SUBJECT: BI-WEEKLY REPORT, PART I, APRIL 2, 1948

To: 6345 Engineers
From: Jay W. Forrester

1.0 WHIRLWIND I COMPUTER ELEMENTS

1.1 Listed by Block Diagram Number

100 Control
(H. Fahnestock)

Scheduling the construction of the WVTI control is reported in M-350. It has been decided to build the time pulse distributor and time pulse distributor control before the control switch and operation matrix. TPD and TPDC should be available coincident with the arithmetic element.

104 Control Switch
(J. A. O'Brien)

The preliminary layout and the final details of the circuit of the control switch are being worked out by Slavin at Sylvania. This work is being carried along with the operation timing matrix.

106 Time Pulse Distributor Control
(J. A. O'Brien)

After many revisions the original scheme of time pulse distributor control was found still faulty. For this reason a different type of control was proposed based on the concept of a crystal matrix switch.

The principle difficulty with the old control was the fact that the complementing of flip-flop by restorer pulses kept opening gate tubes at the wrong time, and gates had to be connected in series to prevent this from causing any harm.

Both methods of control are now under consideration by the block diagram group.
107 Operation Timing Matrix

(J. A. O'Brien)

Progress on the final design of the operation matrix is awaiting the details of the required matrix connections from the block diagram group.

At a timing schedule meeting this past week it was decided that the production of the packaged units in the operation matrix should be included with the production of the repetitive units.

The design of these units is quite slow because of the large number of wires that must be brought out thus making it difficult to attain a satisfactory plug; and also some of the units must include a $0.1 \mu$-sec delay line for which space must be provided. This requires more thought, and consideration is being given to removing the rubber tips from the commercial delay lines and thus reducing their size.

203 Flip-Flop Storage

(H. Fahnestock)

Layout of the flip-flop storage output panel has been received from Sylvania. This panel is under the supervision of Tersian.

300 Arithmetic Control

(G. C. Sumner)

Layout work has begun on the special add memory panel and the divide control panel. A time schedule for construction and test of the arithmetic control panels has been completed. A proposal has been made to locate arithmetic control in two racks next to the O-digit and in a rack in the control-bay opposite the 15-digit. Schedules for arithmetic control are discussed in M-527.

301 A-Register

(H. Fahnestock)

Final drawings for the A-register prototype have been approved for construction subject to corrections noted in M-316. This is about two weeks behind the schedule set in January but Sylvania expects to make up the time and get back on schedule. Prototype should be constructed April 24 and tested May 15. Connors is supervising the A-register at Sylvania.
302 Accumulator

(H. Fahnestock)

Accumulator construction started a few days behind schedule for lack of drawings. Completion of construction is scheduled for April 17.

303 B-Register

(H. Fahnestock)

Final drawings for B-register prototype have been received from Sylvania and are being checked. The B-register is under the supervision of Taylor at Sylvania.

1.2 System Engineering

1.21 Power Control and Distribution

(C. W. Watt)

A number of decisions on the power control and distribution proposals that had been submitted previously have been made.

1. Power supply on voltage regulators—H. R. Boyd and C. R. Wieser. Contact was made during the week of March 29th with the Power Equipment Company of Detroit, and several possible types of rectifier power supplies were suggested. It has been decided that Walter Rogers will spend most of his time working with Boyd and Wieser on power problems and power supply installation.

2. Voltage variation panels—Anderson of Sylvania. The preliminary proposal (see Sylvania's memorandum "Preliminary proposal for power distribution panels and fuse loss indication circuits", March 16, 1946) has been acted upon and approved except for minor details. Anderson will revise the preliminary drawings and bring his proposal up to date incorporating these changes. He will proceed at once to start procurement of necessary relays and parts.

3. Stepping relays for marginal checking—E. S. Rich. The preliminary proposal Memorandum M-294 has been approved. Procurement of relays from the M.I.T. Center of Analysis has begun, and the circuit diagrams for this system are being revised. R. E. Hunt will spend most of his time assisting Rich in the layout and design of the installation of these relays.

4. Cabinets, terminal strips, and fuse mounting—Mainwright of Sylvania. Work is proceeding at Sylvania on a rack prototype. Hunt is investigating what complications will arise and what evera
1.21 Power Control and Distribution (Cont'd)

Design will be necessary if the standard racks are used for mounting the voltage variation panels. Cabling and terminal strip arrangements in these racks will be considerably different from those in the racks used for the electronic elements of the computer.

5. Intercabinet power cabling. The cabling proposal Memorandum U-312 was issued and has been acted upon. The method of intercabinet cabling proposed was simplified, and the a-c filament power distribution system was modified to provide a single pair of leads for the a-c from each rack. Investigation has been started on the procurement time for the required wire. It is hoped that orders for the wire may be placed during the coming two weeks.

6. Filament Transformers. A memorandum detailing the bids received from five possible suppliers of filament transformers has been issued by Rogers in Memorandum M-324. It has been decided to place sample orders with four of the five suppliers for these filament transformers. Delivery is expected on these samples in from three to five weeks, at which time one will be selected and a quantity order placed.

During the next two weeks revised proposals incorporating the changes required will be prepared by the people responsible for the various sections of the power distribution problem, and procurement for all of this equipment will proceed.

1.22 Power Cabling

(H. S. Lee)

Memorandum M-312, subject: "Power Cabling Proposal No. 1" was published on 26 March 1948. This memo outlined in detail a proposed power wiring installation for WW2 and included data on wire sizes and quantities required and the electrical hardware necessary for installation of the system. Also the memo outlined, in general, two other alternative installation methods. One of the latter was the most economical of the three in regard wire requirements and voltage drop.

At a conference held 1 April 1948, it was decided to employ the most economical method and utilizing, with revisions, some provisions of the original proposal. A memorandum will be published outlining in detail the revised design of the wiring installation.

Action has been initiated to ascertain the availability and delivery date of the type wire specified in the above memo M-312 for the estimated sizes and quantities required under revised proposal.
1.22 Power Cabling (Cont’d)

These estimated quantities are only those required for interconnecting the power control panels with the arithmetic elements and flip-flop storage registers and including the installation of the ground matrix. The sizes and quantities are:

<table>
<thead>
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<th>AWG NO.</th>
<th>FOOTAGE REQUIRED</th>
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<tr>
<td>#2/0</td>
<td>1000 Ft.</td>
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<tr>
<td>#12</td>
<td>3000</td>
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<tr>
<td>#20</td>
<td>50,000</td>
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</tbody>
</table>

The requirements for the remainder of WWI elements will be computed as soon as more definite information is available as to the marginal checking arrangements to be employed in the control circuits and electrostatic storage circuits.

1.23 Video Cabling

(R. E. Hunt)

An investigation of video cabling connectors was made to determine the feasibility of redesigning the cable connector wedge clamp, as proposed by D. H. Knowlton of Sylvania.

It was found that his proposal was justified insofar as Waltham Horological's clamp was concerned but that an I.P.C. clamp, now in stock here is perfectly satisfactory. The full results of this investigation is now being issued under Memorandum M-334.

During this investigation it was found that a fixture that would trim video cable without damaging the shielding or wire would greatly accelerate assembly. At present this operation requires considerable skill and care.

A video cable trimming fixture was sketched out employing a hot tungsten wire to cut the insulation back to the braid or wire. A hot tungsten wire was rigged up and used to trim video cable. The results were very satisfactory, and this fixture may be developed in the future or proposed to Sylvania.

1.24 Driver Panels

(W. H. Taylor)

The register drivers (previously called gate drivers) are progressing well. Two basic types have been tested and are ready for preliminary design. One is a 6Y6 driver capable of driving 16 gate tubes with high impedance input circuits. The second is 8 of a 829 driving 32 gate tubes with high impedance inputs. There will probably be two more types, one for driving restorer pulses to flip-flop cathodes and another for sending clear and reset pulses.
1.24 Driver Panels (Cont'd)

to grids of flip-flops.

Consideration of the physical layout is now taking place. It is hoped that a standard panel may be realised which would satisfy the demands of all registers. The maintenance problem will be relieved materially if this aim can be realized.

(H. Pahnestock) (Bus Drivers)

Circuit schematics for bus driver panels have been furnished to Sylvania for prototype layout. These will be under the supervision of Flaherty.

1.25 Time Schedules
(N. A. Osborne)

The following Whirlwind I Time Schedules have been added to the list of required schedules:

<table>
<thead>
<tr>
<th>Schedule Title</th>
<th>Person Responsible</th>
<th>Coordinator</th>
</tr>
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<tbody>
<tr>
<td>Special Add Memory</td>
<td>C-31659 Summer</td>
<td>N. Taylor</td>
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<tr>
<td>Divide Control</td>
<td>C-31660 Summer</td>
<td>N. Taylor</td>
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<tr>
<td>Divide Error Control &amp; Sign Control</td>
<td>C-31661 Summer</td>
<td>N. Taylor</td>
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<tr>
<td>Multiply Control &amp; Shift Control</td>
<td>C-31673 Summer</td>
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<td>Point Off Control</td>
<td>C-31686 Summer</td>
<td>N. Taylor</td>
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<tr>
<td>Add AC-O Functions on Panel in Control Rack</td>
<td>C-31687 Summer</td>
<td>N. Taylor</td>
</tr>
</tbody>
</table>

The above are all part of the arithmetic control.

Summary Whirlwind I Schedules cont. C-31691 Osborne Forrester

The program timing matrix schedule, C-31651, has been eliminated due to the consolidation of the operation matrix and the program timing matrix (E-107).

1.31 Power Supplies
(C. R. Wieser)

The 75HP synchronous motor is scheduled for delivery early next week.

A 500 watt amplidyne generator is being tested to determine its suitability as a variable-voltage supply for marginal checking.
1.31 Power Supplies (Cont'd)
(H. R. Boyd)

I visited the Power Equipment Co. in Detroit on March 29, and discussed power supplies. Our procurement schedule is so tight that it is going to be necessary to adapt their existing designs insofar as possible to meet our needs. They have more available manufacturing personnel than engineering, and we will try to avoid extensive engineering on all supplies except the ones having intermittent loads.

(H. S. Lee) (Filament Transformers)

On 1 April 1948 a conference was held to consider the proposal outlined in Memorandum M-324, subject: "Filament Transformers WWI". A decision was made to order a sample, of the type having four primary windings, from each of the following manufacturers:

Freed Transformer Co.
New England Transformer Co.
Raytheon Mfg. Co.
United Transformer Corp.

It was further decided that at this time no consideration would be given the tapped primary type of transformer.

Accordingly, action has been initiated to implement the decisions resulting from the conference.

1.32 Air Conditioning
(J. C. Proctor)

The air conditioning proposal of the Carrier Co. has been accepted by us, and authorization to place the order is being requested from the Navy. Bids are being submitted by two general contractors for construction of a pent-home to shelter this equipment.

1.33 Cabinets
(R. E. Hunt)

An investigation has been made to determine further possible materials for rack door construction.

A material commonly used for railway coach construction called UVU Plymetal has been proposed in Memorandum M-326.
1.33 Cabinets (Cont'd)

This material has a weight/rigidity ratio of about one-third of the ratio for aluminum. A completed door of this material one-half inch thick with three corners fixed would require a force of about 110 lbs. to deflect the third corner 1/4 inch. This door would weigh less than 35 lbs. and have all edges strongly sealed.

1.4 Unclassified

Elevating Truck
(R. E. Hunt)

A proposal for an elevating test truck for WWI has been issued under Memorandum M-513.

Comments on this piece of equipment are in order from all concerned.

Fire Protection
(J. C. Proctor)

The Rockwood Sprinkler Co. has submitted a proposal for altering the sprinkler system in the WWI area to a dry system with remote control valve which would eliminate any possibility of accidental water damage to the equipment. Navy authorization is being requested for placing the order.

Lighting

A lighting layout has been completed and the necessary fixtures purchased. Installation will start in the near future.

Building Alterations

A partition and door into the storage tube area has been installed. The radiator pipes have been removed from the walls.
### WWI Drawing List
(H. Fahnestock)

<table>
<thead>
<tr>
<th>WWI Elements</th>
<th>Block Diagram</th>
<th>Block Schematic</th>
<th>Circuit Schematic</th>
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<tr>
<td>101 Master Clock</td>
<td>B-37058-1</td>
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<td>SD-39545</td>
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<td>102 Program Counter</td>
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<td>D-31516-1</td>
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<td>103 Program Register</td>
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<td>D-31514-1</td>
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<td>104 Control Switch</td>
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<td>105 Operation Matrix</td>
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<td>W60X6AC0</td>
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<td>107 Operation Timing Matrix</td>
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<td>302 Accumulator</td>
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<td>601 Check Register</td>
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<td>D-31515-2</td>
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</tbody>
</table>
2.0 WHIRLWIND I RESEARCH

2.1 Circuits

2.11 Flip-Flop Design and Stability

(R. L. Best)

A new d-c flip-flop has been designed and built, using 250 volts for both plate and screen supplies. It has 3 volts bias on the "on" tube, and 20 volts bias on the "off" tube. It is hoped that this circuit will allow tubes to age farther without causing sticking.

(W. P. Horton)

Life tests on the a-c flip-flop have been started. Ten flip-flop units are being tested, five of which use 6A07 and five use 7AD7 tubes. Each unit has a separate driver tube as well as a separate error counting circuit.

Before life testing started, the use of 115 volt, 400 cps voltage supply to the equipment associated with the rack was investigated. The results indicate that voltage regulators used in the test, as well as the variable frequency clock pulse generator, operate satisfactorily without excessive heating over extended periods of time.

The tests, therefore, are being conducted using a 400 cps, 2 KVA, motor-generator set to supply all but filament and counter relay power to the rack.

2.13 Drivers

(H. Fahnestock)

The following terminology will be used for drivers:

Bus driver: An amplifier which transmits a signal from a register to the main digit bus or the check bus.

Register driver: An amplifier which is used to drive the horizontal control lines connecting all the digits of a register. It may handle either pulses or gates.

Line driver: An amplifier which is used to drive any other line such as from control to a register driver.
2.13 Drivers (cont’d)

(O. A. Rowland) Register Drivers

The 6Y6 gate pulse amplifier shown in basic circuit 00-1 will be satisfactory assuming that the 22 mmf coupling capacitor can be increased to 220 mmf. This coupling has been tried and preliminary tests indicate that it will be okay.

An 629B amplifier is being added to the basic circuits. This will feed two lines with 32 gate tubes each, and will be useful in shift and carry lines where one half of the 629 will drive the B-register and the other half the accumulator.

A 6Y6B amplifier is being added to the basic circuits to supply 0.1 microseconds pulses to 16 gate tubes at a prf of 1 Mc or lower.

Amplifiers for driving 16 trigger tubes and for feeding negative pulse into 16 flip-flop grids will be specified as soon as possible.

Amplifiers for restoring cathode flip-flops will be worked out later.

The packaged buffer amplifier built by Sylvania will provide ample output with a step-up transformer on the other end of the line feeding into a register driver. However, the amplitude must be maintained between 30 and 40 volts into the grid of the driver. Further the step down-step up arrangement seems to be too prf sensitive for 2 Mc pulses.

2.14 Mixing Circuits

(J. A. O’Brien)

With the new operation timing matrix it is required in a few instances that time pulses be mixed into the inputs of the output gate tubes. See Engineering Note E-107.

There are no coaxial connectors of a type that could be used to attach a small box to a panel; so consideration is being given to making the box small and light enough to be supported on the cables.

A small rectangular box has been built with three inputs, and a smaller cylindrical type is being made.
Basic Circuit investigations are proceeding on the flip-flop gate tubes and the bus driver.

Final testing on the indicator circuit is awaiting a decision on the type of indicator circuit to be used.

Two circuits have been submitted by Rowland for use as two types of register drivers.

It has been found that impedance in the suppressor-circuit of a gate tube has a very harmful effect on the output of the tube. When the control grid is pulsed, the suppressor draws current, lowers its voltage due to the IR drop and cuts down the output by a large factor. This accounts for a large part of the effect of output reduction, the other part being due to a voltage divider (capacitive) action between plate, suppressor and ground - feedback thru the suppressor-plate capacitance. A large capacitance from suppressor to ground is needed to cut down this feedback which gives bad rise times.

A bus driver panel, Basic Circuit BA-1, has been constructed in the shop incorporating the special high conductivity crystals. This panel is complete except for the special 5:1 pulse transformer which must be built. Because no single-formex wire is available this transformer will be wound with double-formex wire which will make it only slightly different from the standard transformer described in the specifications. The non-standard transformer will be used until materials are available to construct a standard one to replace it.

One P-1 and one P-3 power supplies have been modified to provide the variable regulated voltage for testing the effect of power supply variations on the operation of the bus driver. Another P-1 will also be modified.

A test circuit has been designed and built up which will put out groups of three to eight pulses obtained either from a variable prf clock pulse generator or from its own pulse-former driver by a variable frequency sine wave oscillator. The envelope of these pulse groups is
2.16 Basic Circuits (cont'd)

(R. H. Gould) Bus Driver (cont'd)

rectangular so the prf sensitivity of the bus driver can be determined by feeding the pulse groups into the bus driver and observing the shape of the envelope of the output pulse groups.

(J. M. Hunt)

Two tentative proposals for modification of basic circuit IND-1 are described in Memorandum M-329 to be released in the near future. The proposed modifications eliminate both the indicator lamp overloading and the occasional operation at excessively low current (with resultant unsatisfactory lamp brightness) which characterize the present indicator circuit (See M-306).

Measurements of performance characteristics of the flip-flop, basic circuit FF-1, are now nearing completion. Data and photographs of cathode ray oscillograph traces of voltage wave forms are being compiled for specifications and for test purposes.

2.2 Components

2.22 Pulse Transformers (G. G. Hoberg)

A sample shipment of 117 C-type hypersil cones of the type to be used in WWI production-model pulse transformers was received from Westinghouse. Quality control during manufacture was apparently not up to par, so a request for improvement was made.

Latest estimates by Sylvania indicate that more than 2000 pulse-transformers will be required for WWI. An additional 1000 cones (total 2500) have been ordered from Westinghouse.

Three large-size pulse transformers designed for Campling's storage-tube readout circuit perform as well as expected. Two of them, with single-layer primary and secondary windings, responded to 350 volt pulses at a 1000 ohms impedance level with little transient distortion and about 10% amplitude decay in 50 microseconds. The other transformer, having two-layer windings, showed no observable amplitude decay, but rise time was appreciably greater and ringing immediately after rise and fall of the pulse was more violent. At additional sacrifice in rise time this ringing can be removed by addition of shunt capacitance.
2.22 **Pulse Transformers (cont'd)**

(C. A. Rowland)

Specifications for two five to one pulse transformers have been written up. S7-193-8 is a 5:1 transformer designed for bus drivers and register drivers; it will feed into about a 50 ohm load and is for 0.1 microseconds pulses. S7-193-10 is a 5:1 transformer designed to feed a 1/2 microsecond pulse into a load of about 50 ohms.

2.23 **Vacuum Tube Studies**

(J. J. O'Brien)

An Engineering Note E-109 has been prepared on the life data of 6AS6 gate tubes of the Five Digit Multiplier. These tubes stood up very well for 1500 hours with about a 9% drop in plate current.

(M. Hayes and J. J. O'Brien)

Extensive d-c measurements on 9 good and 9 bad 6AG7 tubes have been completed. Pulse tests have been made at normal plate currents and the bad tubes indicate an effective parallel resistor, condenser combination within the tube from the peaked output waveform.

This material will be prepared in an Engineering Note.

(Ray L. Ellis)

The multivibrator designed for pulsing tubes has been built and tried. Two test harnesses for it to work into have also been built. The multivibrator is adjusted for a prf of 50 kc and a duty factor of one-tenth. This means that the test harness can be connected directly to the Master Tube Tester, voltages from it applied to the harness with screen and plate current read on the tube tester meters. The testing time is about the same as that for static tests. As soon as standards for pulse tests are given us, we are ready to make them and prepare a reserve of pulse-tested 6L6, 6V6, 6Y6 and 3E29 tubes.

2.31 **Five Digit Multiplier**

(N. Daggett)

The multiplier step counter has been modified to permit resetting to any desired number. Diode gates
2.31 **Five Digit Multiplier (cont'd)**

(N. Daggett) cont'd

have been added which make it possible to count either add pulses or shift and carry pulses. With these features any number of steps in a problem can be performed cyclically (in conjunction with the periodic program control). Faster and easier trouble location should result.

(R. L. Ziegler)

Installation of multiplier cabinets was completed Thursday, April 1.

Due to considerable difference in the design of the new control panel, complete rewiring of toggle switches and neon indicator lights was necessary. This and the wiring of the pilot lights should be completed this week.

When this work has been completed, the circuit-improvement program will be resumed.
3.0 **SPECIAL CIRCUITS**

3.2 **Test Equipment**

3.21 **Standard Test Equipment**

(H. Kenosian)

*Variable Delay Pulse and Gate Generators.*

The breadboard model has been completed and the prototype is being laid out.

3.22 **Special Test Equipment**

(H. Kenosian)

A 50 kc multivibrator has been developed to enable pulse emission tests on tubes.
4.0 **BLOCK DIAGRAMS**

(R. P. Mayer)

The time pulse distributor control is being investigated, and may be drastically revised.

R-127 revision diagrams are completed except for a few that have not yet returned from reduction.
5.0  CHECKING METHODS

(G. Hoberg & H. Blumenthal)

We have finally developed a scheme we consider satisfactory for the location of steady-state failures in the registers of the Arithmetic Element. Surprisingly, few trouble-location problems are required—less than 40 is estimated as the figure for the 5-digit multiplier.

Auxiliary electronic equipment will consist mainly of a checking register and a stepping register, the former providing indication of digit-column location and the latter, of failure type.