

THE WYLE SCIENTIFIC

MAINTENANCE AND SERVICE MANUAL

JUNE 1966

SM-666-100

W. R. Haer

Copy 35

TABLE OF CONTENTS

INTRODUCTION

SPECIFICATIONS

SECTION I: OPERATING INSTRUCTIONS

SECTION II: THEORY OF OPERATION

- 1.0 Block Diagram Analysis
- 1.1 Timing
- 1.2 Memory
- 1.3 Arithmetic Section
- 1.4 Function Storage and Function Control
- 1.5 Display Section
- 2.0 Summaries of Function Routines
- 2.1 Numeral Entry Routine
- 2.2 Alignment Routine
- 2.3 Transfer Routine
- 2.4 Forward Space Routine
- 2.5 Back Space Routine
- 2.6 Clear Multiplier-Quotient Register Routine
- 2.7 Clear Entry Register Routine
- 2.8 Clear Accumulator Register Routine
- 2.9 Shift Left Routine
- 2.10 Shift Right Routine
- 2.11 Addition Routine
- 2.12 Subtraction Routine
- 2.13 Multiplication Routine
- 2.14 Division Routine
- 2.15 Square Root Extraction
- 2.16 Edit Routine

TABLE OF CONTENTS (CONTINUED)

SECTION III: PERFORMANCE PROCEDURE AND
MALFUNCTION SYMPTOMS

SECTION IV: DISASSEMBLY, ALIGNMENT, AND
ADJUSTMENT PROCEDURES

SECTION V: PARTS LIST

SECTION VI: SCHEMATICS AND DRAWINGS

Figure 6-1	V Counter
Figure 6-2	V Count Decoder
Figure 6-3	Sub-Bit Timing
Figure 6-4	Bit Counter
Figure 6-5	Bit Count Decoder (two sheets)
Figure 6-6	Bit Timing
Figure 6-7	Digit Counter
Figure 6-8	Digit Count Decoder (two sheets)
Figure 6-9	Digit Timing
Figure 6-10	K_P Logic
Figure 6-11	C Counter
Figure 6-12	K_{DC} and K'_{DC} Logic
Figure 6-13	Word Counter
Figure 6-14	A Counter, M Counter, AC In, AC' In, and MC In Gates
Figure 6-15	A Counter
Figure 6-16	M Counter
Figure 6-17	R Counter
Figure 6-18	C Counter Input Gates
Figure 6-19	FC Logic
Figure 6-20	Cycle Counter
Figure 6-21	Cycle Count Decoder and Inhibit Logic

TABLE OF CONTENTS (CONCLUDED)

SECTION VI:

SCHEMATICS AND DRAWINGS

Figure 6-22	Δ b ² Generator
Figure 6-23	LO Logic
Figure 6-24	OF Logic
Figure 6-25	Clear Logic
Figure 6-26	Demultiplexer Logic
Figure 6-27	R S _w Logic
Figure 6-28	Shift Left, Recirculate Logic
Figure 6-29	Record New/Processed Data, Shift Right, Erase Logic
Figure 6-30	Function Control Logic
Figure 6-31	"TO" and "FROM" Storage and Control Logic
Figure 6-32	NC Input "TO" Brightener and "FROM" Brightener Logic
Figure 6-33	Character (N) Counter, Storage (Q) Register, and Decoder Logic
Figure 6-34	Optical Coder
Figure 6-35	Card Reader
Figure 6-36	Delay Line Calculator Keyboard

INTRODUCTION

The Wyle Scientific is a digital electronic calculator with a delay line memory capable of operating on six fixed-length registers and performing addition, subtraction, multiplication, division, and square root extraction functions. Operational input is via a 38-key keyboard and output is displayed in a CRT presentation of the contents of all memory registers.

Provision has been made for addition and connection of external peripheral systems including input, programming, and memory devices.

This manual contains operational, programming, and maintenance information for the Wyle Scientific Model WS-02 and is summarized as follows:

Section I: Operating Instructions

Detailed explanation of keyboard functions, data display identification, and associations used in programming.

Section II: Theory of Operation

Complete functional analysis of operations performed by the calculator with reference to block and flow diagrams.

Section III: Performance Procedure and Malfunctions Symptoms

A keyboard test program is provided to functionally check the calculator for correct operation. Malfunction symptoms and possible causes are listed in tabular form.

Section IV: Disassembly, Alignment, and Adjustment Procedures

Step-by-step instructions for removal and/or replacement of special assemblies or components are outlined. Critical alignment procedures of the read and write circuits and of the delay line, and adjustments of the special display circuits are included.

Section V: Parts List

Component types and values are listed for replacement purposes.

Section VI: Schematics and Drawings

Wiring diagrams and schematics of all printed circuit boards with associated flow diagrams are included.

SPECIFICATIONS

Machine Type:	Electronic desk calculator
Memory:	4. 85-millisecond magneto-strictive delay line
Number of Registers:	Three arithmetic and three storage registers. (Up to 24 additional storage registers are available as peripheral equipment.)
Length of Registers:	Twenty-four digits
Decimal Point:	Automatic and presentable by operator
Negative Sign:	Nine's complement
Logic Elements:	Solid state
Functions Available:	Add Subtract Clear and Multiply Multiply Plus Multiply Minus Division Square Root Extraction Shift Left Shift Right Back Space Forward Space Transfer Clear Registers Numeral Entry Decimal Point Alignment
Power Requirements:	105/125 vac, 60 cycles, 170 watts 220/260 vac, 50 cycles, 170 watts* 90/110 vac, 50 cycles, 170 watts*
Peripheral Connector:	Winchester Part MRA104S (104-pin)

*Optional on special order

SPECIFICATIONS (CONCLUDED)

Speed of Operations:	Add	4.8 milliseconds
	Subtract	4.8 milliseconds
	Multiply*	Less than 1 second
	Divide*	Less than 1 second
	Square Root*	Less than 1 second
	Decimal Point Alignment*	Less than 0.2 second
	Shift Left	4.8 milliseconds
	Shift Right	4.8 milliseconds
	Back Space	4.8 milliseconds
	Forward Space	4.8 milliseconds
	Transfer	4.8 milliseconds
	Clear Register	4.8 milliseconds
	Numeral Entry	4.8 milliseconds

Peripheral Equipment
(Optional):

Punched Card Programmer PC-01

Patch Board Programmer PB-02
(maximum of 512 program steps)

Supplemental Memory Register SM-01 or
SM-02 (8 to 24 additional registers for
data storage)

Intercoupler and Auxiliary Keyboard WS/IC

*Multiple-cycle functions which depend upon operand values and decimal point position.



WYLE SCIENTIFIC SYSTEM Model WSS-5

INTRODUCTION

The Model WSS-5 extends the capability of the basic Wyle Scientific Calculator through the addition of supplemental data storage registers. The WSS-5 includes features which allow easy upgrading of the WSS-5 to the more powerful WSS-10. The additional data storage registers simplify programming, increase the speed of program operation, and allow the system to handle more complex problems.

The Model WSS-5 is truly modular, since the customer's existing Calculator and PC-01 Punched Card Programmer can be incorporated directly into the system. Any of the major system components can be directly replaced by another unit of the same type.

SYSTEM DESCRIPTION

A block diagram of the WSS-5 system is shown in Figure 1. The basic element of the system is the Wyle Scientific Calculator, Model WS-02. This unit performs all arithmetic functions and provides the basic memory of the system, with three working registers and three storage registers. Basic manual controls and a CRT display of the registers' contents are also part of the WS-02.

Programming capability is provided by the Model PC-01 Punched Card Programmer. The Model PC-01 provides a means of rapidly programming special applications and of building a large library of programs.

Programs for the Punched Card Programmer are now available which permit signed algebraic multiplication and division. The operation is fully automatic, requiring no decision or interference by the machine operator.

A Supplemental Memory Unit, Model SM-01, provides eight additional data storage registers, each with a capacity of 24 decimal digits. Data may be freely transferred between these registers and the six basic registers of the WS-02. This transfer of information can be controlled by either the Punched Card Programmer or by the operator, via the Model KB-01 Peripheral Input Keyboard.

SD5-566-1M

Two additional Supplemental Memory Units, Model SM-02, can be added, to provide a total of 24 supplemental registers.

The Model KB-01 Peripheral Input Keyboard provides a channel for the flow of data and instructions between the various units, and the Model KB-01 provides additional control keys for manual addressing of the supplemental registers.

The Supplemental Memory is mounted in the pedestal section of the desk console. The WS-02, the PC-01, and the KB-01 are free-standing units which are placed on the desk, as shown in the photograph.

TECHNICAL SPECIFICATIONS

1. CALCULATOR Model WS-02

MEMORY

Six basic registers. Three (MQ, Entry and Accumulator) working registers and three (R1, R2, and R3) data storage registers. Each register has a capacity of 24 decimal digits.

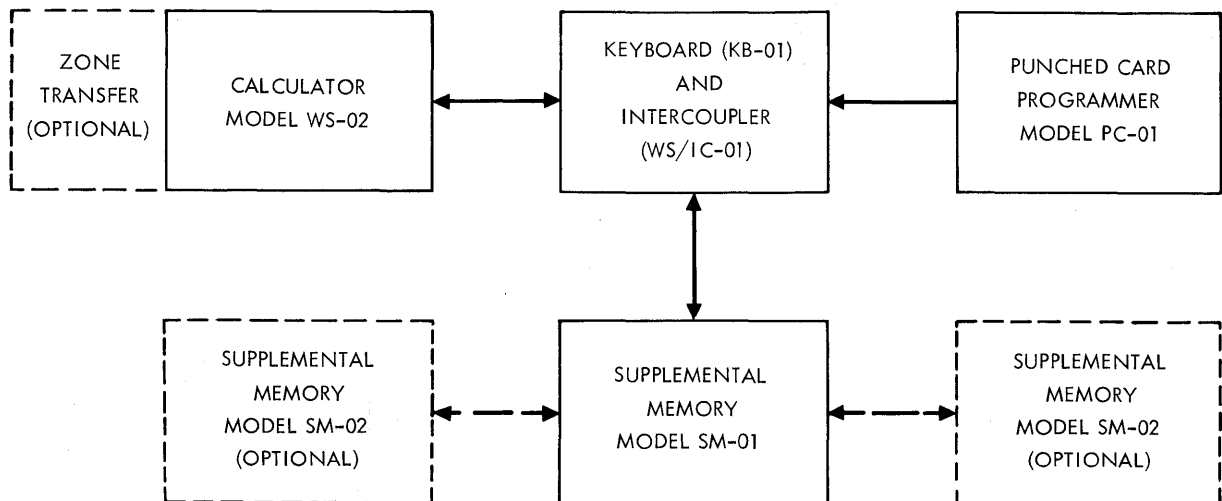


FIGURE 1: MODEL WSS-5 BLOCK DIAGRAM

SD5-566-1M

DECIMAL POINT

Decimal locations selectable from 21 digits, 3 decimal places to 3 digits, 21 decimal places, in increments of 3 digits.

OPERATIONS

In the operations list which follows, register designations are read as if preceded by "Contents of" or "results appear in", as the case may be. For example (ACC) + (Entry) → ACC is read as, "Contents of Entry are added to contents of Accumulator and results appear in Accumulator".

ARITHMETIC OPERATIONS

Add		(ACC) + (Entry)	→	ACC
Sub		(ACC) - (Entry)	→	ACC
Clear & Mult		(MQ) × (Entry)	→	ACC
Mult +	(ACC) +	[(MQ) × (Entry)]	→	ACC
Mult -	(ACC) -	[(MQ) × (Entry)]	→	ACC
Divide		[(ACC) / (Entry)]	→	MQ
√		√(ACC)	→	MQ

REGISTER ADDRESSING

Six instructions allow TO and FROM addressing of each of the six basic registers. The TO addressing designates the register receiving data, whether the source is the keyboard, or the programmers, or another register. The FROM addressing designates the source of data for register transfer operations.

"HOUSEKEEPING"

Shift Right, Shift Left The contents of the register addressed TO are shifted one decimal place in the indicated direction.

Forward Space,
Back Space The position where the next data digit is to be entered is shifted one place right or left. This allows correction of any single digit in a 24-digit word.

Transfer Contents of the register addressed FROM are copied into the register addressed TO.

SD5-566-1M

Clear MQ, Clear
Entry, Clear ACC

The contents of the indicated register are erased and that register is automatically addressed TO.

DATA ENTRY

Eleven instructions (or keys), representing digits 0 - 9 and decimal point, allow entry of numeric data. Numbers are entered in the register addressed TO starting with the most significant digit. When the decimal point instruction is received, the digits previously entered align on the proper decimal point location.

Negative results of computation are represented in 10's complement form. As an example: $-2 = 999\text{---}98$.

MODE SELECT SWITCHES

Three slide switches on the WS-02 keyboard allow manual selection of various operating modes.

1. **ADD ANY REGISTER.** In the OFF position, Entry is added to the ACC when the ADD key is depressed. In the ON position, the contents of the register addressed FROM are added to ACC when ADD key is depressed. Subtraction operates in a similar fashion.
2. **OVERFLOW LOCK OFF.** With overflow lock on, the machine "hangs up" when results of a computation exceed capacity of a register. With lock off, the machine loses the most significant digits but does not hang up.
3. **KEEP REMAINDERS.** Remainders are retained after division and square root operations. See WS-02 Operation Manual for detailed discussion.

KEYBOARD/DISPLAY

The basic keyboard and display are part of the WS-02. The keyboard allows manual control of all operations previously described. The CRT display gives a continuous visual indication of the contents of the six basic registers and, in conjunction with the Peripheral Input Keyboard Model KB-01, an "on demand" display of the contents of supplemental registers.

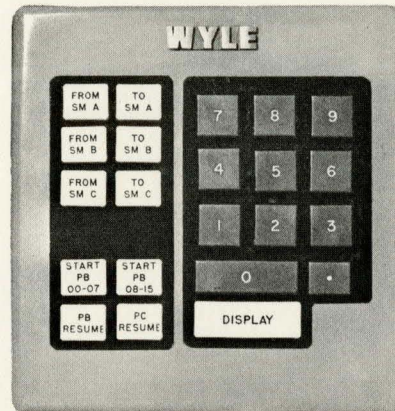
SD5-566-1M

II. PERIPHERAL INPUT KEYBOARD Model KB-01

KEYBOARD

The KB-01 provides an auxiliary manual keyboard used for addressing the supplemental storage registers and for controlling peripherals.

A decimal keyboard is provided for keying in numerics.



SUPPLEMENTAL REGISTER ADDRESSING

Six keys at the upper left of the KB-01 keyboard (one pair for each Supplemental Memory unit) are used, in conjunction with the numeral keys, to address supplemental registers. As an example, TO SM A and numeral 1, addresses TO the first of the 8 registers in the SM-01.

The DISPLAY key provides an "on command" display of the supplemental registers. The register of interest is addressed FROM and the DISPLAY key is depressed. The contents of the addressed register are displayed in the Calculator's R3 register as long as the key is held down. When the key is released, the display of R3 is resumed. The contents of both registers are unchanged.

PROGRAM CONTROL

The STOP instruction of the PC-01 causes the PC-01 to halt, allowing manual data entry of intervention in the program via the keyboard. The PC-01 can then be restarted by the PC RESUME key.

HALT INDICATOR

An indicator on the KB-01 is illuminated by a STOP instruction from the PC-01.

SD5-566-1M

SYSTEM EXPANSION

If the WSS-5 is upgraded to the WSS-10 by the addition of a Patch Board Programmer (Model PB-02), no additional controls are required. The keys which control the PB-02 are provided on the basic KB-01 Peripheral Input Keyboard. Additional memory modules, an optional feature, can also be controlled from the KB-01.

III. PUNCHED CARD PROGRAMMER Model PC-01

PUNCHED CARDS

The Model PC-01 reads a standard size, 40-column punched card. Prescored cards can be prepared with a simple stylus. Unscored cards can be prepared on conventional keypunch equipment.

CARD FORMAT

Cards are read a row at a time. Usually only one column is punched on each row. Thirty-eight of the columns correspond to the 38 manual keys on the WS-02 keyboard. One column is punched in all rows, and this column is used as a "read enable" strobe. The 40th column is a STOP instruction, which causes the programmer to halt until a resume command is received, thus allowing operator intervention in a program. There are 12 rows per card. Any number of cards may be taped together for long programs.

STEP	FROM	TO	NUMBER	OPERATION	EDIT	CLEAR
1				+ C M M +	S S S S	MQ S
2				- L U U	✓ P P H	ENT
3				E L L	A A I I	ACC
4	MQ	MQ		A T T	C C F F	
5	ENT	ENT		R I I	E E T T	
6	ACC	ACC	0 1 2 3 4 5 6 7 8 9	P P		
7	R1	R1		& L L	F B L R	
8	R2	R2		Y	R A E I	
9	R3	R3			W C F G	
10				M	D K T H	
11				U + -		
12				L		
				T		

MULTIPLE INSTRUCTIONS

Some instructions use more than one column punched in a row, as in the following examples. A complete transfer operation is punched in one row:

FROM R1 - TO ACC - TRANSFER

SD5-566-1M

A complete add (or subtract) operation in the ADD ANY REGISTER mode occupies one row:

FROM R2 - ADD

Data may then be simultaneously entered in up to three basic registers, one of which may be a storage register:

TO MQ - TO ENTRY - TO R1

SUPPLEMENTAL REGISTER ADDRESSING

This is a multiple instruction technique. A simultaneous FORWARD SPACE and a numeral (1-8) addresses TO one of the registers in the SM-01's group of 8. BACK SPACE and a numeral (1-8) addresses FROM one register in the group of 8.

SPEED

The PC-01 reads a row at a time and will not read a new instruction until the previous instruction has been executed. Maximum read rate is 8 rows per second.

IV. SUPPLEMENTAL MEMORY Model SM-01

CAPACITY

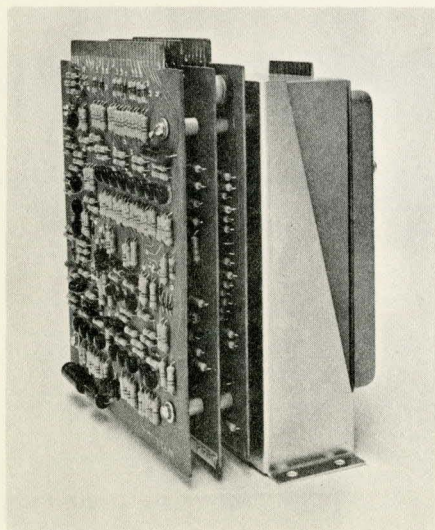
The Model SM-01 provides 8 data storage registers, each with a capacity of 24 decimal digits.

DECIMAL POINT

Identical to basic registers. Set by the same switch.

TRANSFER

Data may be transferred between SM registers and the six basic registers. Data cannot be transferred between SM registers directly, only via the six basic registers. Data cannot be entered directly into SM registers. It must first be entered in one of the six basic registers and transferred to an SM register.



SD5-566-1M

ADD, SUB., OPERATIONS

In the ADD ANY REGISTER mode, the data stored in SM registers can be directly added to or subtracted from ACC. The SM register is addressed FROM and an ADD or SUB instruction executed. The contents of the SM register are unchanged.

ADDRESSING

The 8 registers contained in SM-01 can be addressed from the keyboard of the KB-01 and from the PC-01.

V. OPTIONAL FEATURES

SUPPLEMENTAL MEMORY
Model SM-02

Each SM-02 provides 8 additional data storage registers identical to those in the SM-01. One or two SM-02's can be added for a total of 16 or 24 additional data storage registers.

The SM-02's can be addressed by the KB-01 keyboard but not by the PC-01.

ZONE TRANSFER

Allows selective transfer of the contents of any register. Addressing of registers is as previously explained. However, a numeric command is used with the TRANSFER instruction. Each register is assumed to be composed of 4 zones.

Zone 1: Right hand 6 digits. Digits 0 - 5

Zone 2: Digits 6 - 11

Zone 3: Digits 12 - 17

Zone 4: Left hand 6 digits. Digits 18 - 23

The following simultaneous instructions will transfer the block of data shown.

TRANSFER only	All 24 digits
TRANSFER and numeral 1	Zone 1
TRANSFER and numeral 2	Zone 2
TRANSFER and numeral 3	Zone 3
TRANSFER and numeral 4	Zone 4

SD5-566-1M

Data thus transferred will probably not be properly located with respect to the decimal point. To speed this alignment operation, a special shifting operation is part of the Zone Transfer option.

The operator may program the following multiple instructions.

SHIFT RIGHT and numeral (0-9)
SHIFT LEFT and numeral (0-9)

The instruction shifts the contents of the TO register n decimal places in the indicated direction where n is the numeral which accompanies the SHIFT instruction. This eliminates the need for several successive SHIFT instructions to align data. Numeral 0 causes a shift of 10 decimal places in the indicated direction.

VI. SYSTEM UPGRADING

The Model WSS-5 can easily and quickly be converted to the more powerful Model WSS-10 by the addition of the Patch Board Programmer, Model PB-02, and the associated power supply. The WS/IC-01 Intercoupler is wired to accept the PB-02 and control keys are built into the KB-01 Peripheral Input Keyboard.

The PB-02 can therefore be added to the system as workload requirements increase.

VII. GENERAL SPECIFICATIONS

PACKAGE CONFIGURATION

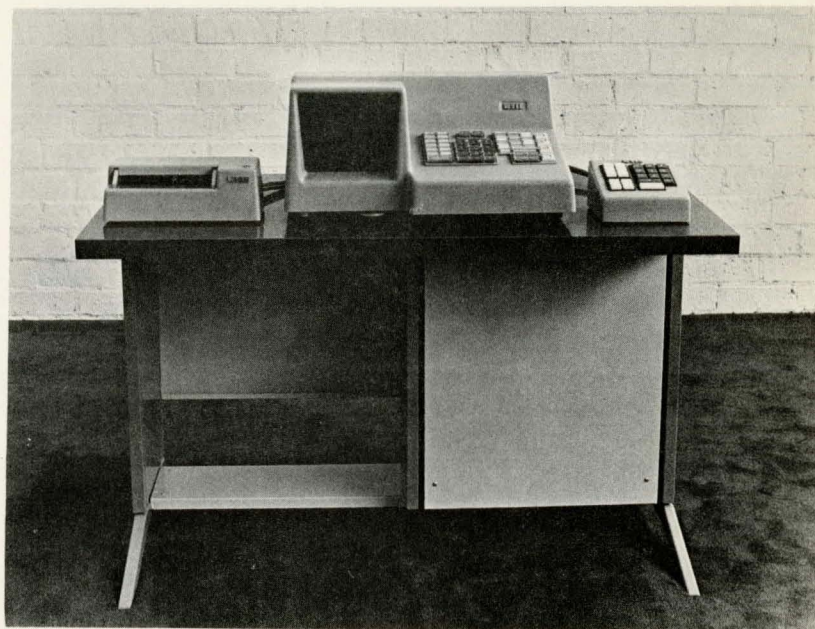
WS-02	Table top, free-standing
PC-01	Table top, free-standing
KB-01	Table top, free-standing
SM-01	Rack-mounted in desk pedestal

POWER 115 ± 10 volts, 60 cps. Approximately 215 watts.

FLOOR SPACE 28 inches wide by 50 inches long. Desk is 30 inches high. WS-02 adds 10-1/4 inches.

NOTE: All options and the PB-02 may be added in the basic desk console. No additional space is required.

SD5-566-1M



WYLE SCIENTIFIC SYSTEM Model WSS-10

INTRODUCTION

The Model WSS-10 extends the capability of the basic Wyle Scientific Calculator through the addition of supplemental data storage registers and of program storage. These features reduce the amount of operator participation in program execution, simplify programming, and increase the speed of program operation. The additional capability allows the WSS-10 to handle a broader range of problems and to deal with more complex applications requiring computer techniques such as branching, looping, conditional transfer, et cetera.

The Model WSS-10 is truly modular, since the customer's existing Calculator and PC-01 Punched Card Programmer can be incorporated directly into the system. Any of the major system components can be directly replaced by another unit of the same type.

SYSTEM DESCRIPTION

A block diagram of the WSS-10 system is shown in Figure 1. The basic element of the system is the Wyle Scientific Calculator, Model WS-02. This unit performs all arithmetic functions and provides the basic memory of the system, with three working registers and three storage registers. Basic manual controls and a CRT display of the registers' contents are also part of the WS-02.

Programming capability is provided by the Model PC-01 Punched Card Programmer and by the Model PB-02 Patch Board Programmer. The Model PC-01 provides a means of rapidly programming special applications and of building a large library of programs. The Model PB-02 provides program storage of up to 512 program steps for rapid access and execution of frequently used programs. The PB-02 also allows the operator to program instructions which control and/or modify the program itself, a feature usually found only in large-scale computers. Programs can be quickly and easily changed by substituting new program modules or by reprogramming of the available modules.

SD10-566-1M

The Patch Board Programmer is entirely modular in construction. Both the program storage and control logic are implemented with plug-in circuit modules.

The Supplemental Memory unit, Model SM-01, provides eight additional data storage registers, each with a capacity of 24 decimal digits. Data may be freely transferred between these registers and the six basic registers of the WS-02. This transfer of information can be controlled by either the Punched Card Programmer, Patch Board Programmer or by the operator via the KB-01 Peripheral Input Keyboard. Two additional Supplemental Memory Units, Model SM-02, can be added, to provide a total of 24 supplemental registers.

The Peripheral Input Keyboard Model KB-01 provides a channel for the flow of data and instructions between the various units and also provides additional control keys for manually addressing the supplemental registers and for manual control of the PB-02.

Plug-in programs are also available which automatically permit the manipulation of negative numbers. Signed algebraic multiplication and division may be carried out without operator intervention or decision.

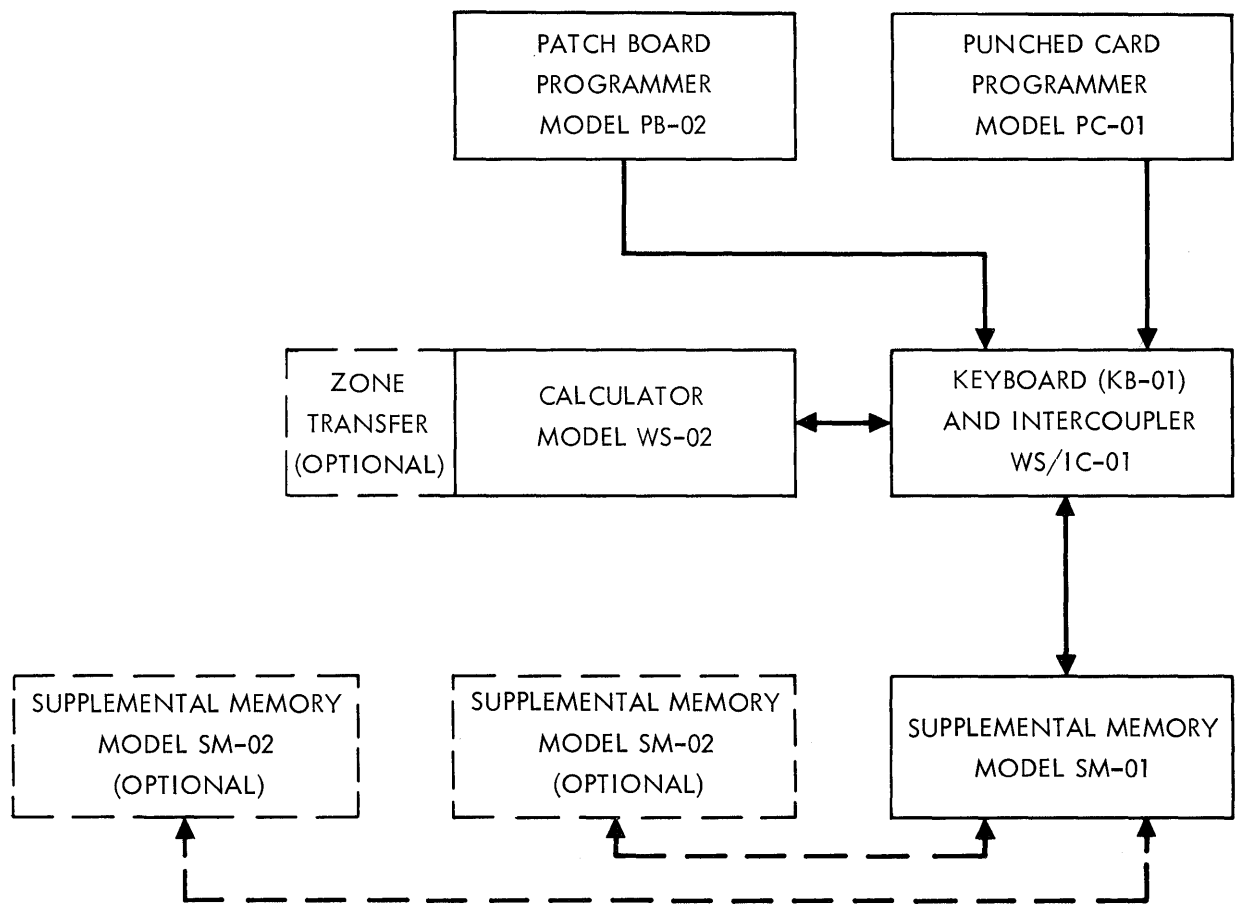


FIGURE 1: MODEL WSS-10 BLOCK DIAGRAM

SD10-566-1M

The Supplemental Memory and the Patch Board Programmer are mounted in the pedestal section of the desk console. The WS-02, the PC-01, and the KB-01 are free-standing units which stand on the desk, as shown in the photograph. The intercoupler portion of the KB-01 is a separate unit located in the desk console.

TECHNICAL SPECIFICATIONS

1. CALCULATOR Model WS-02

MEMORY

Six basic registers. Three (MQ, Entry, and Accumulator) working registers and three (R1, R2, and R3) data storage registers. Each register has a capacity of 24 decimal digits.

DECIMAL POINT

Decimal locations selectable from 21 digits, 3 decimal places to 3 digits, 21 decimal places, in increments of 3 digits.

OPERATIONS

In the operations list which follows, register designations are read as if preceded by "Contents of" or "results appear in", as the case may be. For example (ACC) + (Entry) → ACC is read as, "Contents of Entry are added to contents of Accumulator and results appear in Accumulator".

ARITHMETIC OPERATIONS

Add	(ACC) + (Entry) →	ACC
Sub	(ACC) - (Entry) →	ACC
Clear & Mult	(MQ) × (Entry) →	ACC
Mult +	(ACC) + [(MQ) × (Entry)] →	ACC
Mult -	(ACC) - [(MQ) × (Entry)] →	ACC
Divide	[(ACC) / (Entry)] →	MQ
$\sqrt{\quad}$	$\sqrt{(ACC)}$	→ MQ

REGISTER ADDRESSING

Six instructions allow TO and FROM addressing of each of the six basic registers. The TO addressing designates the register receiving data, whether the source is the keyboard, or the programmers, or another register. The FROM addressing designates the source of data for register transfer operations.

"HOUSEKEEPING"

Shift Right, Shift Left The contents of the register addressed TO are shifted one decimal place in the indicated direction.

SD10-566-1M

Forward Space, Back Space	The position where the next data digit is to be entered is shifted one place right or left. This allows correction of any single digit in a 24-digit word.
Transfer	Contents of the register addressed FROM are copied into the register addressed TO.
Clear MQ, Clear Entry, Clear ACC	The contents of the indicated register are erased and that register is automatically addressed TO.

DATA ENTRY

Eleven instructions (or keys), representing digits 0-9 and decimal point, allow entry of numeric data. Numbers are entered in the register addressed TO, starting with the most significant digit. When the decimal point instruction is received, the digits previously entered align on the proper decimal point location.

Negative results of computation are represented in 10's complement form. As an example: $-2 = 999\text{---}98$.

MODE SELECT SWITCHES

Three slide switches on the WS-02 keyboard allow manual selection of various operating modes.

1. **ADD ANY REGISTER.** In the OFF position, Entry is added to the ACC when the ADD key is depressed. In the ON position, the contents of the register addressed FROM are added to ACC when ADD key is depressed. Subtraction operates in a similar fashion.
2. **OVERFLOW LOCK OFF.** With overflow lock on, the machine "hangs up" when results of a computation exceed the capacity of a register. With lock off, the machine loses the most significant digits but does not hang up.
3. **KEEP REMAINDERS.** Remainders are retained after division and square root operations. See the WS-02 Operation Manual for detailed discussion.

SD10-566-1M

KEYBOARD/DISPLAY

The basic keyboard and display are part of the WS-02. The keyboard allows manual control of all operations previously described. The CRT display gives a continuous visual indication of the contents of the six basic registers and, in conjunction with the Peripheral Input Keyboard, an "on demand" display of the contents of supplemental registers.

II. PERIPHERAL INPUT KEYBOARD Model KB-01

KEYBOARD

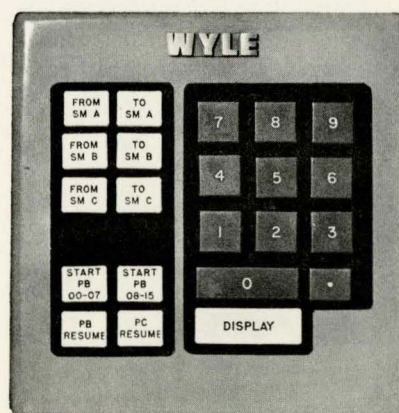
The KB-01 provides an auxiliary manual keyboard for addressing supplemental storage registers and for controlling peripherals.

A decimal keyboard is provided for keying-in numerics.

SUPPLEMENTAL REGISTER ADDRESSING

Six keys at the upper left of the KB-01 keyboard (one pair for each Supplemental Memory unit) are used, in conjunction with the numeral keys at the right, to address supplemental registers. For example, depressing TO SM A and numeral 1 addresses TO the first register of the first set of 8. Depressing FROM SM B and numeral 2 addresses FROM the second register of the second group of 8.

The DISPLAY key provides an "on command" display of the supplemental registers. The register of interest is addressed FROM and the DISPLAY key is depressed. The contents of the addressed register are displayed in the Calculator's R3 register as long as the key is held down. When the key is released, the display of R3 is resumed. The contents of both registers are unchanged.



SD10-566-1M

PROGRAM CONTROL

Two keys allow the operator to manually initiate programs stored in the PB-02. The keys are labelled, "START PB 00-07" and "START PB 08-15." To start program Number Three, the operator depresses START PB 00-07 and numeral 3. To start Program Number 12, the operator depresses START PB 08-15 and numeral 4.

The key labelled PB HALT causes the PB-02 to stop execution and wait for further instructions.

After the PB HALT key or after a programmed MANUAL ENTRY instruction from the PB-02, the PB RESUME key is used to restart the PB-02. If the Punched Card Programmer causes the halt (by a programmed STOP), it is restarted by the PC RESUME key.

HALT INDICATOR

An indicator on the KB-01 is illuminated by a STOP instruction from the PC-01 or by a MANUAL ENTRY instruction from the PB-02.

III. PUNCHED CARD PROGRAMMER Model PC-01

PUNCHED CARDS

The Model PC-01 reads a standard size, 40-column punched card. Prescored cards can be prepared with a simple stylus. Unscored cards can be prepared on conventional keypunch equipment.

CARD FORMAT

Cards are read a row at a time. Usually only one column is punched on each row. Thirty-eight of the columns correspond to the 38 manual keys on the WS-02 keyboard. One column is punched in all rows, and this column is used as a "read enable" strobe. The 40th column is a STOP instruction, which causes the programmer to halt until a resume command is received, thus allowing operator intervention in a program. There are 12 rows per card. Any number of cards may be taped together for long programs.

SD10-566-1M

STEP	FROM	TO	NUMBER	OPERATION	EDIT	CLEAR
1				B + C M M +	S S S S	MO
2				- L U U	✓ P P H H	ENT
3				E L L	A A I I	ACC
4	MO	MO		A T T	C C F F	
5	ENT	ENT		R I I	E E T T	
6	ACC	ACC	0 1 2 3 4	P P		
7	R1	R1		& L	F B L R	
8	R2	R2		Y	R A E	
9	R3	R3		M	W C F G	
10				U + -	D K T H	
11				L	T	
12				T		

MULTIPLE INSTRUCTIONS

Some instructions use more than one column punched in a row, as in the following examples.

A complete transfer operation can be punched in one row:

FROM R1 - TO ACC - TRANSFER

A complete add (or subtract) operation, in the ADD ANY REGISTER mode, can be punched in one row:

FROM R2 - ADD

Three basic registers, one of which may be a storage register, can be addressed in one row:

TO MQ - TO ENTRY - TO R1

SUPPLEMENTAL REGISTER ADDRESSING

This is a multiple instruction technique. A simultaneous FORWARD SPACE and a numeral (1-8) addresses TO one of the registers in the SM-01's group of 8. BACK SPACE and a numeral (1-8) addresses FROM one register in the first group of 8. Only the first 8 registers (SM A) can be addressed from the card.

PATCH BOARD PROGRAMMER CONTROL

Subroutines stored in the PB-02 Patch Board Programmer can be initiated from the PC-01 through the use of a multiple instruction. Only PB-02 Programs 0-7 can be started by the card programmer. A simultaneous STOP and a numeral causes the card programmer to halt and starts the indicated PB-02 program.

SD10-566-1M

SPEED

The PC-01 reads a row at a time and will not read a new instruction until the previous instruction has been executed. Maximum read rate is 8 rows per second.

IV. PATCH BOARD PROGRAMMER Model PB-02

PROGRAM STORAGE

Program steps are stored as patchcord connections on the plug-in patch boards. Up to 16 patch board modules can be used, each of which allows programming of up to 32 steps, a possible total of 512 program steps. Each module has 32 inputs which are energized in sequence by a program counter. Each input can be patched to one or more of 64 possible output lines, representing the 64 instructions in the system repertoire.

Each of 16 program modules can be used as a separate program or several 32-step sequences can be linked to provide longer programs.

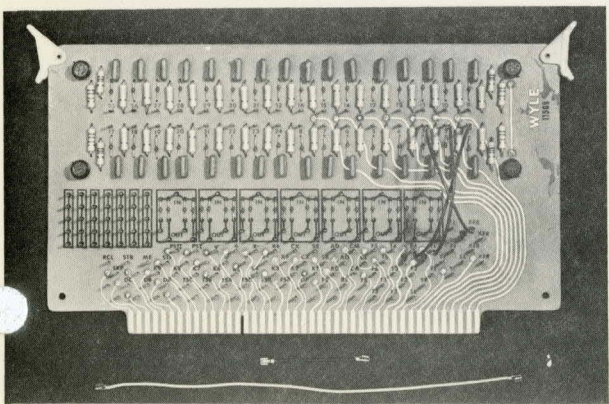
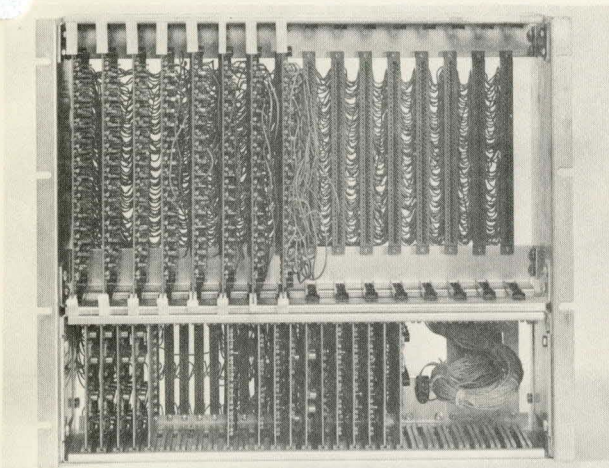
INSTRUCTIONS

WS-02 OPERATION

Thirty-eight instructions directly control the WS-02 Calculator. These instructions correspond to the manual instruction keys on the WS-02 keyboard or to the basic instructions on the punched card.

SUPPLEMENTAL MEMORY ADDRESSING

Six instruction lines are provided to address TO and FROM supplemental registers. Lines TSA, TSB and TSC address TO a block of 8 registers, FSA, FSB and FSC address FROM the blocks. Numeral lines are used to select a specific register. As an example, if input line 3 is connected to both FSB and numeral 6, then step 3 addresses FROM the sixth register of group B.



SD10-566-1M

PROGRAM CONTROL

Six instructions are provided to control the PB-02 itself. These instructions allow programming flexibility comparable to large-scale computers. These instructions are:

SKIP (SKP)

A SKIP on Step n causes the contents of the FROM register to be subtracted from (ACC) and, if the result is negative, the program skips Step $n + 1$, and executes Step $n + 2$. If the results are positive, Step $n + 1$ is executed. Step $n + 1$ can be a branch instruction which starts another program.

STORE (STR)

A STORE instruction is accompanied by a simultaneous TO instruction (TO MQ, TO ENTRY, TO ACC, TO R1, TO R2, or TO R3). A STORE instruction on step n causes the step $n + 1$ to be executed and the number $n + 1$ to be stored in a normally unused portion of the designated register. Step $n + 1$ can be used to branch to a subroutine. Six addresses can be thus stored, one in each of the registers, without affecting the contents of the designated register.

RECALL (RCL)

Accompanied by a FROM instruction (FROM MQ, FROM ENTRY, FROM ACC, FROM R1, FROM R2, or FROM R3). The address ($n + 1$) placed in the designated register by a STORE instruction is transferred to the program counter, and execution resumes at $n + 2$.

As an example, Program P1 has STORE and TO MQ instructions at Step 16. Step 17 transfers to Program P2 and P1-17 is stored. Program 2 has RECALL and FROM MQ instructions at Step 20. P2 is terminated and P1 is resumed at Step 18. This feature allows a master program to address subroutines.

SD10-566-1M

PB-02 START I (PSI), PB-02 START II (PSII)

Allows unconditional branching to another program. A step wired to PS I and numeral 0 - 7 will automatically start execution of the designated program (0 - 7). A step wired to PS II and numeral 0 - 7 will automatically start the designated PB-02 program (8 - 15).

MANUAL ENTRY (ME)

The PB-02 program halts and the indicator on the KB-01 is lit. This allows manual intervention or data entry. An ME instruction on Step n causes the PB-02 to halt on Step n. Depressing the PB RESUME key causes the program to resume at Step n + 1.

STOP (STP)

Indicates the end of a program and causes a halt. If there is no STOP in Program One the PB-02 will proceed automatically to execute Program Two, and so on. This allows continuous programs up to 512 steps long.

SPARES

Twenty spare instruction lines, designated DA, DB, DC and SP 1 - SP 17 are available to control various system functions. In the WSS-10 only SP 1 is assigned a function. Simultaneous STOP and SP 1 will cause the PB-02 to stop and the PC-01 to start. This allows the PC-01 to use PB-02 programs as subroutines and to resume operation when the subroutine is completed.

MULTIPLE INSTRUCTIONS

Diode expanders are provided on the program modules to expand the inputs. Non-diode expanders allow several inputs to be tied to a single output line.

In addition to the multiple instruction functions already mentioned, all those multiple instruction functions which can be performed with punched cards (such as FROM R1 - TO MQ - TRANSFER) can also be programmed on the PB-02.

SD10-566-1M

OPERATING MODES

A MODE SELECT switch located on the back of the KB-01 allows selection of either the RUN mode or the SINGLE STEP mode. In the RUN mode, programs are executed automatically at the maximum rate. In the SINGLE STEP mode, one instruction is executed each time the PB RESUME key on the KB-01 is depressed. This mode is useful in program checkout and in maintenance procedures.

V. SUPPLEMENTAL MEMORY Model SM-01

CAPACITY

The Model SM-01 provides 8 data storage registers, each with a capacity of 24 decimal digits.

DECIMAL POINT

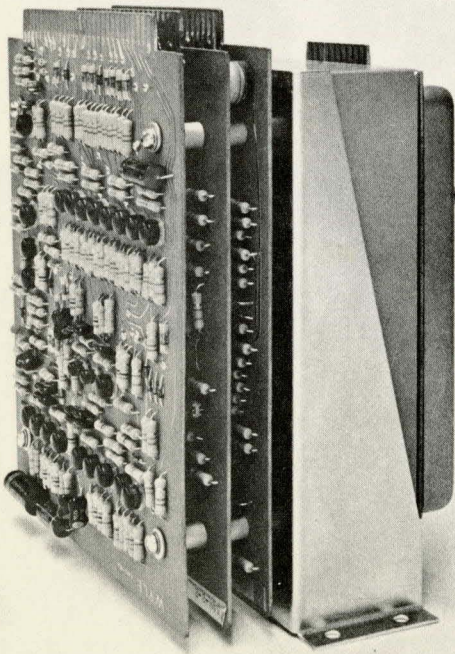
Identical to basic registers. Set by the same switch.

TRANSFER

Data may be transferred between SM registers and the six basic registers. Data cannot be transferred between SM registers directly, only via the six basic registers. Data cannot be entered directly into SM registers. It must first be entered in one of the six basic registers and transferred to an SM register.

ADD, SUB, OPERATIONS

In the ADD ANY REGISTER mode, the data stored in SM registers can be directly added to or subtracted from (ACC). The SM register is addressed FROM and an ADD or SUB instruction executed. The contents of the SM register are unchanged.



SD10-566-1M

ADDRESSING

The 8 registers contained in SM-01 can be addressed from the keyboard of the KB-01, from punched cards via the PC-01, and from the PB-02.

VI. OPTIONAL FEATURES

SUPPLEMENTAL MEMORY Model SM-02

Each SM-02 provides 8 additional data storage registers identical to those in the SM-01. One or two SM-02's can be added for a total of 16 or 24 additional data storage registers.

The SM-02's can be addressed by the PB-02 or by the KB-01 keyboard but not by the PC-01.

ZONE TRANSFER

Allows selective transfer of the contents of any register. Addressing of registers is as previously explained. However, a numeric command is used with the TRANSFER instruction. Each register is assumed to be composed of 4 zones.

Zone 1: Right hand 6 digits. Digits 0 - 5

Zone 2: Digits 6 - 11

Zone 3: Digits 12 - 17

Zone 4: Left hand 6 digits. Digits 18 - 23

The following simultaneous instructions will transfer the block of data shown.

TRANSFER only	All 24 digits
TRANSFER and numeral 1	Zone 1
TRANSFER and numeral 2	Zone 2
TRANSFER and numeral 3	Zone 3
TRANSFER and numeral 4	Zone 4

Data thus transferred will probably not be properly located with respect to the decimal point. To speed this alignment operation a special shifting operation is part of the Zone Transfer option.

SD10-566-1M

The operator may program the following multiple instructions:

SHIFT RIGHT and numeral (0 - 9)
SHIFT LEFT and numeral (0 - 9)

The instruction shifts the contents of the TO register n decimal places in the indicated direction where n is the numeral which accompanies the SHIFT instruction. This eliminates the need for several successive SHIFT instructions to align data. Numeral 0 causes a shift of 10 decimal places in the indicated direction.

VI. GENERAL SPECIFICATIONS

PACKAGE CONFIGURATION

WS-02	Table top, free-standing
PC-01	Table top, free-standing
KB-01	Table top, free-standing
SM-01	Rack-mounted in desk pedestal
PB-02	Rack-mounted in desk pedestal

OPTIONS

The options require no additional physical space. Space is available in the desk to accommodate both packages.

POWER

115 ± 10 volts, 60 cps. Approximately 215 watts.

FLOOR SPACE

28 inches wide by 50 inches long. Desk is 30 inches high. WS-02 adds 10-1/4 inches.

SD10-566-1M