32492-2 | D-32602 |
| 303 B-Register | B-37097-3<br>B-37069-3 | B-31212-3 | D-31277-3 |
| 304 Sign Control &<br>308 Divide Error Control | | C-31576-2 | E-31619-1 |
| 305 Step Counter | B-37074-5 | D-31828-1 | D-39764 |
| 306 Multiply &<br>307 Shift Control | | C-31532-3 | E-31588-2 |
| 308 Divide Control | | C-31552-2 | R-31718-3 |
| 309 Special Add Memory & ACC Carry | | C-31575-2 | E-31632-1 |
| 310 Point Off Control | | C-31600-5 | E-31717-3 |
| 403 In-Out Register | B-37119-2 | B-32434-1 | D-31277-3 |
| 404 Comparison Register | B-37120-2 | B-32578 | E-32576 |
| 601 Check Register | B-39816-2 | B-32577 | E-32576 |
| Bus Driver, Arithmetic Element | | A-32297-1 | D-31727-5 |
| Bus Driver, Flip-Flop Storage | | A-32296-1 | D-31726-5 |
| Register Driver, Type I | | B-32207 | E-32261-2 |
| Register Driver, Type II | | A-32691 | D-32690 |
| Fuse Indication Panel | | | W60PP00-7-C |
| Voltage Variation Panel | | | W60PP00-6 |
| WWI Power Connector Pin Connections | | | C-31955-4 |

## 2.0 WHIRLWIND I RESEARCH

### 2.1 Circuits

#### 2.11 Flip-Flop Design and Stability

(R. L. Best)

A flip-flop has been loaded with two gate tubes on each side, as in the divide control, with one gate tube on each side being pulsed coincidently with the flip-flop's trigger tube. This operates satisfactorily with no added capacitance between control and suppressor grids of the gate tubes, but requires up to 21 volts input to trigger tube when 12 micro-micro-farads are added between each gate tube control and suppressor grid. Some smaller value of capacitance might be tolerated, however.

With the flip-flop loaded with only one gate tube on each side, as in a different part of divide control, 12 micro-micro-farads between control and suppressor grids of the gate tubes do not make prohibitively large trigger tube inputs required, and may therefore be used.

Simulation of other WWI circuits is in progress.

(J. J. O'Brien)

Marginal checking schemes for the basic flip-flop circuit are being investigated.

So far, using separate plate voltage supplies looks feasible.

#### 2.16 Basic Circuits

(A. K. Susskind)

An investigation of the trigger-tube circuit is being conducted. Characteristics such as prf sensitivity, input impedance, gain, effect of supply voltage variations, and pulse shape reproduction will be determined. Particular attention will be paid to methods of increasing the input impedance which appears rather low in the present circuit.

## 2.2 Components

### 2.23 Vacuum-Tube Studies

(J. J. O'Brien)

A check of a few tubes that are on life test under WWI conditions indicated again the poor life characteristic of 6AG7 tubes for these circuit applications. The 7AD7 tubes dropped to about 85 percent of their initial plate current. The length of time of operation was 1450 hours.

All 6AS6 tubes of the Five-Digit-Multiplier were removed and tested. Their hours of operation vary from 1000 to 4000 hours. Many dropped greatly in plate current. An examination of this data indicated a strong tendency for the 6AS6 plate current to drop to a value of about 10 ma. independently of its initial plate current. A report is being prepared.

WWI Specifications for the testing and preburning of 6Y6, 6SN7, 7AD7 and 7AK7 have been prepared under the Standard Specification Nos. S-7.400-2 to S-7.400-5.

## 2.3 Systems

### 2.31 Five-Digit Multiplier

(H. L. Ziegler)

Continuous operation of the Multiplier is being maintained to provide further data on the life of vacuum tubes and of the various components.

A study is being made of circuit alterations necessary to provide for marginal checking of the Multiplier by WWI methods. These circuit alterations will be made as soon as the study has been completed.

(E. S. Rich)

Plans are being drawn up for installing marginal checking controls on the Multiplier prior to the start of life tests. A study has been made of what voltages will be varied and of the amount of work involved in making the wiring changes required and in building the control. A proposal covering this will be prepared the first of next week.

## 3.0 SPECIAL CIRCUITS

### 3.2 Test Equipment

#### 3.21 Standard

(R. L. Massard)

Henry Amplifier. A much better and faster method for lining up the amplifiers has been worked out. It involves using a step-function voltage (a very fast rise-time gate) and observing the transient response of the various stages of the amplifier. The lining-up time for an amplifier has been cut by a factor of 50. The gain vs. frequency method was not worth the time which it consumed.

(H. Kenosian)

Pulse Standardizer. Prototype testing is complete. Production is now under way.

Cathode Follower Probe. Tests on the prototype are nearly complete. Production will begin this week.

## 4.0 BLOCK DIAGRAMS

(R.P. Mayer, J.M. Salzer)

Revision of all block diagrams is contimuing. Block diagrams have been coordinated with existing Block Schematics and a number of corrections made.

## 5.0 CHECKING METHODS

(G. C. Sumner)

In a conversation with J. A. O'Brien a possible means of improving the present CR checking system was devised. As pointed out in M-413 a faulty transfer in the rightmost digit permits the CR to be cleared by the transfer-check pulse. This is undesirable for trouble location because valuable information is wasted. If the proposed modification is not satisfactory, further study should be made to find a system which preserves the contents of the CR after a faulty transfer.

The study of trouble location has now progressed far enough so that a thesis report can be written. Since the last report a method has been devised for locating faults in shifting registers which cause a particular FF to receive simultaneous set and reset pulses.