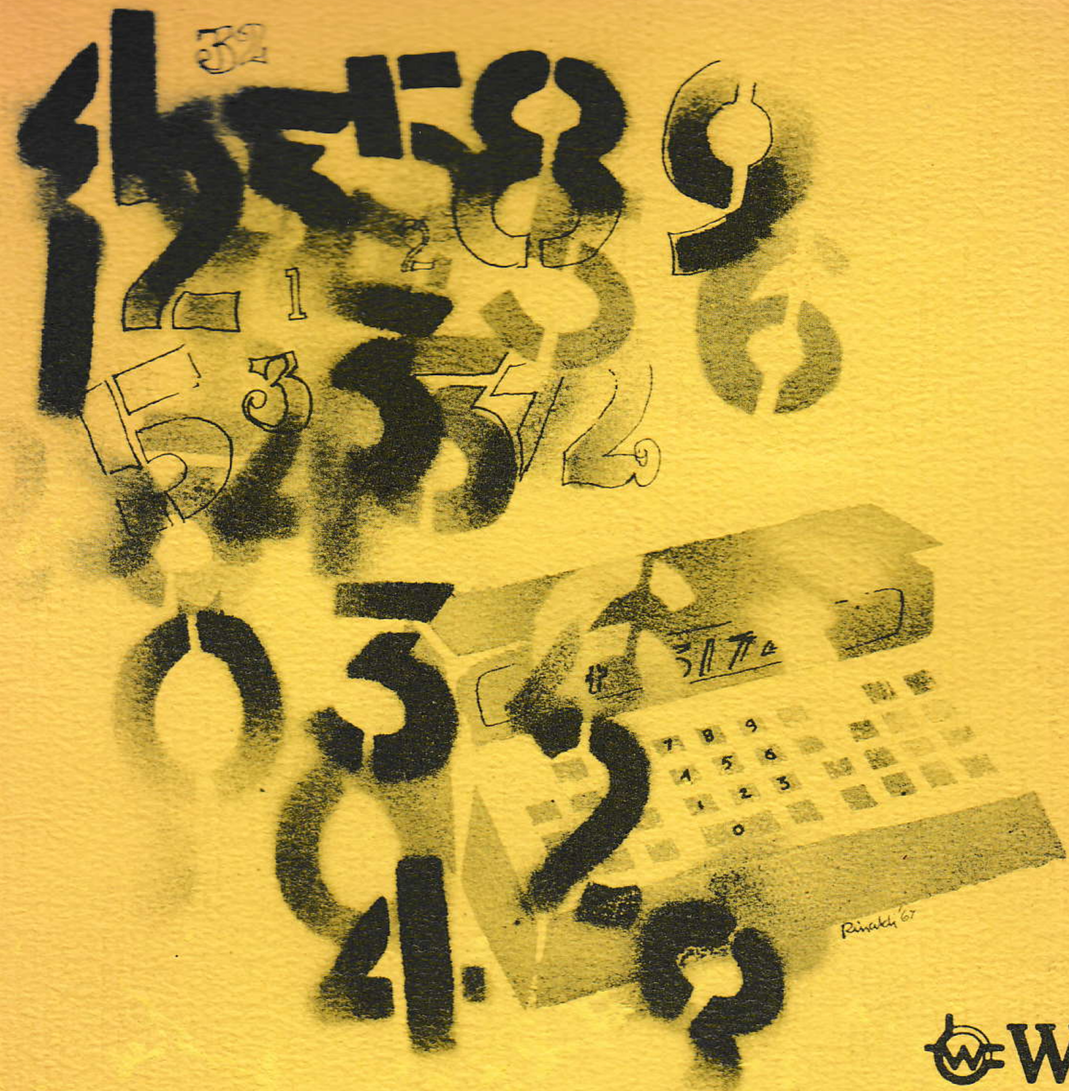

WANG
LABORATORIES, INC.

300 series electronic calculator

instruction manual

volume 1

300 series electronic calculator instruction manual

WANG
LABORATORIES, INC.

FOREWORD

Thank you for purchasing your new calculator from Wang Laboratories. We are confident you will be fully satisfied with your new equipment and ask that you take a few minutes to peruse this manual for some of the operational shortcuts and recommended installation methods. Many extra benefits can be obtained from your Wang calculator by learning its capabilities.

In addition to the basic equipment and accessories described in this manual, Wang Laboratories offers a wide range of supplementary equipment that can be added to your initial system. These include auxiliary data storage units, input and output peripheral devices such as typewriters and teletypewriters, CRT display units, universal interfaces for on-line applications, etc. Please call or write for our complete product catalog that contains specifications and prices.

Publications Department

ACKNOWLEDGEMENT

We wish to acknowledge that the cover design of this manual is the courtesy of a friend of Wang Laboratories, Mr. G.W. Rinaldi, who has submitted other designs for the Wang Laboratories Programmer.

Publications Department

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SECTION 1

INTRODUCTION

1.1 GENERAL

The Wang 300 Series of solid-state electronic calculators comprises several models, each tailored to perform a specific range of arithmetic operations. Table 1-1 lists in general terms the applications normally supported by the various models. Each model is discussed in detail throughout this manual to give the user a full working knowledge of his particular equipment. It is suggested that a new user read and become familiar with the contents of this manual before attempting installation and operation. Operating techniques are very simple and can be readily learned in a few minutes. Model numbers, if not known, can be found on the identification tags, located on the bottom of each unit.

Each calculator is comprised of two major units; the keyboard, and the electronic package. The "K" suffix to a keyboard model number signifies a conventional keyboard, a "KT" suffix signifies a trigonometric keyboard, and a "KR" suffix signifies a trigonometric keyboard with radian input. The electronic package portion of the calculator bears an "E" suffix for non-simultaneous operation and an "SE" suffix for simultaneous operation. Section 2 of this manual explains the many installation arrangements possible with Wang calculators.

Two accessories, a card programmer (CP-1) and an item counter (IC-1) are available for use on any model in the 300 Series. The card programmer is an especially helpful addition for users that perform repetitive operations. It is connected in series between the keyboard and the electronic package and uses standard 80-step data cards that can be readily punched by the user for his particular programs. The item counter proves its value for users that require item counts, operational step monitoring, and function monitoring. It is connected to the keyboard, and like the card programmer can be placed on the user's desk for convenience. Detailed descriptions and operating instructions for each are included, where applicable, throughout this manual.

Table 1-1
300 Series Models and Applications

Model	Range of Applications
300	Business to simple engineering calculations.
310	Statistical and business calculations.
320	Scientific, engineering, statistical, and business calculations.
320KT	Same as Model 320 with trigonometric capabilities for sine, cosine, arc sine, and arc tangent (input in degrees).
320KR	Same as Model 320KT except input in radians.
360	Same as Model 320 with four additional random-access storage registers.
360KT	Same as Model 360 with trigonometric capabilities for sine, cosine, arc sine, and arc tangent (input in degrees).
360KR	Same as Model 360KT except input in radians.
362	Same as Model 320 with twelve additional random-access storage registers or twenty-four half-registers.
362KT	Same as Model 362 with trigonometric capabilities for sine, cosine, arc sine, and arc tangent (input in degrees).
362KR	Same as Model 362KT except input in radians.

1.2 MODEL 300 ELECTRONIC CALCULATOR

The Model 300 Calculator is the basic model in the 300 Series. Operational capabilities include addition, subtraction, multiplication, chain multiplications, divisions, reciprocals, percentages, automatic extensions, weighted averages, etc. Two independent adders, one on each side of the keyboard, provide storage and recall capability. Accumulating switches are provided for automatic accumulation of entries and / or multipliers in the right adder, and product or extension accumulations in the left adder.

All operations, as well as number and decimal input, are initiated by the keys on the keyboard. Display is provided by ⅝ in. high glare-free indicator tubes that display the readout in conventional form (algebraic sign and numerical value with properly positioned decimal point).

A "clear display" key enables the user to clear the display without destructing the contents of the accumulators, etc. A "clear all" key is provided to clear the accumulators and

Figure 1-1. Model 300K Keyboard.

display when desired. A "change sign" key, when depressed, reverses the sign of the number in the display.

Both simultaneous and non-simultaneous operations are available with this model. The installation section of this manual depicts the many methods of installation and operation. All accessory equipment can be utilized with the Model 300.

1.3 MODEL 310 ELECTRONIC CALCULATOR

The Model 310 provides all the features and functions of the Model 300 plus two additional operational keys for the functions of X and X^2. Both operations are performed instantaneously and furnish direct 10-digit readout in the display window. The accumulation switches, in addition to their normal functions, provide ΣX, ΣX^2, ΣY, ΣY^2, $\Sigma(X+Y)$, $\Sigma(X \cdot Y)$, $\Sigma\sqrt{X}$, and $\Sigma\frac{1}{X}$. The accumulated totals are recallable to the display at any time. Both simultaneous and non-simultaneous operations are available with the Model 310, as well as accessory equipment.

Figure 1-2. Model 310K Keyboard.

1.4 MODEL 320 ELECTRONIC CALCULATOR

The Model 320 provides all the features and functions of the Model 310 plus two additional operational keys for the functions of $\log_e x$ and e^x. Both operations are performed instantaneously and furnish direct 10-digit readout in the display window; the accuracy for $\log_e x$ functions is 12 digits, the e^x accuracy is 11 digits. The addition of the log functions allow the user to generate logs and exponents to any base, simplifying calculations in many areas of applications. Chain multiplication and division, using cumbersome numerical values, can be readily manipulated by using the log and antilog approach. Techniques for using the log keys are discussed in the operation section of this manual and can be readily learned in minutes. Both simultaneous and non-simultaneous operations are available with the Model 320, as well as accessory equipment. Trigonometric keyboards for single keystroke generation of sine, cosine, arc sine, and arc tangent in degrees or radians are also available in this model.

Figure 1-3. Model 320K Keyboard

1.5 MODEL 360 ELECTRONIC CALCULATOR

The Model 360 provides all the features and functions of the Model 320 plus four storage registers with capacity for 14-digit numbers and algebraic signs. Eight additional keys have been added to the keyboard to furnish random-

Figure 1-4. Model 360K Keyboard

access recall and store operations. The "clear all" function does not affect the registers and numbers previously put into any storage register will remain until a new number is stored. The ability to store constants, intermediate answers, or multiple results allows the user to perform many calculations without re-entering the data. The Model 360 is available with trigonometric keyboards for degree or radian inputs. Simultaneous electronic packages are available with this model.

1.6 MODEL 362 ELECTRONIC CALCULATOR

The Model 362 provides all the features and functions of the Model 320 and has a keyboard arrangement similar to the Model 360. The four extra registers of the latter are replaced by 12 registers, each with a 14-digit capacity (plus sign and decimal storage). Each register may be used as a storage register or as an accumulator. When used as storage, any register may be "split" into two "halves", each with independent store and recall capabilities. Capacity of the "half registers" is six digits, sign, and full 10-place decimal location. Two keystrokes are required to command the registers (i.e., store full and 9). The number keys 0-9, clear display key, and change sign key are used to differentiate between the registers. The execution of the register operation keys prior to depressing the address key prevents the normal key functions.

Figure 1-5. Model 362K Keyboard

The Model 362 is available with trigonometric keyboards for degree or radian inputs. Simultaneous electronic packages are not available with this model.

1.7 TRIGONOMETRIC KEYBOARDS

Six trigonometric keyboards are available in the 300 Series (320KT or 320KR, 360KT or 360KR, and 362KT or 362KR). Two configurations are available depending on user's requirements; the KT models accept angular input in degrees, the KR models accept angular input in radians. The keyboards are identical to the non-trigonometric keyboards with the exception of four additional keys (SIN, COS, SIN^{-1}, TAN^{-1}). All trigonometric keyboards operate with their associated standard electronic packages.

Results are readily obtained by entering the angle, sine, or tangent and depressing the appropriate key. The answer in degrees and fractions is read in the display eliminating the need for table references and error-prone tedious

Table 1-2 Trigonometric Function Accuracies

[illegible]	RANGE OF INPUT VARIABLES		PRECISION OF OUTPUT
	DEGREES	RADIANS	
[illegible]	$0° \leq \lvert X \rvert \leq 67.5°$	$0 \leq \lvert X \rvert \leq 1.178$	Error $\leq 10^{-9}$
	$67.5° \leq \lvert X \rvert \leq 90°$	$1.178 \leq \lvert X \rvert \leq 1.571$	Error $\leq 10^{-8}$
[illegible]	$0° \leq X \leq 22.5°$	$0 \leq X \leq .393$	Error $\leq 10^{-8}$
	$22.5° \leq X \leq 157.5°$	$.393 \leq X \leq 2.749$	Error $\leq 10^{-9}$
	$157.5° \leq X \leq 180°$	$2.749 \leq X \leq 3.1415$	Error $\leq 10^{-8}$

[illegible]	RANGE OF INPUT	PRECISION OF OUTPUT	
		DEGREES	RADIANS
[illegible]	$.013 \leq X \leq 1$	Error $\leq 5 \times 10^{-7}$ Deg.	Error $\leq 10^{-8}$ Rad.
[illegible]	$.106 \leq X \leq 7.596$	Error $\leq 10^{-6}$ Deg.	Error $\leq 10^{-8}$ Rad.
	$0 \leq X \leq .106$	Error $\leq 5 \times 10^{-6}$ Deg.	Error $\leq 10^{-7}$ Rad.
	$7.596 \leq X \leq 10^9$	Error $\leq 5 \times 10^{-6}$ Deg.	Error $\leq 10^{-7}$ Rad.

Figure 1-6. Model 360KT Keyboard

interpolation. Table 1-2 lists the range of input variables and accuracies.

Trigonometric functions utilize both accumulators, as well as the log registers; therefore, these registers should not be used before trigonometric calculations. If extra storage is necessary for other operations, a Model 360 or 362 Calculator with additional storage registers (not affected by trigonometric calculations) should be chosen.

1.8 MODEL CP-1 CARD PROGRAMMER

The Model CP-1 Card Programmer is a compact, general-purpose plug-in accessory which enables automatic calculator operations when used with any 300 Series Keyboard. It reads 80-step 2-digit octal program codes, corresponding to keyboard operations, from punched tab cards.

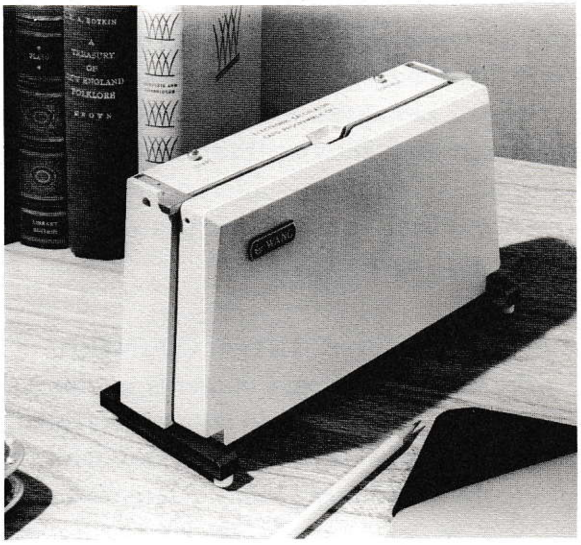


Figure 1-7. Model CP-1 Card Programmer

A Card Programmer is series-connected between the electronic package and the keyboard by use of the attached 12-foot cable and side-panel connector. One CP-1 may be used with each terminal of the electronic package (up to four for a simultaneous electronic package). The CP-1 may be used in conjunction with a trigonometric keyboard on the same electronic package terminal, but cannot initiate trig programs under card program control. Extension cables up to 50 feet in length may be used to interconnect the CP-1 with an electronic package.

The CP-1 is enclosed in a cast housing with START and CONTINUE push button controls at the top. Bifurcated contacts and a high mechanical advantage lever closure mechanism provide reliable reading of static tab cards. Built-in electronic circuits are solid-state, and of plug-in construction. An auto/manual switch on the side of the programmer enables the user to examine and verify each program step when initiating a new program.

Programs are recorded using pre-scored tab cards, prepared using a port-a-punch and stylus. The sequence of manual keystrokes required to execute the problem are determined and recorded. The corresponding program code bits are sequentially punched out on the pre-scored tab cards. A "stop" code provides the means for entering the variables into a program.

An excellent library of programs is furnished free with each CP-1.

1.9 THE MODEL IC-1 ITEM COUNTER

The Model IC-1 Item Counter is an optional accessory that can be used with any keyboard in the 300 Series. It provides the user with the means for obtaining a ready reference to the number of addition, subtraction, multiplication, division, square root, and square operations, or any combination of these operations in any calculation. The capacity of the counter is 10,000 less 1 (9,999).

Operation is controlled by a series of selector switches. When a function count is desired, the appropriate switch is placed to the up position. A reset control is provided for resetting the counter to zero between calculations.

The counter has an attached 18-inch cable that connects to any 300 Series Keyboard that has been modified with an IC-1 mating connector. Connectors are factory installed on keyboards shipped with item counters, other keyboards can be returned to the factory for retrofitting.

Figure 1-8. Model IC-1 Item Counter

1.10 MISCELLANEOUS ITEMS

T Connector. – A T Connector is a small device used to connect two keyboards in parallel to one terminal of an electronic package. T Connectors may be arranged to allow the operation of four keyboards from one non-simultaneous electronic package or up to sixteen from one simultaneous electronic package. When the latter setup is used, one keyboard of each group of four may be operated at any one time.

PT Connector. – A PT Connector is similar to a T Connector except one input side has priority over the other side.

MX Multiplexer. – The MX Multiplexer is a [illegible] that contains solid-state logic and [illegible] switching relays for automatic interconnection of any combination of sixteen keyboards to a single simultaneous electronic package. Any four of the sixteen keyboards can be simultaneously used.

MX Connector. – The MX Connector is a T connector used with the MX Multiplexer to enable up to sixteen additional keyboards to be connected to the multiplexer for occasional use.

Filters and Transformers. – A line filter is offered to reduce interference from devices which impress electrical noise on the AC power line. Examples are some mechanical calculators and X-ray machines. Two sizes of isolation transformers are also offered for the same purpose. A voltage control transformer is offered for excellent voltage regulation of varying or consistently low-voltage power lines and moderate line noise suppression. Before ordering these devices, it is suggested that the user contact the nearest Wang office for an on-the-job trial, rarely are they needed.

Carrying Cases. – A ruggedized "suitcase" is offered for transporting non-simultaneous electronic packages, and an attache case is available for carrying one or two keyboards and a card programmer.

Cables and Connectors. – Cable may be ordered in bulk, with separate connectors, as required. 30-conductor AWG No. 26 wire, in a 0.003 in. O.C., 80°C PVC Jacket is furnished. Male connectors are offered for connection to the electronic packages and female connectors for the keyboards. Connector assembly dwg. no. 5315 gives soldering information. If cables are installed within or behind walls, a surface mounting box and wall mount cover plate are available to provide a neat termination of the extension cable near the user's desk. Standard lengths of extension cable with attached connectors are available in 25 foot incremental lengths ranging from 25 feet to 200 feet.

Port-a-punch. – The Port-a-punch, manufactured by IBM, is recommended as ideally suited for low-cost preparation of CP-1 program cards. A stylus is included with the Port-a-punch.

Program Pads and Cards. – Pad-form worksheets for preparation of programs, retention of program running instructions and description are available. Also, prescored 80-step tab cards for use with the CP-1 Card Programmer are available in various quantities.

SECTION 2

INSTALLATION

2.1 GENERAL

This section includes installation setup, and [illegible] information necessary for trouble-free operation of Model 300 Series equipment. It is suggested that the new user read and become familiar with the information contained herein before attempting to operate the equipment. Full utilization of the equipment with the many possible configurations can be readily understood by careful perusal of the arrangement diagrams. The relatively few precautionary requirements should always be followed to eliminate possible equipment malfunctions.

2.2 UNPACKING AND INSPECTION

Carefully unpack your equipment. Inspect all units for shipping damage; if damage is noticed, do not proceed. Notify shipping agency. Check equipment received against purchase order. Decals specifying model numbers can be found on all Wang equipment. The decals are normally located on the bottom of the units.

2.3 SPECIAL INSTALLATIONS

If special installation requirements are desired (i.e., over-the-ceiling or between-the-wall), contact your Wang representative for detailed instructions. Users who prefer having the cables in walls or ceilings must furnish their own electrician. For such installations, Wang Laboratories can provide suggestions on extension cables, location of electronic packages, and environmental accessories needed to make the Wang equipment function effectively. If actual soldering work (i.e., connectors to extension cables) is requested of Wang Laboratories, time and travel charges will be billed at standard rates.

2.4 LOCATION OF ELECTRONIC PACKAGES

Electronic packages, both simultaneous and non-simultaneous operate efficiently at room temperature. Because a certain amount of heat accumulates in the package when power is applied, it is advisable to place the unit in a location where there is some free air movement. Unventilated storage cabinets, closets, etc. are undesirable; cases have been known when a very close environment caused temperatures inside the electronic package to rise above 130° F. This temperature would present an operating limitation to the equipment and can cause malfunctions to occur.

2.5 EQUIPMENT INTERCONNECTING ARRANGEMENTS

Many different hookup configurations are possible with the 300 Series equipment line. Figure 2-1 illustrates in block diagram form some of the most common configurations. Because of design parameters, limitations are imposed on some configurations. If in doubt about special arrangements not included herein, please contact your Wang representative for further information. Connector shape allows only one method of mating; note configuration of connectors. Secure connectors with spring locks.

2.6 SPECIAL CONSIDERATIONS

Keyboard extension cables cannot be placed in a conduit which is already occupied by an AC power line. Conduits should be used to protect extension cables which are subjected to indefinite exposure outdoors, extreme tropical conditions of saturation, humidity, and high ambient temperatures.

For multiple-outlet installations, the non-simultaneous electronic package, or each of the four output channels of the simultaneous package, is limited to a two-tier, three T-Connector maximum setup for branching to four regular keyboard outlets.

A maximum length limitation of 200 feet should not be exceeded when using extension cables between standard keyboards (not KTs) and electronic packages.

The branching maximum is limited to a two T-Connector, three outlet setup whenever a CP-1 Card Programmer, or a KT Trigonometric Keyboard is attached. Further, either of these items must be connected to a first-tier or primary T-Connector. This rule also applies when a priority PT-Connector is used.

Due to power requirements, the extension cable from the electronic package to the CP-1 Programmer or to the KT Trigonometric Keyboard is limited to a 50-foot maximum length.

Caution must be taken to prevent overloading a channel with more than one KT Trigonometric Keyboard or more than one CP-1 Card Programmer. For maximum safety in control of outlets, the T-Connectors should be located close to the electronic package.

Using T-Connectors, the keyboard turned on first will go "on line". Displays on the remaining outlets will not light up. In all T-branched connections, each keyboard user should establish a courtesy habit of turning off the keyboard after use.

A priority PT-Connector permits one of three interlinked keyboards to preempt the electronic package for immediate use and interrupt any unfinished work initiated on another keyboard. The electronic package supports only one priority keyboard on the first tier of a PT-Connector. Two additional normal outlets can be used.

When a CP-1 Card Programmer and a KT Trigonometric Keyboard are used together, they must be directly coupled to the electronic package.

Four outlets are the maximum amount available from any one channel of an electronic package (please remember KT and CP-1 restrictions).

A simultaneous electronic package can always be substituted for a non-simultaneous electronic package.

When a high numbered model of electronic package is installed, it can accept keyboards of a lower numbered series as well as its own numbered series. A lower numbered electronic package can operate with a higher numbered keyboard (except 360K with 320E), but added key functions of higher unit will not be operative.

Because of design characteristics, a Model 360K Keyboard and a Model 320K Keyboard should not be attached to the same T-Connector. When this condition exists, the Model 360K Keyboard loses the use of its extra storage registers. Two Model 360K Keyboards attached to a T-Connector would function normally.

A Model 360K Keyboard should not be attached to a Model 320 Electronic Package; erroneous indications may occur.

2.7 TURN-ON PROCEDURE

After interconnecting the various units of the system, peruse your equipment for power switches. Place all power switches to OFF.

CAUTION:

The preceding procedure is extremely important. Damage to the equipment can result if power is applied to equipment with power switches ON.

Connect units that require AC power to external AC power outlet. Three-pronged connectors for common grounding are provided on all Wang equipment for your safety.

IMPORTANT – Place power switch of electronic package to ON before placing remaining power switches to ON. This sequence should always be followed when turning on the equipment.

If a simultaneous electronic package is used, depress PRIME switch (red button) on top of package. This purges all the circuits and resets the circuits for operation; this also turns on a flashing signal light on each keyboard display.

Depress CLEAR ALL switch(es) on keyboard(s). This switch should always be depressed before beginning any set of calculations to clear accumulators, registers, etc. of any previous data. The keyboard display should show +.0000000000.

Equipment is now functioning and ready to solve calculations. Refer to Section 3, Operating Instructions for detailed instructions.

2.8 TURN-OFF PROCEDURE

Turn-off procedure is simple but important. Always place keyboard power switch(es) to OFF before disconnecting keyboards from electronic packages. This simple precaution prevents any transistor damage that could arise from a voltage surge caused by a sudden disconnection. Electronic packages can remain ON without damage. If a CP-1 Card Programmer is used, the keyboard should be disconnected before the card programmer. Likewise, the reverse is advisable for connection policy.

REMEMBER!!

Always make certain that the keyboard is turned off before connecting or disconnecting equipment. Also, heed turn-on order; electronic package first, then the keyboard(s).

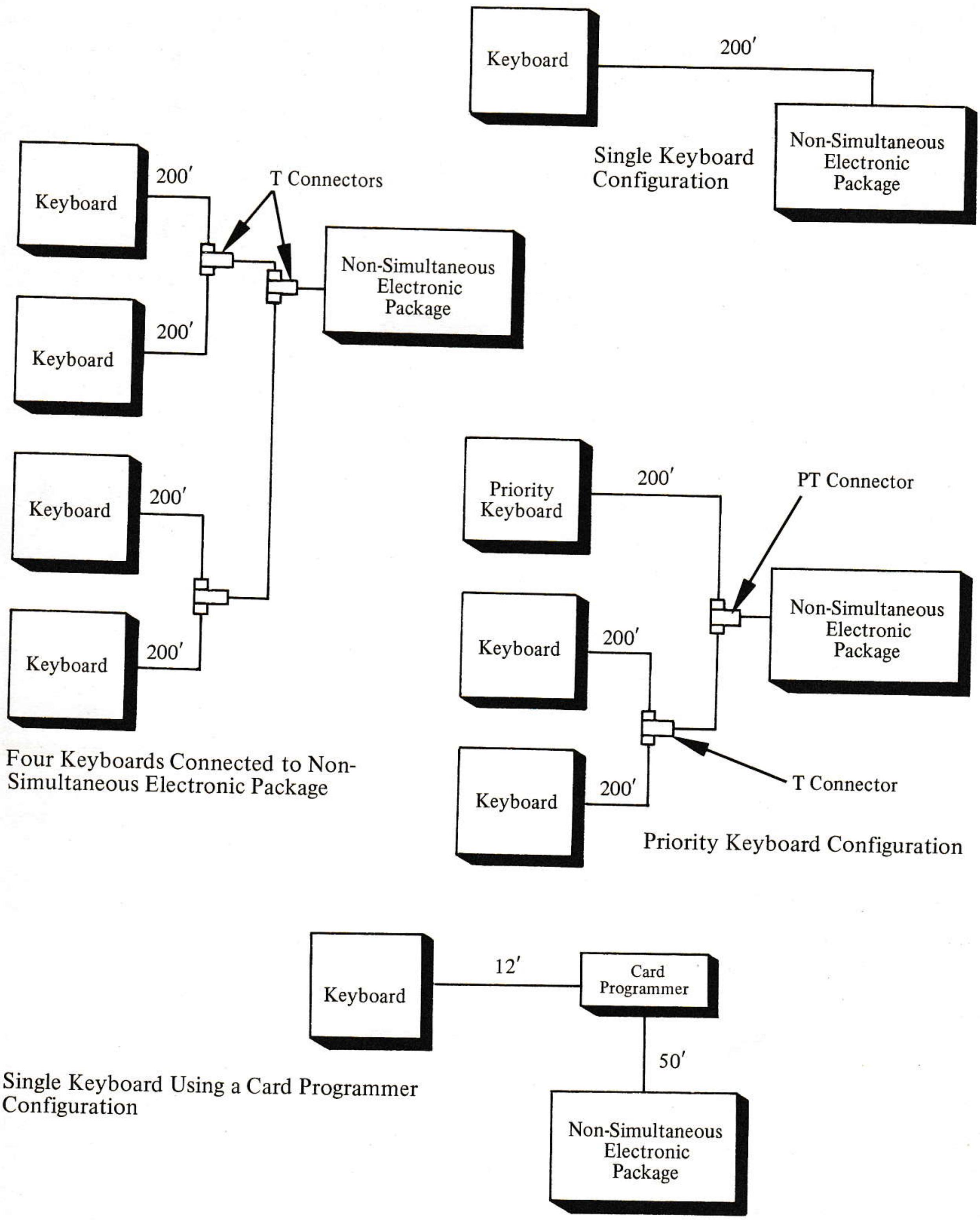
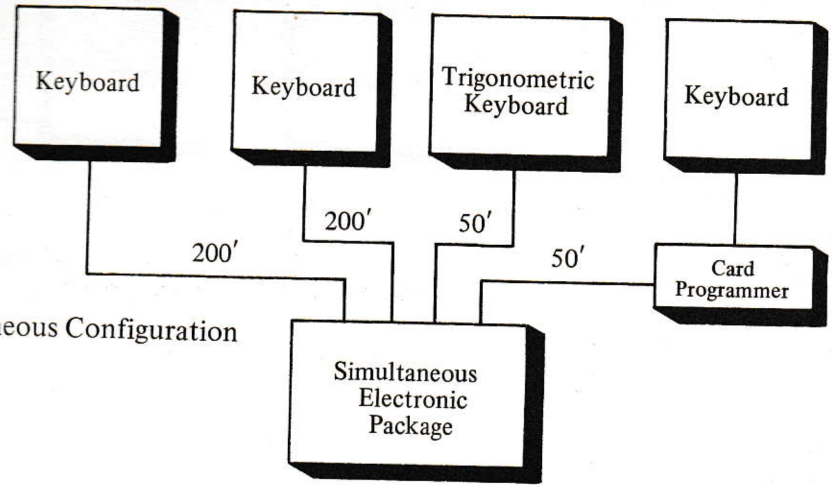
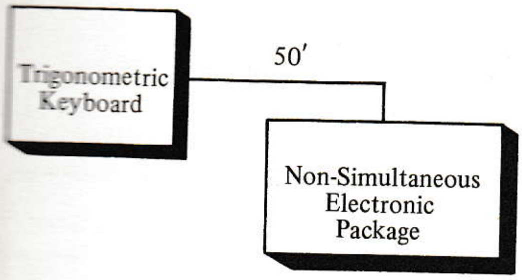


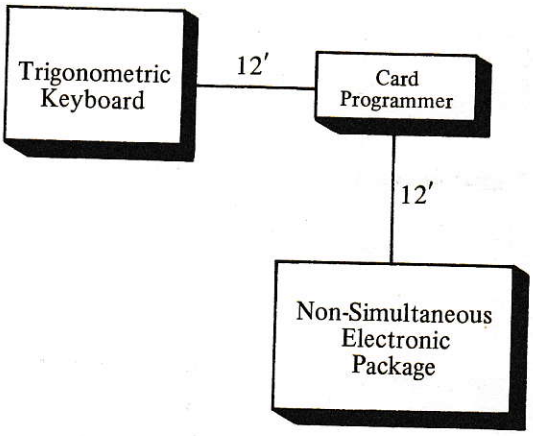
Figure 2-1. Interconnecting Arrangements



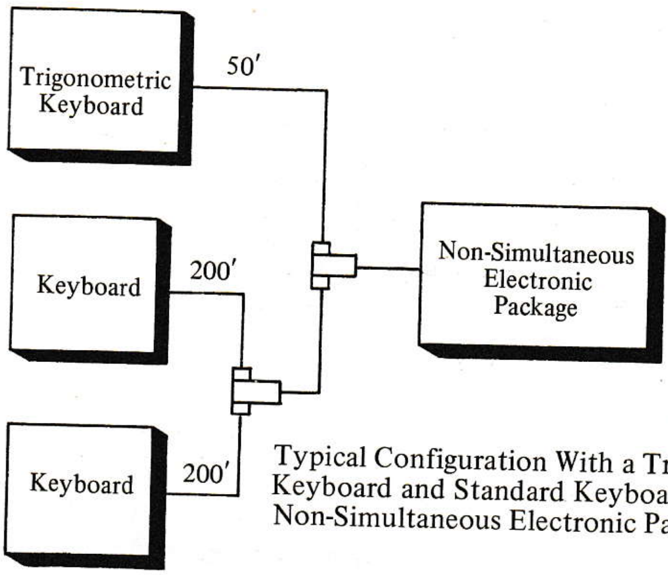
Typical Simultaneous Configuration



Single Trigonometric Keyboard Configuration

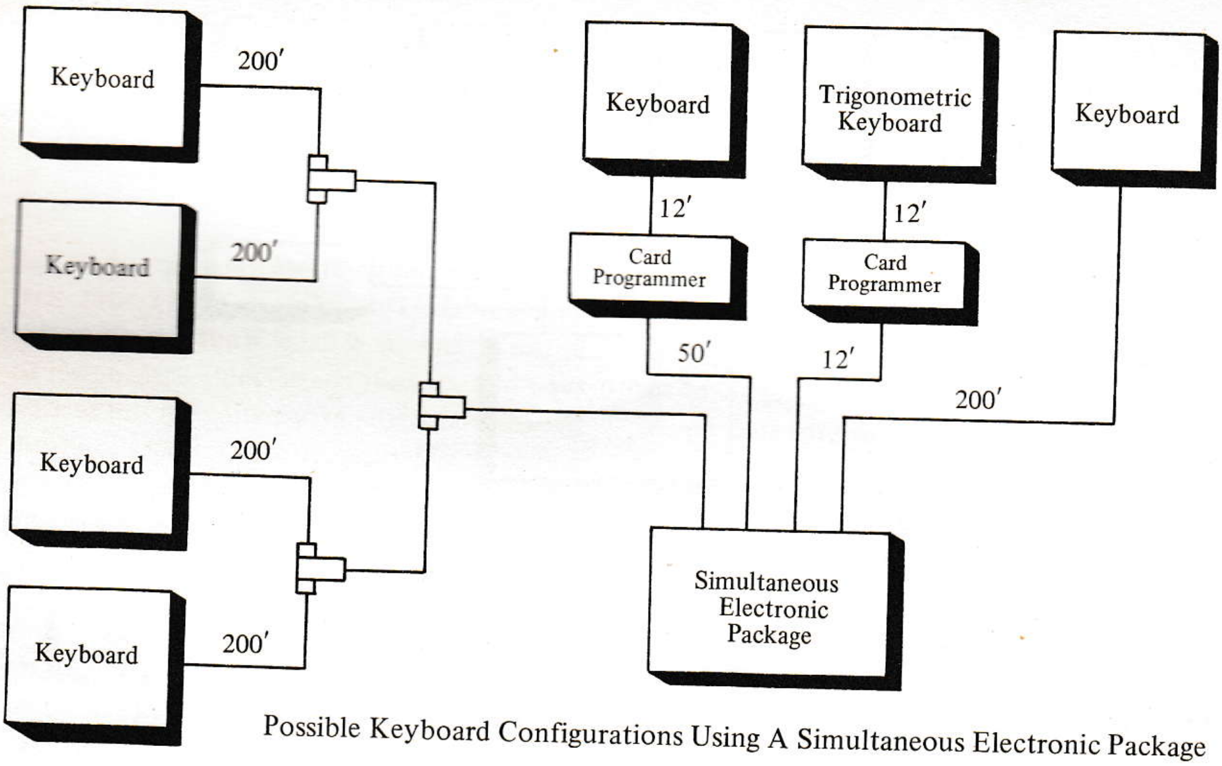


Trigonometric Keyboard and Card Programmer Configuration

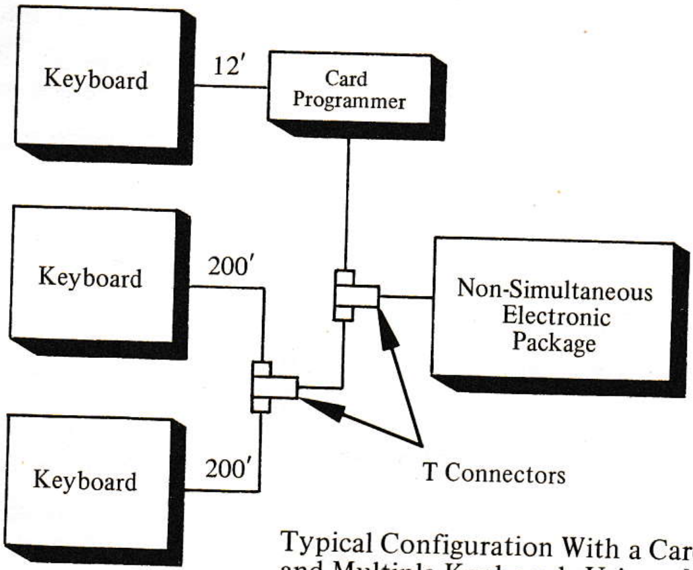


Typical Configuration With a Trigonometric Keyboard and Standard Keyboards Using a Non-Simultaneous Electronic Package

Figure 2-1. Interconnecting Arrangements (contd.)



Possible Keyboard Configurations Using A Simultaneous Electronic Package



Typical Configuration With a Card Programmer and Multiple Keyboards Using a Non-Simultaneous Electronic Package

Figure 2-1. Interconnecting Arrangements (contd.)

SECTION 3
OPERATION

3.1 GENERAL

This section explains, by using typical examples, the operation of each keyboard function. It is suggested that the reader actually perform the sample problems on a keyboard to gain experience and insight into the techniques used for the many calculations.

3.2 PRECISION and ROUND OFF

Every register on the 300 Series contains 14 digits (not including decimal point). Although they are not normally seen on the display, the 14 digits' full precision is used in the operation of addition, subtraction, and calculations of logs and exponentials. In multiplication, division, and computing of squares and square roots, the calculations are performed to 14-digit precision, and then rounded to 10 digits for the display.

3.3 BASIC REGISTERS

All 300 Series Calculators contain three basic kinds of registers: a work register (display window), two adders (left and right), and the product or log register. The basic keyboard is comprised of the black adder keys, the blue log register keys, and the white numeral keys. A distinctive feature of the Wang calculating logic is the ability to generate logarithms and exponentials. This ability is most readily seen in the e^x and $\log_e x$ keys. While the use of this type of logic adds considerable basic power to the calculator, the explanations in this section do not consider the arithmetic operation from the point of view of logarithms. Multiplication, division, squaring, and extracting square roots are all considered as normal algebraic calculations.

3.4 KEYBOARD ARRANGEMENTS

Table 3-1 lists the keys associated with the various models in the 300 Series calculator line. Operating examples start with the keys that are common to all models and progress through the series to the explanations of the keys peculiar to the more sophisticated models. Each sample problem has been carefully chosen to allow a fuller understanding of the calculator operations. Users that require additional information for special applications are urged to contact their local Wang Representative for assistance. The "Code" columns following the various keystroke commands are listed for familiarity and are associated with the card programming capability discussed in Section 4.

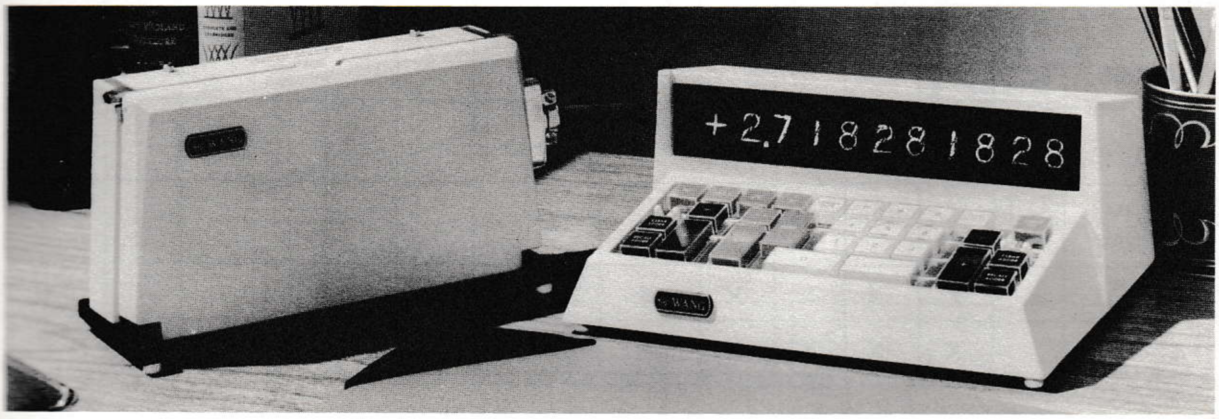


Table 3-1

Keys and Associated Models

KEY LABEL	MODEL 300	310	320	360	362	KT/KR
0-9						
DECIMAL POINT						
CLEAR ALL						
CLEAR DISPLAY						
CHANGE SIGN						
÷ =						
X=						
ENTER		ALL MODELS				
CLEAR ADDER (R&L)						
RECALL ADDER (R&L)						
+ ADDER (R&L)						
– ADDER (R&L)						
PROD. ACCUM.						
MULT. ACCUM.						
ENTRY ACCUM.						
$\sqrt{X}$		X	X	X	X	X
X^2		X	X	X	X	X

KEY LABEL	MODEL 300	310	320	360	362	KT/KR
e^X			X	X	X	X
LOG_eX			X	X	X	X
STORE 0 – 3				X		360
RECALL 0 – 3				X		360
STORE FULL					X	362
RECALL FULL					X	362
ADD FULL					X	362
SUB. FULL					X	362
STORE Ha					X	362
RECALL Ha					X	362
STORE Hb					X	362
RECALL Hb					X	362
SIN						X
COS						X
SIN^{-1}						X
TAN^{-1}						X

Table 3-2

Partial Cross Reference Between Keys and Mathematical Operations

Trigonometric Functions	Numerical Storage	Antilogarithms	Logarithms	Square	Square root	Automatic Accumulation	Division	Multiplication	Clear accumulator values	Recall accumulator values	Subtraction	Addition	Clear calculator	Clear display	Numerical Inputs	
															X	0 – 9
															X	Decimal Point
													X			Clear All
														X		Clear Display
															X	Change Sign
							X									÷=
								X								X=
							X	X								Enter
									X							Clear Adder (R & L)
	X									X						Recall Adder (R & L)
	X											X				+ Adder (R & L)
	X										X					– Adder (R & L)
						X										Prod. Accum.
						X										Mult. Accum.
						X										Entry Accum.
					X											$\sqrt{X}$
				X												X^2
		X						X								e^X
			X					X								Log_eX
	X															Store 0 – 3
	X															Recall 0 – 3
	X															Store Full
	X									X						Recall Full
	X											X				Add Full
	X															Subtract Full
	X															Store Ha
	X															Recall Ha
	X															Store Hb
	X															Recall Hb
X																Sin
X																Cos
X																Sin^{-1}
X																Tan^{-1}

3.5 CLEAR DISPLAY and CLEAR ALL KEYS

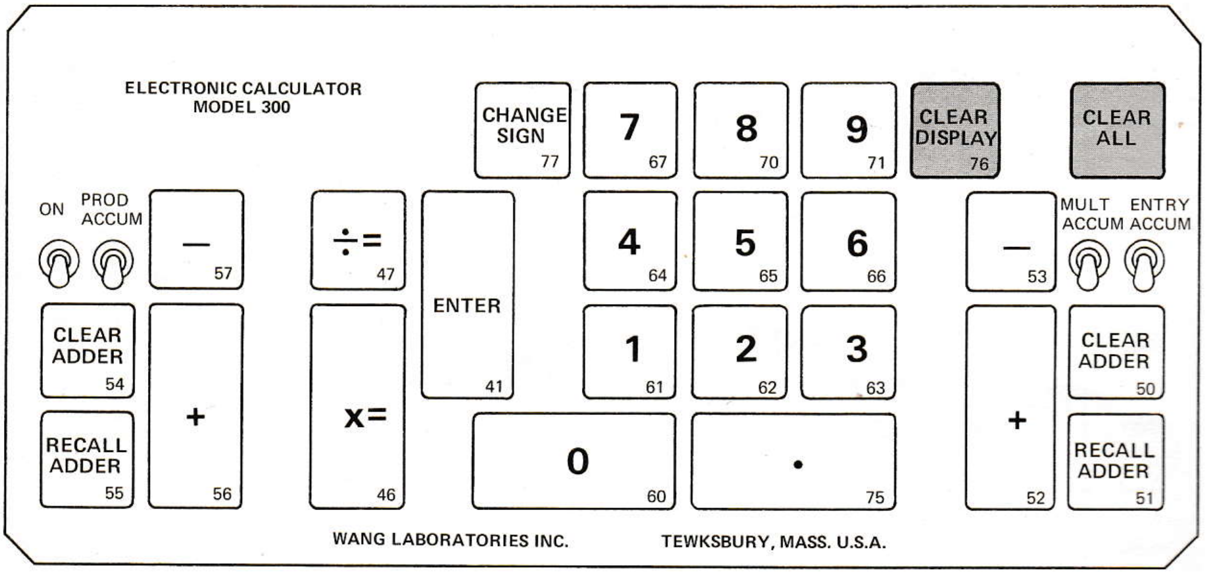


Figure 3-1. Clear Display and Clear All Keys.

OPERATION/EXAMPLE

Clear the calculator for new calculations.

KEYSTROKE	CODE
Clear All	None

REMARKS

This operation clears the calculator's accumulators and other circuits of any previously keyed-in data. The work register displays all zeroes.

OPERATION/EXAMPLE

Clear the display (work register)

KEYSTROKE	CODE
Clear Display	76

REMARKS

This operation darkens the entire display, and zeroes are put into the work register circuits. New digits are ready to be entered from the left-hand end of the display.

3.6 NUMERICAL KEYS

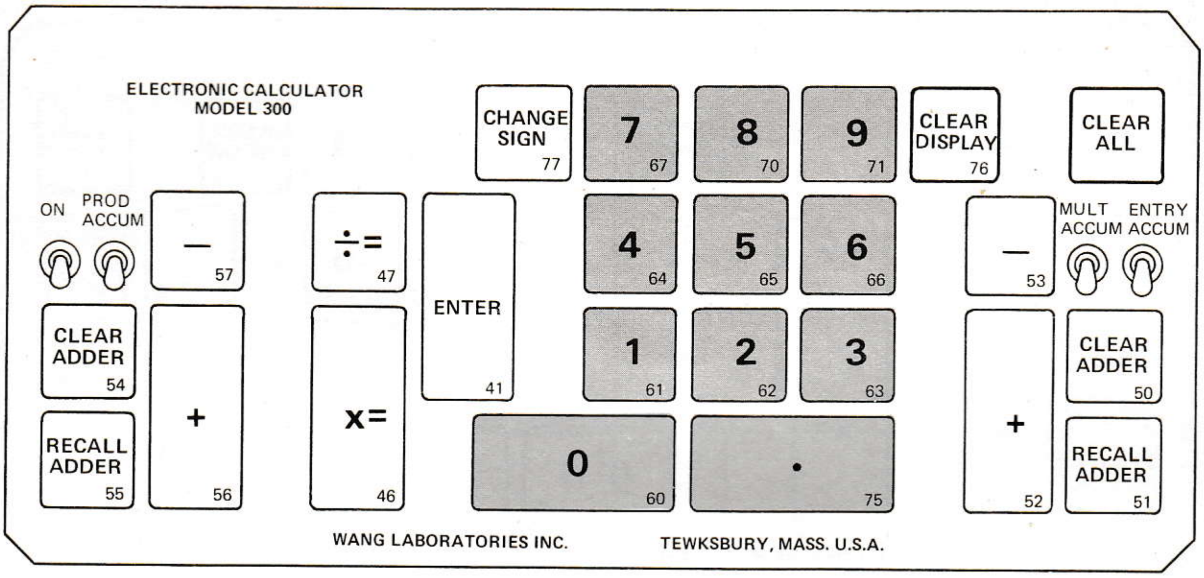


Figure 3-2. Numerical Keys.

OPERATION/EXAMPLE

Key in data.

REMARKS

Simply index the numerical keys and index the decimal key in its proper place. Use the same sequence as when writing.

KEYSTROKE	CODE
Assorted numerical keys and decimal point.	

OPERATION/EXAMPLE

Key in the number 3.1416

REMARKS

The number is in the work register and will remain until a further operation is performed.

KEYSTROKE	CODE	KEYSTROKE	CODE
3	63	4	64
•	75	1	61
1	61	6	66

3.7 CHANGE SIGN KEY

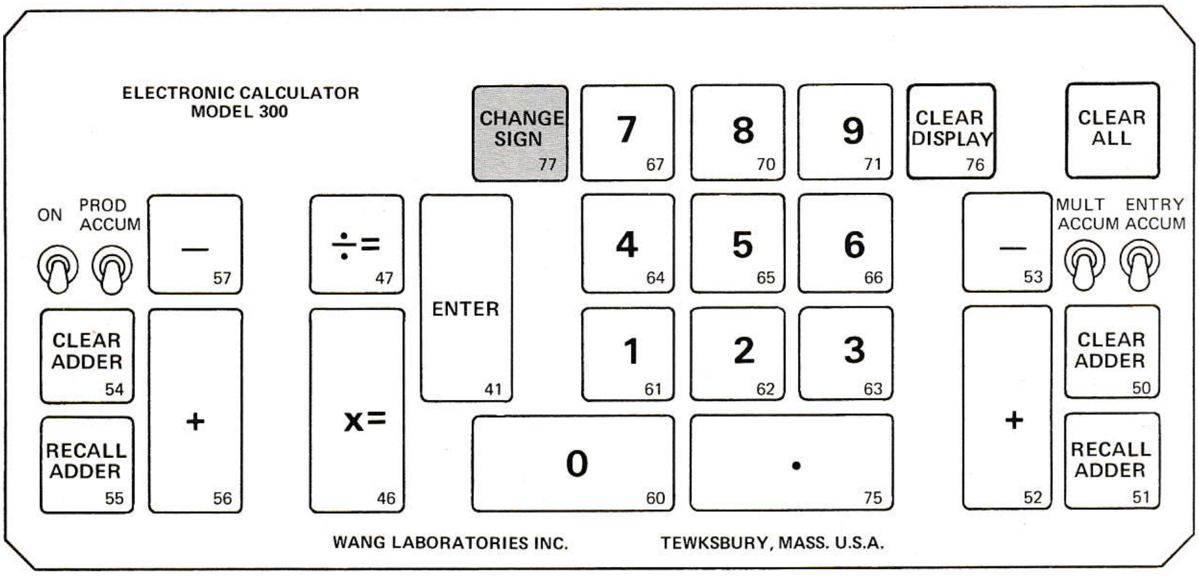


Figure 3-3. Change Sign Key

OPERATION/EXAMPLE

Key in a negative number.

KEYSTROKE	CODE
Assorted numeric keys and CHANGE SIGN key	

REMARKS

Index the positive number and then depress the CHANGE SIGN key.

OPERATION/EXAMPLE

Key in the number –.069

KEYSTROKE	CODE	KEYSTROKE	CODE
.	75	9	71
0	60	CHANGE SIGN	77
6	66		

REMARKS

The negative number is in the work register and will remain until a further operation is performed.

3.8 CLEAR ADDER KEYS

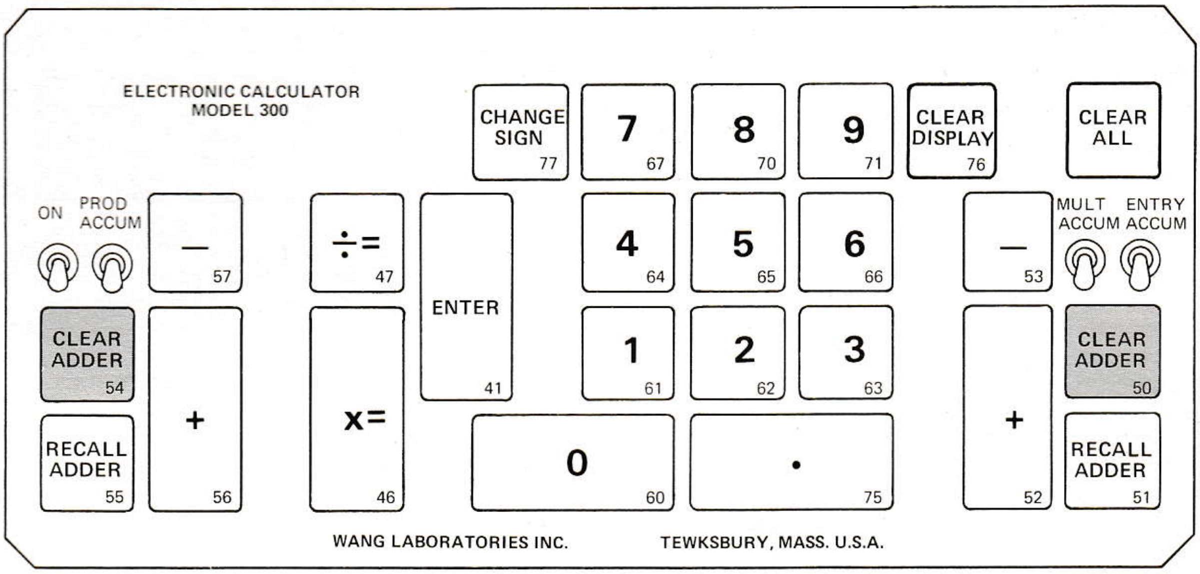


Figure 3-4. Clear Adder Keys.

OPERATION / EXAMPLE

Clear right adder.

REMARKS

This operation will remove any data that may be in the right adder circuits.

KEYSTROKE	CODE
CLEAR ADDER (AR)	50

OPERATION / EXAMPLE

Clear left adder.

REMARKS

This operation will remove any data that may be in the left adder circuits.

KEYSTROKE	CODE
CLEAR ADDER (AL)	54

3.9 ADDITION and SUBTRACTION KEYS

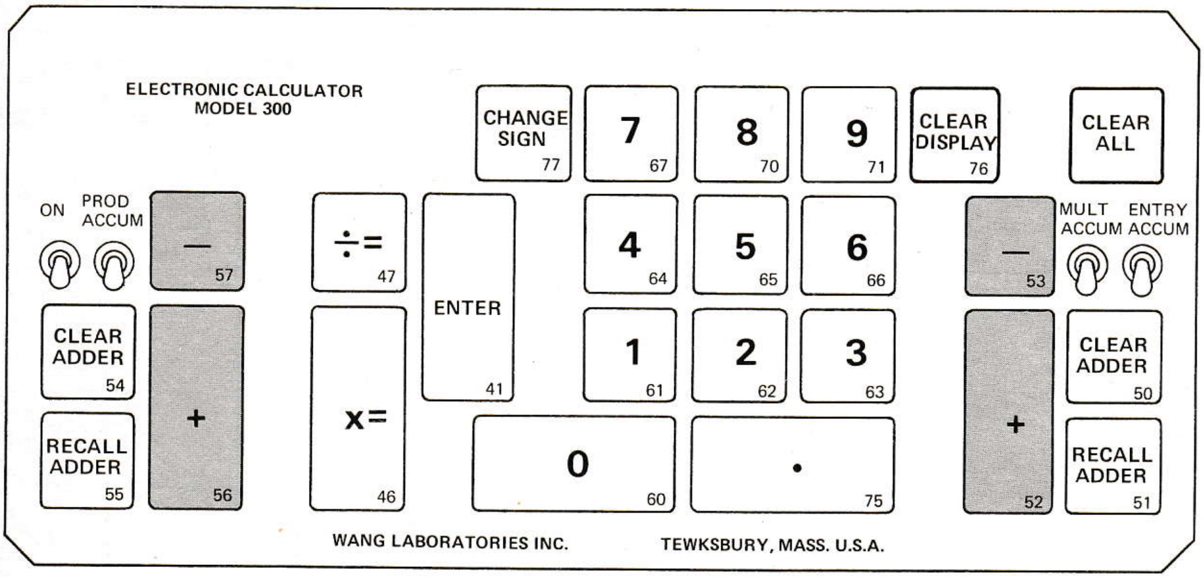


Figure 3-5. Addition and Subtraction Keys.

OPERATION/EXAMPLE

Add using the left adder.

KEYSTROKE	CODE
+ (AL)	56

REMARKS

This operation adds the number in the display to the contents of the left adder. The answer remains in the adder and also is shown in the display.

OPERATION/EXAMPLE

Add using the right adder.

KEYSTROKE	CODE
+ (AR)	52

REMARKS

This operation adds the number in the display to the contents of the right adder. The answer remains in the adder and also is shown in the display.

OPERATION/EXAMPLE

Put 2 in the left adder.

KEYSTROKE	CODE
CLEAR ADDER (AL)	54
2	62
+ (AL)	56

REMARKS

This operation clears the adder circuit and puts the 2 that is in the window into the left adder. The 2 will remain in the window and the adder.

OPERATION/EXAMPLE

Put 9 in the right adder.

REMARKS

This operation puts 9 in the window, then clears the adder before putting the number into the adder. Notice that the adder can be cleared after the number has been indexed into the display. The + (AR) operation places the number in the window into the adder. The number remains in the display and also in the adder.

KEYSTROKE	CODE
9	71
CLEAR ADDER (AR)	50
+ (AR)	52

OPERATION/EXAMPLE

Add 2 + 5.7 using the left adder.

REMARKS

After the adder is cleared, the number 2 is indexed into the window and placed into the adder by the + AL operation. The 5.7 is then indexed into the display. Remember that the 2 is still in the adder. By depressing the + (AL) key again, the 5.7 is added to the 2 in the adder to produce the sum of 7.7. Note that the answer is in the window and also in the adder.

KEYSTROKE	CODE	KEYSTROKE	CODE
CLEAR ADDER (AL)	54	•	75
2	62	7	67
+ (AL)	56	+ (AL)	56
5	65		

OPERATION/EXAMPLE

Add 9 + 4.5 in the right adder.

REMARKS

This is the same sequence of operation as the previous addition operation using the left adder. Answer is 13.5 as shown in the display.

KEYSTROKE	CODE	KEYSTROKE	CODE
CLEAR ADDER (AR)	50	•	75
9	71	5	65
+ (AR)	52	+ (AR)	52
4	64		

OPERATION/EXAMPLE

Subtract using the left adder.

REMARKS

This operation subtracts the number in the display from the number in the adder. The resultant number appears in the display with the appropriate algebraic sign.

KEYSTROKE	CODE
– (AL)	57

OPERATION/EXAMPLE

Subtract using the right adder.

REMARKS

This operation is identical to the subtraction operation using the left adder.

KEYSTROKE	CODE
– (AR)	53

OPERATION/EXAMPLE

Find 2 – 1.5 using the left adder.

REMARKS

The result (+.5) is displayed in the display and also retained in the adder. Note that other registers are not disturbed.

KEYBOARD	CODE	KEYBOARD	CODE
CLEAR ADDER (AL)	54	•	75
2	62	5	65
+ (AL)	56	– (AL)	57
1	61		

OPERATION/EXAMPLE

Find 1.1 – 11 using the right adder.

REMARKS

Result is –9.9 as displayed in the window and retained in the adder.

KEYSTROKE	CODE	KEYSTROKE	CODE
CLEAR ADDER (AR)	50	+ (AR)	52
1	61	1	61
•	75	1	61
1	61	– (AR)	53

3.10 RECALL ADDER KEYS

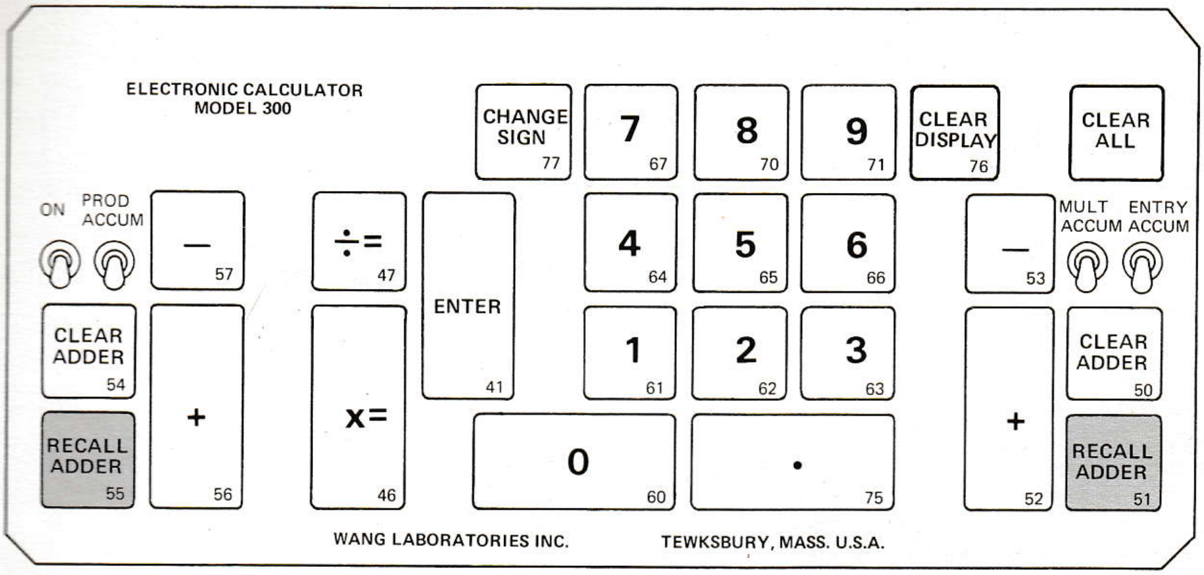


Figure 3-6. Recall Adder Keys.

KEYSTROKE	CODE
RECALL ADDER (AL)	55

OPERATION/EXAMPLE

Recall the contents of the left adder.

REMARKS

This operation recalls the contents of the left adder and displays it in the window. The number still remains in the adder. If the previous examples were done and if the adder has not been cleared, the recall command will display +.5.

KEYSTROKE	CODE
RECALL ADDER (AR)	51

OPERATION/EXAMPLE

Recall the contents of the right adder.

REMARKS

This operation recalls the contents of the right adder and displays it in the window. The number still remains in the adder. If the previous examples were done, and if the adder has not been cleared, the recall command will display −9.9.

3.11 MULTIPLICATION KEYS

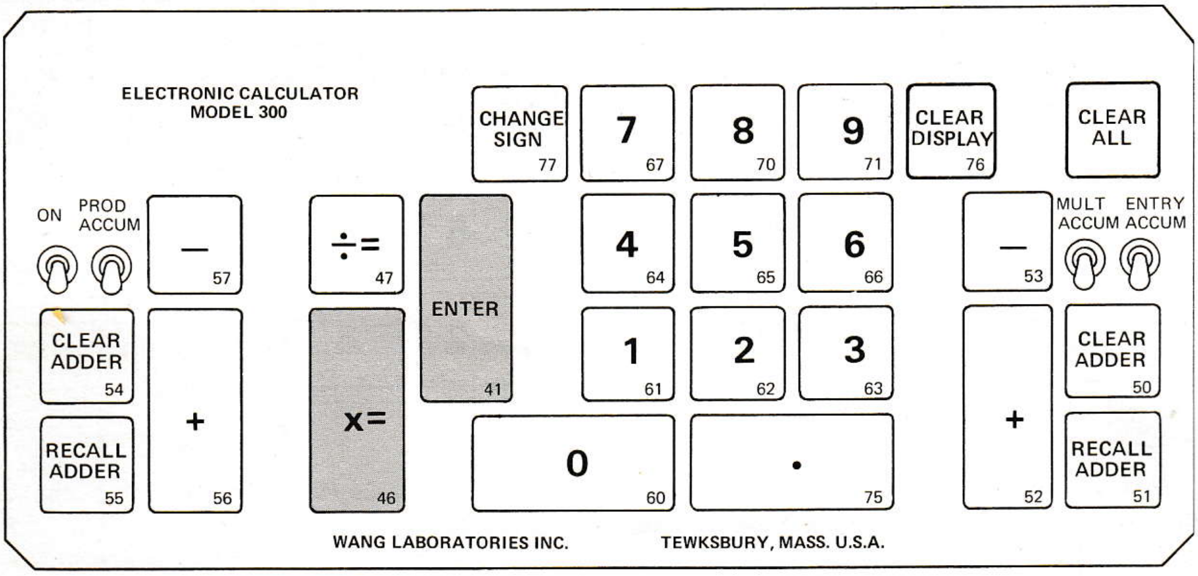


Figure 3-7. Multiplication Keys

OPERATION / EXAMPLE

Clear the multiplication register.

KEYSTROKE	CODE
X=	46

REMARKS

The multiplication operation of the calculator uses the log register, (abbrev. L). It is normally in the cleared state after each operation. An exception is given on p. 3-13. A simple way to clear it is to index the **X=** key. In the cleared state, L contains a +1.

OPERATION / EXAMPLE

Multiply.

KEYSTROKE	CODE
ENTER	41
X=	46

REMARKS

Two keys on the keyboard are associated with a multiplication operation. These keys are labeled **ENTER**, and **X=**. The **ENTER** key multiplies the number in the window by the number in the log register. The answer is left in the log register and the window is cleared to zeroes. The **X=** key multiplies the number in the window by the number in the log register. The result is brought into the window and the log register is cleared to +1.

OPERATION / EXAMPLE

Multiply 3 x 4.7

REMARKS

Window displays the answer of +14.1. The log register is cleared to 1. This is the general method of multiplying; key in first factor and **ENTER** it, then key in second factor and index **X=**.

KEYSTROKE	CODE	KEYSTROKE	CODE
3	63	•	75
ENTER	41	–7	67
4	64	X=	46

OPERATION / EXAMPLE

Multiply 2 x (–3) x 4

REMARKS

Window displays the answer of –24. The log register is cleared to +1. This is the general method for chain multiplication. Note that the **X=** key is depressed only after the last factor is indexed.

KEYBOARD	CODE	KEYBOARD	CODE
2	62	ENTER	41
ENTER	41	4	64
3	63	X=	46
CHANGE SIGN	77		

NOTE:

Overflow may occur when large numbers are multiplied together. In general, a product must be less than 10^9. Otherwise, overflow will occur (a flashing decimal point will indicate this condition). When overflow occurs, the decimal point is remaindered by 10.

While the characteristics of overflow are physically determined by the decimal point display, the log register itself has an upper and lower maximum range. This capacity is between e^{-40} and e^{40}, corresponding approximately to $.42 \times 10^{-17}$ and 2.35×10^{17} respectively. Chained operations resulting in a number falling above the upper limit yields unpredictable answers. For example, a chain multiplication of 5,000,000 x 4,000,000 x 30,000 results in +110111112.2 with a flashing decimal point. A chain multiplication that falls below the lower limit yields a zero for an answer. For example, .000000001 x .000000001 results in zero.

OPERATION / EXAMPLE

Find 1200000^2.

REMARKS

Window displays +144.0000000, with a flashing decimal point. The decimal point should be shifted 10 places to the right to get the true result.

KEYBOARD	CODE	KEYBOARD	CODE
1	61	1	61
2	62	2	62
0	60	0	60
0	60	0	60
0	60	0	60
0	60	0	60
0	60	0	60
ENTER	41	X=	46

3.12 DIVISION KEYS

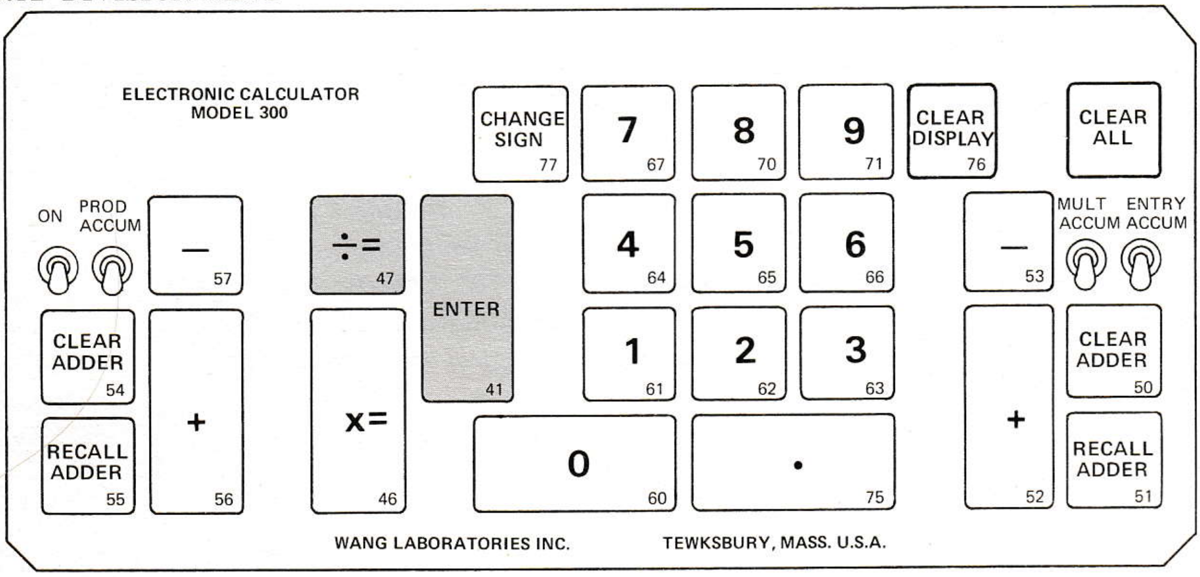


Figure 3-8. Division Keys.

OPERATION / EXAMPLE

Divide.

REMARKS

Division utilizes the **ENTER** and the ÷= keys. Recall that the **ENTER** key multiplies the number in the window by the number in the log register. It is therefore suitable for entering the numerator of a division problem. The ÷= key divides the number in the log register by the number in the window. The result is displayed in the window and the log register is cleared to +1.

KEYSTROKE	CODE
ENTER	41
÷=	47

OPERATION/EXAMPLE

Find 2 ÷ 3

KEYSTROKE	CODE	KEYSTROKE	CODE
2	62	3	63
ENTER	41	÷=	47

REMARKS

Answer is .6666666667 as displayed in the window. Log register is cleared to +1. This is the general method for division. Note that the tenth digit is rounded, in both division and multiplication problems.

OPERATION/EXAMPLE

Find 1/2

KEYSTROKE	CODE
2	62
÷=	47

REMARKS

Answer is +.5 as shown in window. Remember that the log register contains a +1 when cleared. Note that this method can be used to find any reciprocal.

OPERATION/EXAMPLE

Find (2x3) / (4x5)

KEYSTROKE	CODE	KEYSTROKE	CODE
4	64	ENTER	41
ENTER	41	2	62
5	65	ENTER	41
X=	46	3	63
÷=	47	X=	46

REMARKS

Answer is +.3 as shown in window. Log register is cleared to +1. This is the general method for solving such a problem. Consider it as two chain multiplication problems. First, find the product of the denominator and take its reciprocal; second, chain multiply the reciprocal with the numerator terms.

NOTE:

The previous method must be modified if the numbers are very large or very small. In these cases, a long chain multiplication problem should be broken down into several smaller problems. Otherwise, a loss of precision or overflow may result. This is especially important in a program. Consider the calculation of (2000 x 3000 x 100) / (4000 x 5000 x 100) as an example.

3.13 SQUARE ROOT and SQUARE KEYS

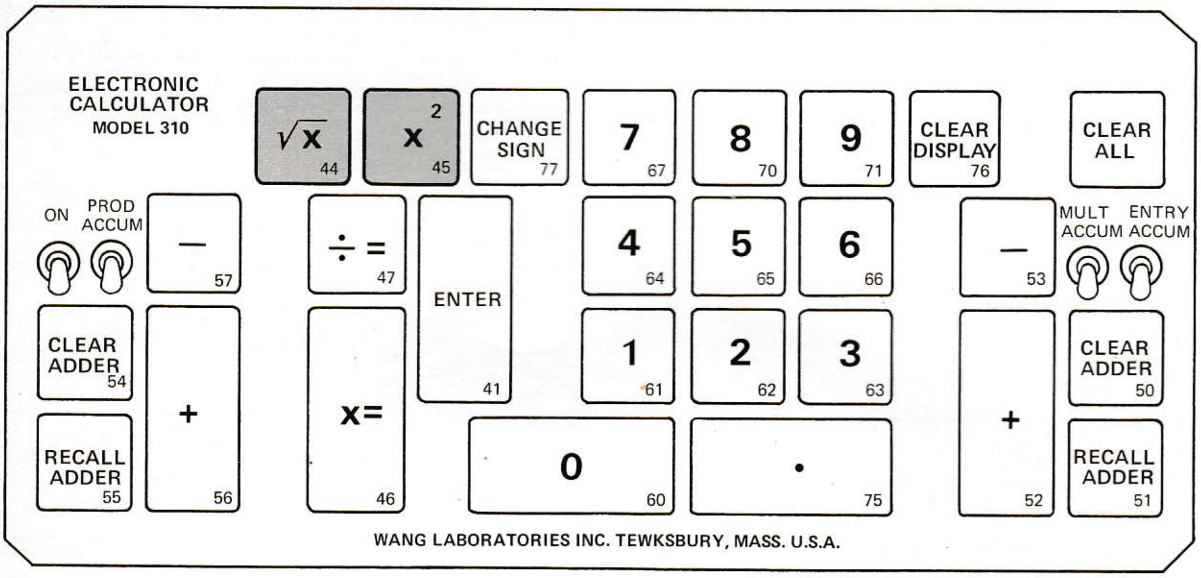


Figure 3-9. Square Root and Square Keys.

OPERATION/EXAMPLE

Find $\sqrt{X}$

REMARKS

The square root of a number can be easily obtained by depressing the $\sqrt{X}$ key. The square root of the number in the window is multiplied by the number in the log register and displayed. The log register is cleared to +1.

KEYSTROKE	CODE
$\sqrt{X}$	44

OPERATION/EXAMPLE

Find the $\sqrt{2}$

REMARKS

The answer is 1.414213562 as displayed in the window and the log register is cleared to +1.

KEYSTROKE	CODE
2	62
$\sqrt{X}$	44

OPERATION/EXAMPLE

Find $3\sqrt{2}$

REMARKS

The answer, displayed in the window, is +4.242640687. Note that a chain multiplication problem with a square root operation can be handled in this manner.

KEYSTROKE	CODE	KEYSTROKE	CODE
3	63	2	62
ENTER	41	$\sqrt{X}$	44

OPERATION / EXAMPLE

Find X^2

REMARKS

The $\mathbf{X^2}$ operation multiplies the square of the number in the window by the number in the log register. The result is displayed in the window and the log register is cleared to +1.

KEYSTROKE	CODE
X^2	45

OPERATION / EXAMPLE

Find $(-11)^2$

REMARKS

The answer of +121 is displayed in the window. The log register is cleared to +1.

KEYSTROKE	CODE	KEYSTROKE	CODE
1	61	CHANGE SIGN	77
1	61	X^2	45

OPERATION / EXAMPLE

Find 2×5^2

REMARKS

The answer of +50 is displayed in the window. The log register is cleared to 1. Observe that a chain multiplication problem with a value to be squared can be handled by the same method that was explained in the $\sqrt{X}$ discussion.

KEYSTROKE	CODE	KEYSTROKE	CODE
2	62	5	65
ENTER	41	X^2	45

3.14 LOG and ANTILOG KEYS

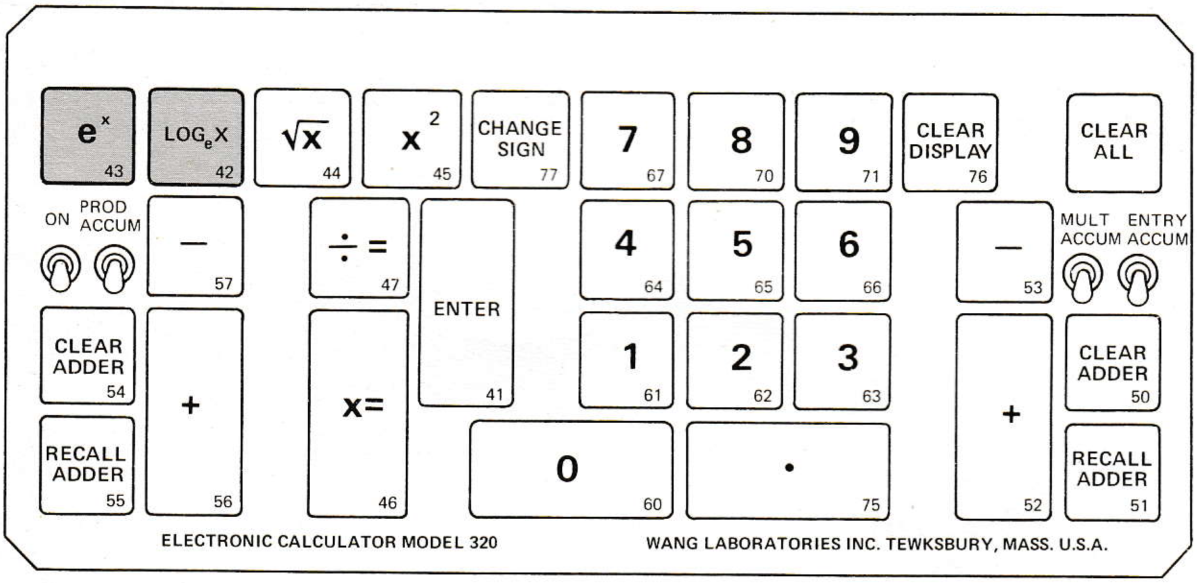


Figure 3-10. Log and Antilog Keys.

OPERATION/EXAMPLE

Find Log_eX

REMARKS

Finding LOG_eX of a number is similar to finding $\sqrt{X}$. Indexing the **LOG_eX** key multiplies the number in the window to the previously **ENTER**ed number (s) in the log register. The log of the product is displayed in the window. The log register is cleared to +1. Normally, the log register contains a +1, and indexing the **LOG_eX** key simply generates the log of the number in the window.

KEYSTROKE	CODE
LOG_eX	42

OPERATION/EXAMPLE

Find Log_e 2

REMARKS

The answer, displayed in the window, is +00.69314718.

KEYSTROKE	CODE
2	62
LOG_eX	42

OPERATION / EXAMPLE

Find Log_e (2 x 8)

REMARKS

The answer, displayed in the window, is +02.77258872. Log register is cleared to +1.

KEYSTROKE	CODE	KEYSTROKE	CODE
2	62	8	70
ENTER	41	LOG_eX	42

NOTE:

It is mathematically incorrect to take the log of a negative number. An anomaly of the calculators is that it takes the log of the absolute value. However, the minus sign is left in the log register. This can be cleared by depressing the **X=** key.

OPERATION / EXAMPLE

Find the Log_e (−3)

REMARKS

This is an erroneous operation. The answer displayed in the window is +01.09861228. A minus 1 is in the log register. Observe that indexing X= now will display −1.098612289 and clear the log register to +1.

KEYBOARD	CODE
3	63
CHANGE SIGN	77
LOG_eX	42

OPERATION / EXAMPLE

Find Log_{10} 100

REMARKS

The answer of +2 is displayed in the window and the log register is cleared to +1.

KEYSTROKE	CODE	KEYSTROKE	CODE
1	61	0	60
0	60	0	60
LOG_eX	42	LOG_eX	42
CLEAR ADDER (AL)	54	ENTER	41
+(AL)	56	RECALL ADDER (AL)	55
1	61	÷=	47

NOTE:

The log operation of the calculators is based on the natural log system with base e. To convert to base 10, use the formula

$$Log_{10}X = Log_eX / Log_e10$$

OPERATION/EXAMPLE

Find e^X

KEYSTROKE	CODE
e^X	43

REMARKS

Finding e^X of a number is again similar to $\sqrt{X}$. Indexing the e^X key generates the exponential (or anti-log to the base e) of the number in the window, multiplies it by the number in the log register and displays the result in the window. The log register is cleared to +1.

NOTE:

An anomaly of the e^X key is that the number in the window must contain less than 3 decimal places. For example, e^X of 000.1 will result in an overflow indicated by a flashing decimal point.

The following table illustrates many cases of values that overflow and the correction factors.

TABLE 3-3
Overflow and Correction Factors

x	e^x	Position of Decimal Point													Overflow	Correction
0	e^0	+	1	.	0	0	0	0	0	0	0	0	0	0	No	None
1	e^1	+	2	.	7	1	8	2	8	1	8	2	8	No	None
20.7	$e^{20.7}$	+	9	7	7	0	0	2	7	2	5	.	8	No	None
20.8	$e^{20.8}$	+	.	1	0	7	9	7	5	4	9	9	9	Yes	1×10^{10}
30.8	$e^{30.8}$	+	2	3	7	8	.	3	1	8	6	5	6	Yes	1×10^{10}
40.8	$e^{40.8}$	+	5	2	3	8	5	9	5	4	.	5	3	Yes	1×10^{10}
42.8	$e^{42.8}$	+	3	8	7	0	8	2	7	5	6	.	8	Yes	1×10^{10}
43.7	$e^{43.7}$	+	9	5	2	0	6	9	9	5	2	.	9	Yes	1×10^{10}
43.8	$e^{43.8}$	+	.	1	0	5	2	2	0	0	0	2	3	Yes	1×10^{20}
50	e^{50}	+	5	1	.	8	4	7	0	5	5	2	8	Yes	1×10^{20}
60	e^{60}	+	1	1	4	2	0	0	7	.	3	8	9	Yes	1×10^{20}
65	e^{65}	+	1	6	9	4	8	8	9	2	4	.	4	Yes	1×10^{20}
66.7	$e^{66.7}$	+	9	2	7	7	7	3	4	5	5	.	8	Yes	1×10^{20}
67	e^{67}	+	.	1	2	5	2	3	6	3	1	7	0	Yes	1×10^{30}
77	e^{77}	+	2	7	5	8	.	5	1	3	4	5	4	Yes	1×10^{30}
87	e^{87}	+	6	0	7	6	0	3	0	2	.	2	5	Yes	1×10^{30}
89	e^{89}	+	4	4	8	9	6	1	2	8	1	.	9	Yes	1×10^{30}
89.7	$e^{89.7}$	+	9	0	4	0	9	6	9	9	7	.	0	Yes	1×10^{30}
89.8	$e^{89.8}$	+	9	9	9	1	8	1	7	0	8	.	2	Yes	1×10^{30}
89.9	$e^{89.9}$	+	.	1	1	0	4	2	6	6	5	6	5	Yes	1×10^{40}
99	e^{99}	+	9	8	8	.	9	0	3	0	3	1	9	Yes	1×10^{40}

Note: For "x" < 0, the decimal point remains fixed at the first position following the "+" sign, and leading zeros can exist. Thus, if $x = -5$, $e^x = .00673\ 79469$. This is the general case for a number between 0 and 1 in absolute value. (See page 3.14 on how to find e^x.)

OPERATION / EXAMPLE

Find e

REMARKS

Answer is 2.718281828

KEYSTROKE	CODE
1	61
e^X	43

OPERATION / EXAMPLE

Find $e^{-1.5}$

REMARKS

Answer is .2231301601

KEYSTROKE	CODE	KEYSTROKE	CODE
1	61	CHANGE SIGN	77
•	75	e^X	43
5	65		

OPERATION / EXAMPLE

Find $(2.1)^{1.9}$

REMARKS

Answer is +4.094648818

KEYSTROKE	CODE	KEYSTROKE	CODE
2	62	1	61
•	75	•	75
1	61	9	71
LOG_eX	42	X=	46
ENTER	41	e^X	43

NOTE:

The **LOG_eX** and **e^X** keys lend themselves quite naturally to calculations in raising numbers to powers and in finding roots. Any expression x^y can be computed with only four operational keystrokes: Index X, **LOG_eX**, **ENTER**, index Y, **X=**, **e^X**. As a variation, an expression $\sqrt[y]{X}$ requires: index X, **LOG_eX**, **ENTER**, index Y, **÷=**, **e^X**.

OPERATION/EXAMPLE

Find the constant payment on a 10 year mortgage if the interest is 6% annually, or 0.5% monthly, and the principal is $8,400. The formula for finding constant payments on a mortgage is given below:

$$R = P \frac{i}{1 - (1+i)^{-n}} = P \frac{i}{1 - \frac{1}{(1+i)^n}}$$

Where:

- i = interest (6% annually, 0.5% monthly)
- P = principal ($8,400)
- n = number of interest payments (10 years or 120 months).

$$R = 8400 \frac{.005}{1 - \frac{1}{(1.005)^{120}}} \text{ (monthly payment)}$$

REMARKS

Answer +93.26

KEYSTROKE	CODE	KEYSTROKE	CODE
CLEAR ALL		÷=	47
•	75	CLEAR ADDER (AL)	54
0	60	– (AL)	57
0	60	1	61
5	65	+ (AL)	56
+ (AR)	52	RECALL ADDER (AR)	51
+ (AL)	56	ENTER	41
1	61	RECALL ADDER (AL)	55
+ (AL)	56	÷=	47
LOG_eX	42	ENTER	41
ENTER	41	8	70
1	61	4	64
2	62	0	60
0	60	0	60
X=	46	X=	46
e^X	43		

OPERATION/EXAMPLE

Find the yearly payments on a 10 year mortgage of $11,000, at an interest rate of 4¼%.

REMARKS

Answer is $1,373.13

OPERATION/EXAMPLE

Minimum spouting velocity – The formula for finding the minimum fluid velocity needed to spout a solid in a column is given by the equation:

$Vs = (d_i/d_c)^{1/3} (d_p/d_c) [2g\lambda (P_s - P_f)/P_f]^{1/2}$

Where

Vs = fluid velocity, ft./sec.
d_i = fluid inlet diameter, feet
d_p = particle diameter, feet
d_c = column diameter, feet
g = acceleration of gravity, 32.2 ft./sec.^{2}
λ = bed depth, feet
P_s = absolute density of solid, lb/ft.^{3}
P_f = fluid density, lb/ft.^{3}

Find the minimum spouting velocity when the following conditions exist:

d_i = .375 in. λ = 1 ft.
d_p = .25 in. P_s = 86.6 lb/ft.^{3}
d_c = 6 in. P_f = .073 lb/ft.^{3}

REMARKS

Answer: +4.57 ft./sec.

KEYSTROKE	CODE	KEYSTROKE	CODE
CLEAR ALL		$\sqrt{X}$	44
8	70	ENTER	41
6	66	•	75
•	75	2	62
6	66	5	65
+ (AR)	52	ENTER	41
•	75	6	66
0	60	÷=	47
7	67	CLEAR ADDER (AL)	54
3	63	+ (AL)	56
+ (AL)	56	•	75
– (AR)	53	3	63
ENTER	41	7	67
RECALL ADDER (AL)	55	5	65
÷=	47	ENTER	41
ENTER	41	6	66
1	61	÷=	47
ENTER	41	LOG_eX	42
3	63	ENTER	41
2	62	3	63
•	75	÷=	47
2	62	e^X	43
ENTER	41	ENTER	41
2	62	RECALL ADDER (AL)	55
X=	46	X=	46

OPERATION/EXAMPLE

Find minimum spouting velocity (Vs) if bed depth is 1,000 feet and other data is the same as previous problem.

REMARKS

Answer: 144.47 ft./sec.

3.15 ACCUMULATOR SWITCHES

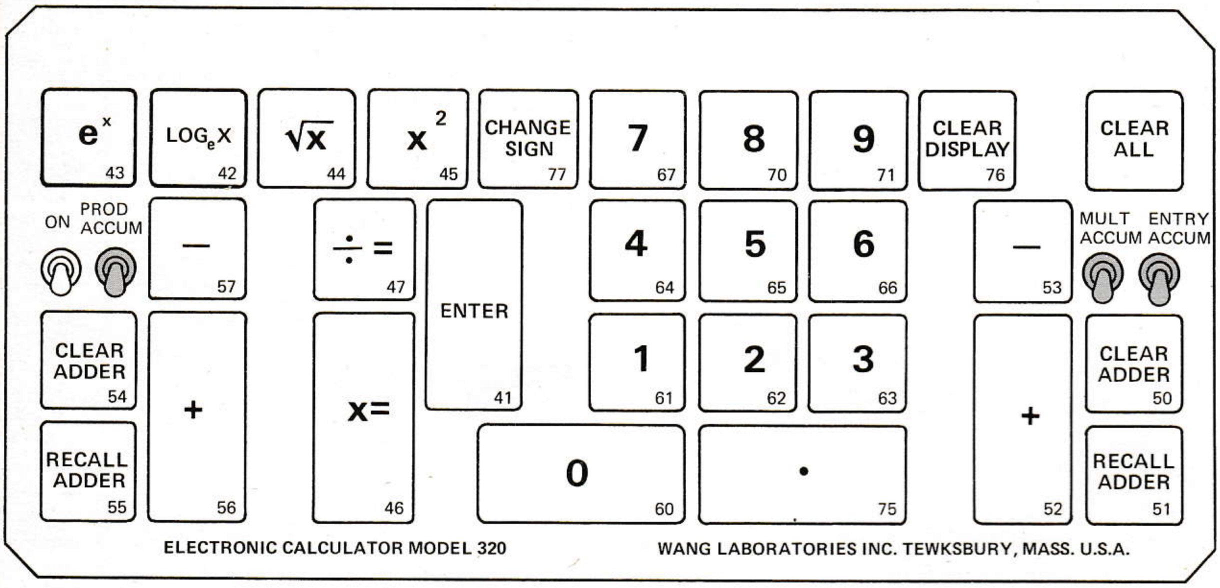


Figure 3-11. Accumulator Switches.

OPERATION/EXAMPLE

The **PRODUCT ACCUMULATOR** switch is on the left side of the keyboard. In the UP position, it operates in conjunction with (either singly or jointly) four keyboard functions, X=, ÷=, $\sqrt{X}$, X^2, to provide automatic accumulation in the left adder of all products, quotients, square root values, and square values. The accumulated totals are recallable to the display at any time by depressing the **RECALL ADDER** key.

OPERATION/EXAMPLE

Perform 2 x 3 + 4 x 5 and tally the sum of the products automatically by using the **PROD ACCUM** switch.

REMARKS

By depressing **RECALL ADDER (AL)**, the answer of +26 is displayed.

KEYSTROKE	CODE	KEYSTROKE	CODE
P.A. – UP		4	64
CLEAR ADDER (AL)	54	ENTER	41
2	62	5	65
ENTER	41	X=	46
3	63	RECALL ADDER (AL)	55
X=	46		

OPERATION/EXAMPLE

Solve $2 \times 3 + 16 \div 4 + \sqrt{9} + 3^2$ and find sum automatically.

REMARKS

Answer is +22. Note that four different keyboard functions were automatically accumulated.

KEYSTROKE	CODE	KEYSTROKE	CODE
P.A. – UP		ENTER	41
CLEAR ADDER (AL)	54	4	64
2	62	÷=	47
ENTER	41	9	71
3	63	$\sqrt{x}$	44
X=	46	3	63
1	61	X^2	45
6	66	RECALL ADDER (AL)	55

OPERATION/EXAMPLE

Find the sum of 1/2 + 1/3 + 1/4. This example illustrates how reciprocals can be automatically summed. Typical usage could be total resistance values of parallel resistors and total capacity of series capacitors.

REMARKS

Answer is 1.083333333

KEYSTROKE	CODE	KEYSTROKE	CODE
P.A. – UP		÷=	47
CLEAR ADDER (AL)	54	4	64
2	62	÷=	47
÷=	47	RECALL ADDER (AL)	55
3	63		

OPERATION/EXAMPLE

The **MULTIPLIER ACCUMULATOR** switch is on the right side of the keyboard. In the UP position, it operates in conjunction with (either singly or jointly) the same keyboard functions as the **PRODUCT ACCUMULATOR** switch. It provides automatic accumulation in the right adder of the multipliers, divisors, etc., before the keyboard operations are performed.

OPERATION/EXAMPLE

Perform 2 x 3 + 4 x 5 and find the sum of the multipliers automatically by using the **MULT ACCUM** switch.

REMARKS

By recalling the right adder, the sum of 8 is displayed.

OPERATION/EXAMPLE

Solve 1/2 + 1/3 + 1/4 and find the sum of the divisors by using the **MULT ACCUM** switch.

REMARKS

Answer is 9

OPERATION/EXAMPLE

Find the sum of X and X^2 when X has values of 3, 4, 8, and 11.

REMARKS

The sum of the X values is 26 as obtained by recalling the right adder.

The sum of the X^2 values is 210 as obtained by recalling the left adder.

KEYSTROKE	CODE	KEYSTROKE	CODE
PROD ACCUM UP		8	70
MULT ACCUM UP		X^2	45
CLEAR ALL		1	61
3	63	1	61
X^2	45	X^2	45
4	64	RECALL ADDER (AR)	51
X^2	45	RECALL ADDER (AL)	55

NOTE:

The **PROD ACCUM** and **MULT ACCUM** switches using the two independent adders (AL & AR) allow the accumulation of ΣX^2 and ΣX with a single keystroke per variable.

OPERATION/EXAMPLE

Find the variance using the same data as in the previous problem. Do not clear adders from previous problem.

$$\text{Variance } (\partial^2) = \frac{\Sigma X^2 - \frac{1}{N}(\Sigma X)^2}{N}$$

REMARKS

Answer: 10.25

KEYSTROKE	CODE	KEYSTROKE	CODE
PROD ACCUM DOWN		÷=	47
MULT ACCUM DOWN		−(AL)	57
RECALL ADDER (AR)	51	ENTER	41
X^2	45	4	64
ENTER	41	÷=	47
4	64		

NOTE:

It is important to turn off all accumulation switches after the the data has been entered. This is normally necessary in the final calculations as in the example for variance.

OPERATION / EXAMPLE

The **ENTRY ACCUMULATOR** switch is located next to the **MULTIPLIER ACCUMULATOR** switch on the right side of the keyboard. It is directly associated with the **ENTER** function and automatically accumulates, using the right adder, all inputs entered via the **ENTER** key.

OPERATION / EXAMPLE

Perform 2 x 3 + 4 x 5 and find the sum of the entries automatically by using the **ENTRY ACCUM** switch.

REMARKS

The answer of 6 is read by recalling the contents of the right adder.

OPERATION / EXAMPLE

Repeat the same multiplication problem and find the sum of the entries and multipliers by using the two applicable accumulator switches.

REMARKS

The answer of 14 is again read by recalling the contents of the right adder.

3.16 MODEL 360 STORAGE REGISTER KEYS

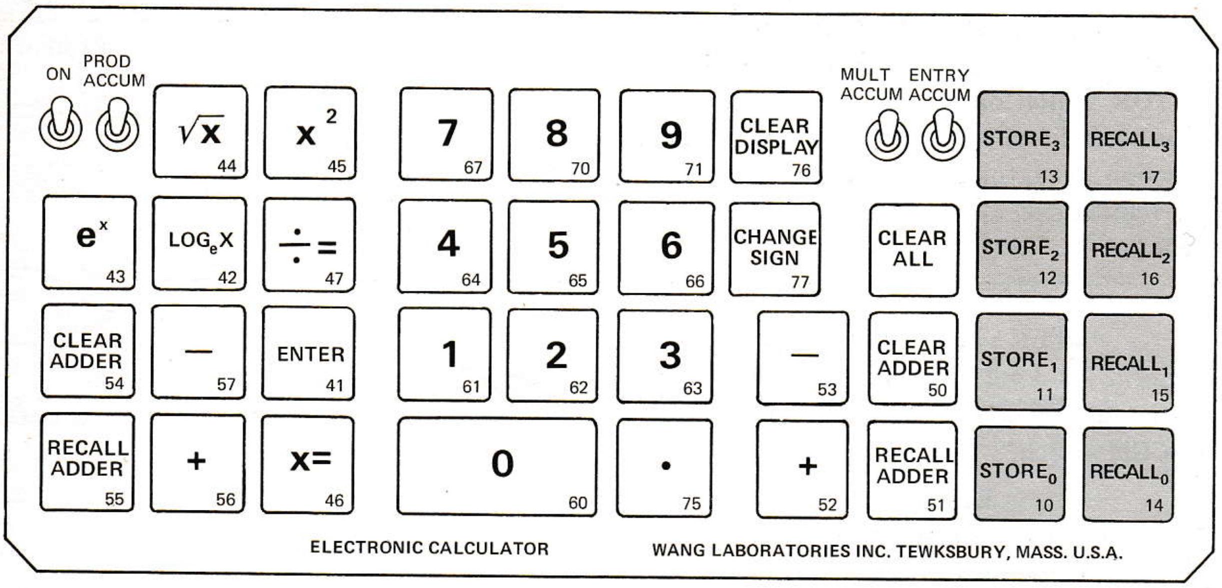


Figure 3-12. Model 360 Storage Register Keys.

The four storage registers of the Model 360 can be considered as scratch pads for the retention of constants and temporary results. Two keyboard commands are associated with each storage register, one command for the storing function, and one command for the recall function.

A **STORE #** command places the number that is in the display window into the appropriate storage register. Likewise, a **RECALL #** command recalls the number from the storage register and displays it in the display window.

The number in a register is not destroyed until it is superseded by a new number. This advantage enables the user to repeatedly recall the register contents throughout the course of calculations.

OPERATION / EXAMPLE

Store 3.1416 in **STORAGE REGISTER** 0.

KEYSTROKE	CODE	KEYSTROKE	CODE
3	63	1	61
•	75	6	66
1	61	STORE REG 0	10
4	64		

OPERATION/EXAMPLE

Store 99.1768 in **STORAGE REGISTER** 3.

KEYSTROKE	CODE	KEYSTROKE	CODE
9	71	7	67
9	71	6	66
•	75	8	70
1	61	STORE REG 3	

OPERATION/EXAMPLE

Recall **STORAGE REGISTER** 0.

REMARKS

The number +3.1416 will be displayed in the window.

KEYSTROKE	CODE
RECALL REG 0	14

3.17 MODEL 362 STORAGE REGISTER KEYS

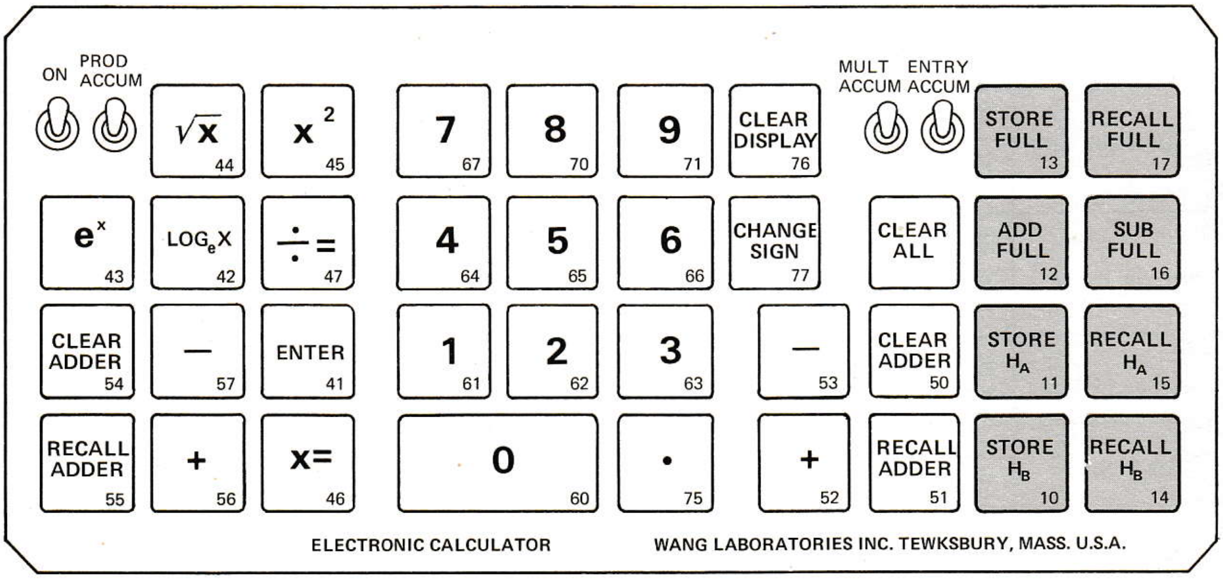


Figure 3-13. Model 362 Storage Register Keys.

The twelve full storage registers of the Model 362, like the registers of the Model 360, can be considered as scratch pads for the retention of constants and temporary results. However, because of the split-register capability, utilization of existing keys for addressing, and accumulator functions, the register addressing and operating modes differ.

Two keystrokes are required to address a register; the command function key, then the register address key (i.e., **STORE FULL 3**). The eight command keys, located on the right side of the keyboard, determine whether the number in the display window will be stored in a full register (**STORE FULL**), added or subtracted from an existing number in a full register (**ADD FULL** or **SUB FULL**), or stored in either half of a full register (**STORE Ha** or **STORE Hb**). The recall keys display the contents of the particular register that is addressed (i.e., **RECALL Ha 0** command recalls the "A" half contents of register 0). Numeral keys 0 through 9 are used to address ten of the twelve registers. The remaining two registers are addressed via the **CLEAR DISPLAY** and **CHANGE SIGN** keys; for example, full register no. 10 can be addressed by the commands **STORE FULL CLEAR DISPLAY**. By depressing one of the eight right-side command keys first, the conventional functions of the address keys are aborted.

NOTE:

The full registers have a capacity of 14 digits, decimal point, and algebraic sign. When used as half registers, each half has a capacity of 6 digits, decimal point, and algebraic sign. If a number larger than six digits is in the display window when the half register store command is performed, only the six most significant digits will be stored. The half register recall command will readily illustrate this fact. If by accident a storage register command key and a blue log register key is depressed instead of a storage register command key and a proper address key, the keyboard may "lock up" until the **CLEAR ALL** key is depressed.

Table 3-4. Function and Register Key Explanations

Function Key	Register No.	0	1	2	3	4	5	6	7	8	9	10	11
	Register Key	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Clear Display**	**Change Sign**
STORE FULL	Stores number that is in display window into desired full register. The number will remain in the display window. Any number previously stored in this register will be destroyed.												
RECALL FULL	Recalls number that is in full register and displays it in display window. Number will remain in register.												
ADD FULL	Adds number in display window to number that is in full register. New total will be displayed in display window.												
SUB FULL	Subtracts number in display window from number that is in full register. New total will be displayed in display window.												
STORE Ha	Stores number that is in display window into the first half of the desired register. The number will remain in the display window. Any number previously stored will be destroyed.												
RECALL Ha	Recalls number that is in first half of register and displays it in display window. Number will remain in half register.												
STORE Hb	Stores number that is in display window into the second half of the desired register. The number will remain in the display window. Any number previously stored in this register will be destroyed.												
RECALL Hb	Recalls number that is in second half of register and displays it in the display window. Number will remain in half register.												

<table>
<tr><td colspan="2">Full Register
Capacity</td></tr>
<tr><td colspan="2">14 digits, dec. pnt., ± sign</td></tr>
<tr><td>Half Register
Capacity</td><td>Half Register
Capacity</td></tr>
<tr><td>6 digits, dec. pnt., ± sign</td><td>6 digits, dec. pnt., ± sign</td></tr>
</table>

Figure 3-14. Register Capacity

OPERATION/EXAMPLE

Place the number 3.1416 into full register no. 9.

REMARKS

The STORE FULL 9 addresses register no. 9 and stores the value of π.

KEYSTROKE	CODE	KEYSTROKE	CODE
3	63	1	61
•	75	6	66
1	61	STORE FULL	13
4	64	9	71

OPERATION/EXAMPLE

Place the number $2/3\pi$ into the first half of register no. 11.

REMARKS

The answer of +2.0944 is displayed in the window and also stored in the first half of register no. 11 Note that the value of π was recalled from register no. 9.

KEYSTROKE	CODE	KEYSTROKE	CODE
2	62	3	63
ENTER	41	÷=	47
RECALL FULL	17	STORE Ha	11
9	71	CHANGE SIGN	77
ENTER	41		

OPERATION/EXAMPLE

Find the value of 1/5 + 1/7 and store in register no. 0. Also, find the value of 1/5 – 1/7 and store in register no. 9.

REMARKS

The answer of +.3428571429 is stored in register no. 0.

The answer of +.1571428571 is stored in register no. 9.

Note that the adder was used because of the display window change when the register accumulator was used.

KEYSTROKE	CODE	KEYSTROKE	CODE
5	65	CLEAR ADDER (AL)	54
÷=	47	+ (AL)	56
STORE FULL	13	ADD FULL	12
0	60	0	60
STORE FULL	13	RECALL ADDER (AL)	55
9	71	SUB FULL	16
7	67	9	71
÷=	47		

OPERATION / EXAMPLE

Distribute the following costs into four categories. Use register numbers 0 through 3.

A	B	C	D
$1500	$ 75	$461	$ 73
350	183	227	172
1200	258	500	51
3050		1188	296

KEYSTROKE	CODE	KEYSTROKE	CODE
CLEAR ALL		2	62
1	61	7	67
5	65	3	63
0	60	STORE FULL	13
0	60	3	63
STORE FULL	13	3	63
0	60	5	65
7	67	0	60
5	65	ADD FULL	12
STORE FULL	13	0	60
1	61	1	61
4	64	8	70
6	66	3	63
1	61	ADD FULL	12
STORE FULL	13	1	61
		Continue until all numbers are entered.	

OPERATION EXAMPLE

Using the results of the preceding problem, divide the grand total of all categories by the amount in each category. Use as many registers as required to accumulate data and store results.

NOTE:
It is suggested that identifications of register contents be retained on scratch paper to eliminate confusion when many registers are used.

KEYSTROKE	CODE	KEYSTROKE	CODE
RECALL FULL	17	4	64
0	60	ENTER	41
STORE FULL	13	RECALL FULL	17
4	64	1	61
RECALL FULL	17	÷=	47
1	61	STORE FULL	13
ADD FULL	12	6	66
4	64	RECALL FULL	17
RECALL FULL	17	4	64
2	62	ENTER	41
ADD FULL	12	RECALL FULL	17
4	64	2	62
RECALL FULL	17	÷=	47
3	63	STORE FULL	13
ADD FULL	12	7	67
4	64	RECALL FULL	17
ENTER	41	4	64
RECALL FULL	17	ENTER	41
0	60	RECALL FULL	17
÷=	47	3	63
STORE FULL	13	÷=	47
5	65	STORE FULL	13
RECALL FULL	17	8	70

3.18 TRIGONOMETRIC KEYS

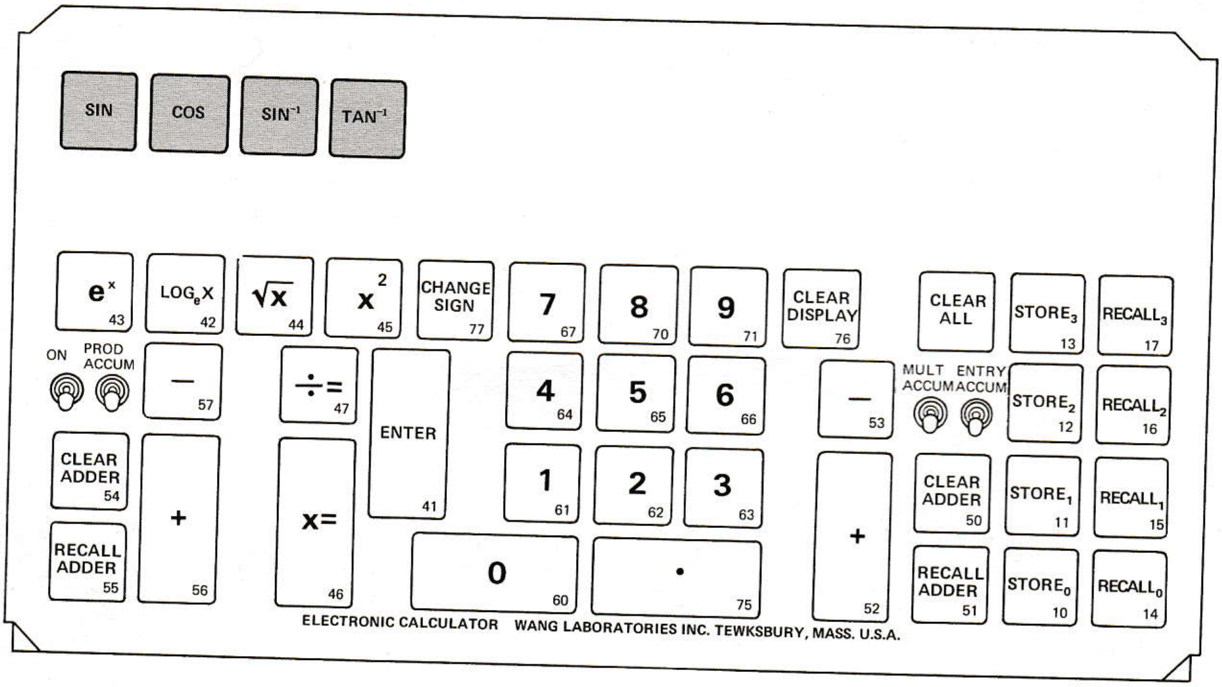


Figure 3-15. Trigonometric Keys.

All trigonometric functions, **SIN**, **COS**, **SIN^{-1}**, and **TAN^{-1}**, are performed in the same manner. Indexing a function key results in the computation of that function for the input variables in the display window. Degree input is directly keyed into the display window when KT Models are used; likewise, radian input is directly keyed into the display window when KR Models are used.

When performing trigonometric functions, the right adder must be cleared beforehand or erroneous results will occur. Both adders and log register are affected by the trigonometric functions, and any previously stored data in these locations will be destroyed. After the function has been performed, the adders and log registers are again available for use.

NOTE:

If a wrong angle or radian has been indexed, but the trigonometric-function calculation has not been started, the error can be corrected by depressing the **CLEAR DISPLAY** key. However, if a trigonometric-function calculation has been started, it should be allowed to finish. Then a new and correct function can be initiated.

When using a simultaneous electronic package, if a trigonometric function is accidently stopped before the calculation has been completed, the entire system will become inoperative. If this condition should develop, the simultaneous electronic package must be reprimed.

OPERATION/EXAMPLE

Find the sine of 30°

REMARKS

The answer of +.5000000000 is displayed in the window.

KEYSTROKE
CLEAR ALL
3
0
SIN

OPERATION/EXAMPLE

Find the cosine of 45°

REMARKS

The answer of +.7071067813 is displayed in the window.

KEYSTROKE
CLEAR ALL
4
5
COS

OPERATION/EXAMPLE

Find the arcsine of .50754

REMARKS

The answer of 30.5° is displayed in the window.

KEYSTROKE	KEYSTROKE
CLEAR ALL	7
•	5
5	4
0	SIN^{-1}

OPERATION/EXAMPLE

Find the value of "a" in the formula

$$\frac{a}{\text{SIN A}} = \frac{b}{\text{SIN B}}$$ using a Model 360 KT

When A = 40.5°
B = 70.85°
b = 250′

$$a = \frac{\text{SIN } 40.5°}{\text{SIN } 70.85°} \times 250$$

REMARKS

The answer of +153.3773858 is displayed in the window.

KEYSTROKE	CODE	KEYSTROKE	CODE
CLEAR ALL		•	75
7	67	5	65
0	60	SIN	None
•	75	ENTER	41
8	70	2	62
5	65	5	65
SIN	None	0	60
STORE REG 0	10	ENTER	41
4	64	RECALL REG 0	14
0	60	÷ =	47

OPERATION/EXAMPLE

Find the radian equivalent of 55°

REMARKS

The answer of +.959931088 is displayed in the window.

KEYSTROKE
PROD ACCUM
5
5
SIN

SECTION 4
PROGRAM OPERATION

4.1 GENERAL

Programming capability, added to any calculator in the 300 Series, enables the user to perform repetitive calculations without manually performing the keyboard functions. Punched data cards provide the program media and are prepared by the user as required; special programming knowledge is not required. Programs are prepared by tabulating the steps of a calculation, converting the key commands to key codes, and punching the card. A Model CP-1 Card Programmer, (discussed on P. 1-5), serves as the interface between program cards and the calculator.

4.2 PROGRAM CARD

The program card (figure 4-1) is basically an 80-step 2-column pre-scored data card. The two columns are identical except for step count numbers. By holding the card in a vertical position, the step numbers 00 through 39 for the left column and 40 through 79 for the right column can easily be read. A 2-digit octal code is printed over the pre-scored contact ports in each of the 80 steps.

A program command is recorded onto a card by punching out the octal code corresponding to the appropriate program command. For example, a "41" code for the **ENTER** function requires that the "40" and "1" contact ports be punched on the appropriate card step. A "66" code for the numeral 6 requires that the "40", "20", "4", and "2" contact ports be punched (Figure 4-2).

Card punching is accomplished manually by using an IBM Port-a-Punch and stylus (available

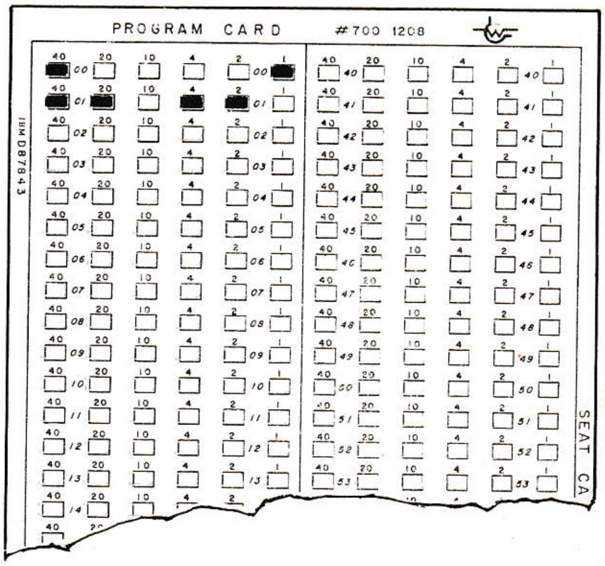


Figure 4-1. Typical Program Card; Row 00 punch for "41", Row 01 punched for "66"

from Wang Laboratories). If these accessories are not available and care is taken, punching can be done with a paper clip.

4.3 PROGRAM PADS

Program worksheets (figure 4-2) are normally used to develop and record programs. The worksheet format contains 80 steps to correspond to the steps on the data cards. Each step of the worksheet has space for the command, code, and comments. Additional space is provided for program description and special instructions. A list of the operations and their associated codes is also on each worksheet for user convenience.

4.4 PROGRAM PREPARATION PROCEDURE

All programs, whether simple or complex, are prepared by using the same general procedure. The steps listed herein are followed by typical program examples.

a. Determine program desired and method of calculation.

b. Using a program worksheet, record title and description of program.

c. Under the description, write the commands **CLEAR ALL** and **START**. The **CLEAR ALL** key clears the calculator and the **START** switch (located on the top of the card reader) commences the program punched on the data card.

d. In the "command" column of the worksheet and starting with step no. 00, list the sequence of calculator commands necessary to complete the calculation. Use the command **STOP** wherever it is necessary to manually key-in data.

NOTE:

A **STOP** command punched in the program stops the sequence of programmed steps. To continue the program, the **CONTINUE** switch (located on the top of the card reader) must be depressed.

e. Normally, it is necessary to input data prior to starting the program. If this is the case, write the instructions on the program worksheet and before the **START** command.

f. Continue this procedure for all steps of the program. If the program exceeds 80 steps and multiple cards are required, each card must contain a **STOP** command to allow the insertion of the additional cards. If the **STOP** command is not programmed on the last row of the card, the program will automatically recycle to step no. 00 and repeat the operations.

NOTE:

It is good practice to use the **STOP** command at the end of each program regardless of the length.

g. After the program commands and instructions are logged on the worksheet, fill in the command codes next to the commands. These codes are listed on the worksheet, keyboards, and in Table 4-1.

h. The next step in the program preparation is the punching of the data card. Insert the data card into the IBM Port-a-Punch so that the cropped corner of the card is positioned in the right lower corner between the clear perforated punch sheet and the rubber backing.

i. Using a stylus, punch out the codes listed on the worksheet. Care should be exercised to avoid unpunched rows in the data cards. If this occurs, the program will be halted at the blank row and be unable to proceed until the **CONTINUE** switch is depressed.

After a program is punched, the card should be carefully checked for errors by matching the card to the program sheet.

NOTE:

If an error in punching is made and the quantity of program steps is not critical, punch the **CHANGE SIGN** code "77" on the erroneously-punched row and also on the following row. This, of course, will expand your program by two steps. But final results will be the same.

It is suggested that the card(s) be immediately identified after punching. This is best accomplished by placing the card(s) on a flat surface and marking with a felt-tipped marker. A sharp pencil or pen could accidentally pierce the card and, in turn, produce erroneous results. Any identifying code number that corresponds to the worksheet number is recommended.

CALCULATOR PROGRAM

No. Date:

No.	Cmd	Code	Comment	No.	Cmd	Code	Comment
00				40			
01				41			
02				42			
03				43			
04				44			
05				45			
06				46			
07				47			
08				48			
09				49			
10				50			
11				51			
12				52			
13				53			
14				54			
15				55			
16				56			
17				57			
18				58			
19				59			
20				60			
21				61			
22				62			
23				63			
24				64			
25				65			
26				66			
27				67			
28				68			
29				69			
30				70			
31				71			
32				72			
33				73			
34				74			
35				75			
36				76			
37				77			
38				78			
39				79			

Code Listing for Program Control

PROGRAM CODE	300-360 OPERATION	362 OPERATION
01	Stop	Stop
10	Store Reg 0	Store Half B
11	Store Reg 1	Store Half A
12	Store Reg 2	Add Full
13	Store Reg 3	Store Full
14	Recall Reg 0	Recall Half B
15	Recall Reg 1	Recall Half A
16	Recall Reg 2	Subtract Full
17	Recall Reg 3	Recall Full
41	Enter	Enter
42	$\text{Log}_e X$	$\text{Log}_e X$
43	e^x	e^x
44	$\sqrt{x}$	$\sqrt{x}$
45	X^2	X^2
46	X =	X =
47	÷ =	÷ =
50	Clear Right Adder	Clear Right Adder
51	Recall Right Adder	Recall Right Adder
52	+ Right Adder	+ Right Adder
53	− Right Adder	− Right Adder
54	Clear Left Adder	Clear Left Adder
55	Recall Left Adder	Recall Left Adder
56	+ Left Adder	+ Left Adder
57	− Left Adder	− Left Adder
60	Numeral 0	0 and Reg 0
61	Numeral 1	1 and Reg 1
62	Numeral 2	2 and Reg 2
63	Numeral 3	3 and Reg 3
64	Numeral 4	4 and Reg 4
65	Numeral 5	5 and Reg 5
66	Numeral 6	6 and Reg 6
67	Numeral 7	7 and Reg 7
70	Numeral 8	8 and Reg 8
71	Numeral 9	9 and Reg 9
75	Decimal .	Decimal .
76	Clear Display	Cl. D. and Reg 10
77	Change Sign	Ch. S. and Reg 11

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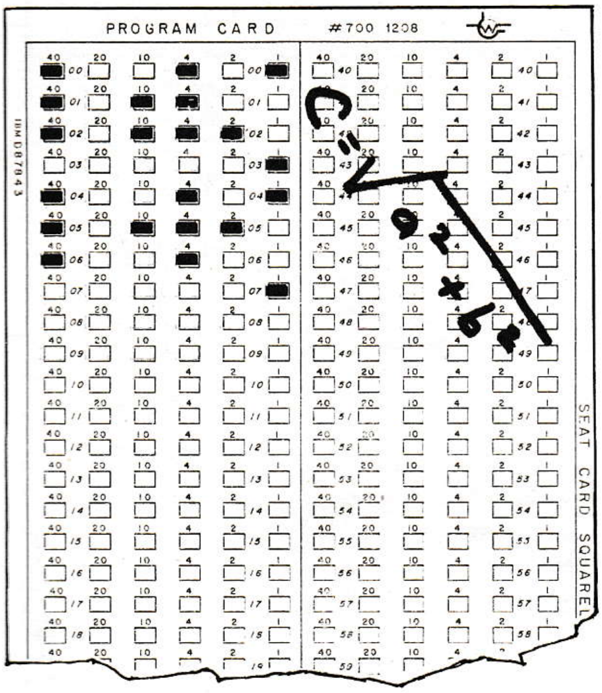
700 – 1201 A ©

Figure 4-2. Program Worksheet.

Table 4-1
Code Listing for Program Control

Program Code	300-360 Operation	362 Operation
01	Stop	Stop
10	Store Reg 0	Store Half B
11	Store Reg 1	Store Half A
12	Store Reg 2	Add Full
13	Store Reg 3	Store Full
14	Recall Reg 0	Recall Half B
15	Recall Reg 1	Recall Half A
16	Recall Reg 2	Subtract Full
17	Recall Reg 3	Recall Full
41	Enter	Enter
42	Log_eX	Log_eX
43	e^x	e^x
44	$\sqrt{X}$	$\sqrt{X}$
45	X^2	X^2
46	X=	X=
47	÷=	÷=
50	Clear Right Adder	Clear Right Adder
51	Recall Right Adder	Recall Right Adder
52	+ Right Adder	+ Right Adder
53	– Right Adder	– Right Adder
54	Clear Left Adder	Clear Left Adder
55	Recall Left Adder	Recall Left Adder
56	+ Left Adder	+ Left Adder
57	– Left Adder	– Left Adder
60	Numeral 0	0 and Reg 0
61	Numeral 1	1 and Reg 1
62	Numeral 2	2 and Reg 2
63	Numeral 3	3 and Reg 3
64	Numeral 4	4 and Reg 4
65	Numeral 5	5 and Reg 5
66	Numeral 6	6 and Reg 6
67	Numeral 7	7 and Reg 7
70	Numeral 8	8 and Reg 8
71	Numeral 9	9 and Reg 9
75	Decimal Point	Decimal
76	Clear Display	Cl. D. and Reg 10
77	Change Sign	Ch. S. and Reg 11



4.5 EXAMPLES OF CARD PROGRAMS

The Pythagorean Law states that $c^2 = a^2 + b^2$, or $c = \sqrt{a^2 + b^2}$. The following program uses this equation to find the value of "c". Note that just the calculations are programmed, and the variables are manually keyed-in where necessary. This approach enables the user to use the same program regardless of the variables.

CALCULATOR PROGRAM No. Date:

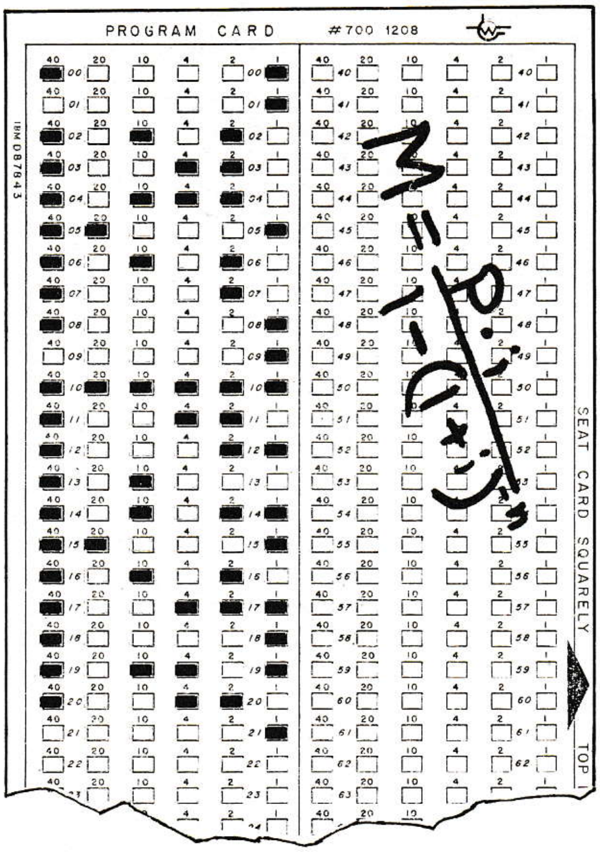
$c = \sqrt{a^2 + b^2}$

1. Depress CLEAR ALL
2. Index value of "a"
3. Press START
4. Index value of "b"
5. Press CONTINUE
6. Record answer

No.	Cmd	Code	Comment	No.	Cmd	Code	Comment
00	X^2	45		40			
01	CL AL	54		41			
02	+ AL	56		42			
03	STOP	01		43			
04	X^2	45		44			
05	+ AL	56		45			
06	$\sqrt{X}$	44		46			
07	STOP	01		47			
08				48			
09				49			
10				50			
11				51			
12				52			
13				53			
14				54			
15				55			
16				56			
17				57			
				58			

Code Listing for Program Cont

PROGRAM



The following program computes monthly mortgage payments and uses the Formula

$$M = \frac{P \cdot i}{1 - (1 + i)^{-n}}$$

Where:

P = principal
i = rate of interest per month
n = number of monthly periods.

Note the test written on the worksheet for checking program card.

CALCULATOR PROGRAM No. Date:

Monthly Mortgage Payment

$$M = \frac{P \cdot i}{1 - (1 + i)^{-n}}$$

1. Depress CLEAR ALL
2. Index P
3. Press START
4. Index i
5. Press CONTINUE
6. Index n
7. Press CONTINUE
8. Read answer

TEST

P = $16,000
i = 6%/yr = .005/mo.
n = 15 yrs or 180 mos.
Ans. = $135.0170925
List of operations.

No.	Cmd	Code	Comment	No.	Cmd	Code	Comment
00	ENTER	41		40			
01	STOP	01	Index i	41			
02	+ AR	52		42			
03	X =	46		43			
04	+ AL	56		44			
05	1	61		45			
06	+ AR	52		46			
07	Log_eX	42		47			
08	ENTER	41		48			
09	STOP	01	Index n	49			
10	CHS	77		50			
11	X =	46		51			
12	e^x	43		52			
13	CL AR	50		53			
14	– AR	53		54			
15	1	61		55			
16	+ AR	52		56			
17	÷ =	47		57			
18	ENTER	41		58			
19	RE AL	55		59			
20	X =	46		60			
21	STOP	01	Read M	61			

Code Listing for Program Control

PROGRAM CODE	300-360 OPERATION	362 OPERATION
01	Stop	Stop
10	Store Reg 0	Store Half B
11	Store Reg 1	Store Half A
12	Store Reg 2	Add F
13	Store Reg 3	

4.6 GENERAL PROGRAM COMMENTS

Programs tend to be as original as their creators, however, a few conventions, which lead to a smooth solution, should be followed. A STOP command must be provided for each variable that must be indexed, except for the one that is indexed prior to the start of the program. A STOP command is mandatory at step 79 (row 80) and step 158 (row 80 of second card) and step 237 (row 80 of third card) of multi-card programs.

It is recommended that no lines be skipped within a program, since the program will stop at a blank step and CONTINUE must be pushed. Also, use of unassigned code numbers may cause incorrect results, so CLEAR ALL must be pushed and the program re-started.

Multi-card programs (2 or more cards) require, as mentioned above, STOP commands at step 80 (and step 160 and step 240, etc.). When the end of the first card is reached, it is removed, the next card is inserted, and without clearing anything, START is pushed. This procedure is repeated for any subsequent cards.

The Model CP-1 Card Programmer also has STEP-AUTO switch located on the side panel. When the switch is on AUTO, the program steps are read automatically in sequence. When the switch is on STEP, only one step at a time is read. START must be pushed for the first step and CONTINUE for each step thereafter. The STEP mode is particularly useful when de-bugging a program.

When the programmed automatic routine is started, it should be allowed to run its course. If the program must be stopped, the best procedure is to open up the Card Programmer. The CLEAR ALL key should not be depressed to stop a program when a simultaneous electronic package is used. If this condition should accidently occur, the electronic package may require repriming.

4.7 PROGRAM LIBRARIES

Program libraries are furnished with each Model CP-1 Card Programmer and range from statistical applications to surveying applications. The libraries contain actual working programs that have been developed to assist users with their requirements.

4.8 PROGRAM SETUP PROCEDURE

The setup procedure consists of merely connecting the Model CP-1 Card Programmer between the keyboard and the electronic package. Refer to the installation instructions in Section 2 for detailed instructions.

CAUTION:
Ascertain that keyboard power is off before interconnecting equipment.

4.9 STARTING AND RUNNING THE PROGRAM

This procedure consists of inserting the program card, starting the program, and keying-in the data as required throughout the course of the program. The following procedural steps are basic to all programs.

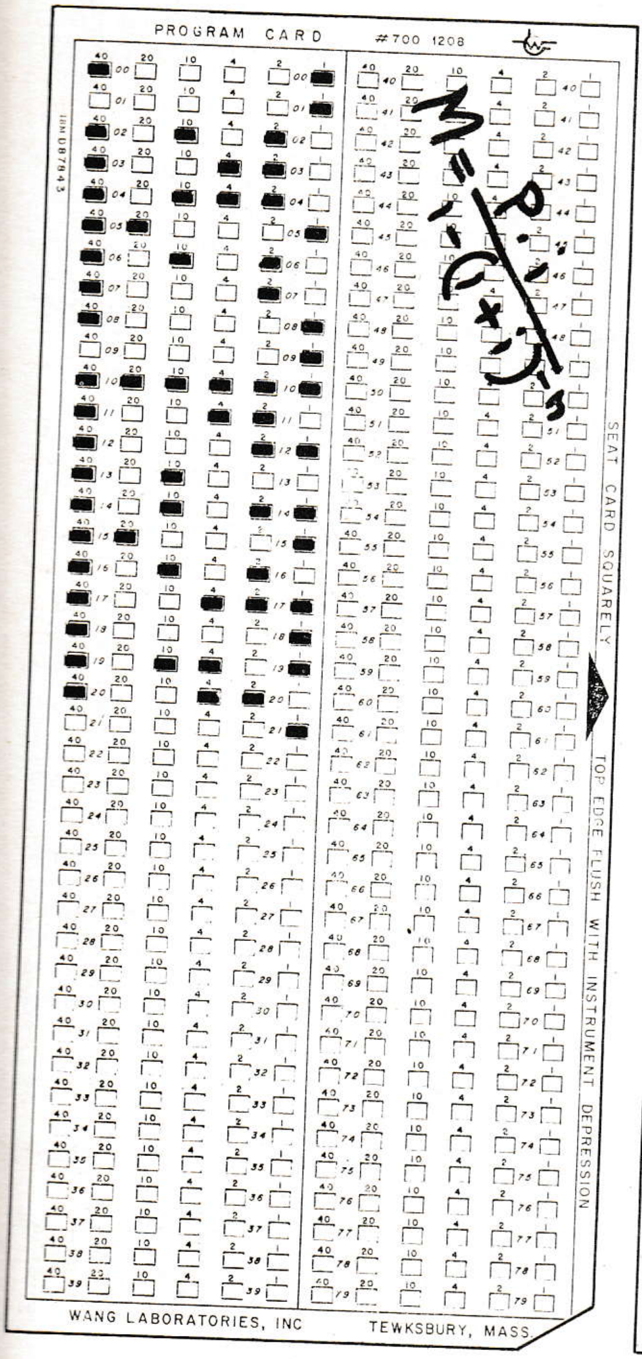
a. Insert program card into Card Programmer. Card is inserted with printed side facing the pin contacts and cropped corner to the upper right hand corner of the Card Programmer. Close Card Programmer by depressing thumb locks.

b. Turn on keyboard if "off" and depress **CLEAR ALL** key.

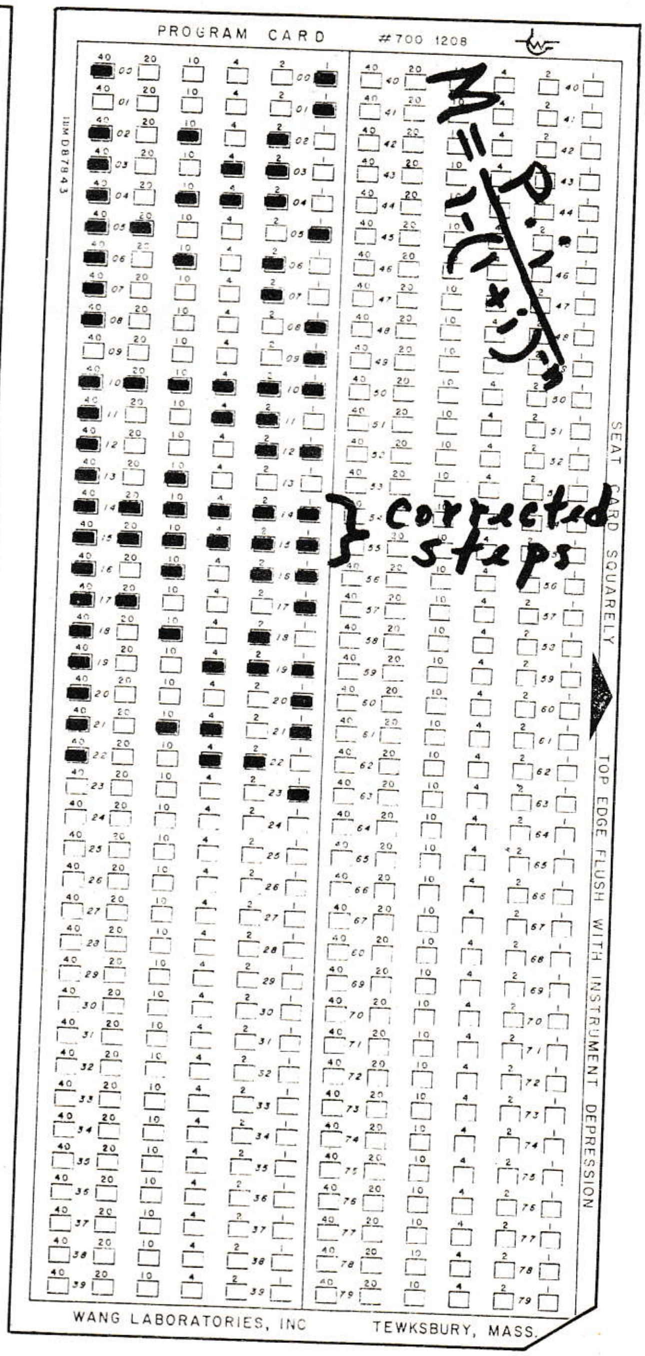
c. Peruse program work sheet for specific instructions.

d. Ascertain that **AUTO-STEP** switch on Card Programmer is in **AUTO** position.

NOTE:
Step position of **AUTO-STEP** switch is used to sequentially check each step of a program. The **CONTINUE** switch is used to advance the program step-by-step for this operation mode.



Correct Card



Corrected Card

Figure 4-3 Example of Correct and Corrected Cards

e. Key in data and depress **START** switch located on top of card programmer.

f. Program will automatically perform the programmed calculations and stop at the predetermined program steps to allow the keying of data, etc. After each programmed stop, the **CONTINUE** switch must be depressed to resume the programmed operations.

g. After completion of the program, the card may be removed from the Card Programmer. The calculator will operate normally and disregard the condition of the Card Programmer. It may remain connected, open or closed. To prevent accidental damage to the pin contacts, however, it is recommended that it be closed.

4.10 SCIENTIFIC NOTATION

Models 320, 360, and 362 Calculators can multiply, divide and find powers of X^n such that the magnitude of the results can range from 10^{-99999} to 10^{99999}! This type of calculation can be done using the two programs, *Multiplication and Division Using Scientific Notation,* No. 329.24 – MA, and X^n *Using Scientific Notation,* No. 320.23 – MA; and the principles of scientific notation.

Most users are familiar with the concept of scientific notation. Basically it is a method used to represent extremely large or extremely small numbers. A number in scientific notation has two parts; the number itself followed by a power of 10 which designates where the decimal point should be. A positive power, such as 10^n means the decimal point is to be moved n places to the right; a negative power indicates that the decimal point is to be moved n places to the left. Thus, 8.67 X 10^4 in scientific notation represents the number 86700; 8.67 X 10^{-4} represents the number .000867.

Therefore, these two programs are quite useful when we wish to perform calculations on extremely large or extremely small numbers. For instance, if we wish to calculate $986.5^{-36.5}$, the answer is extremely small, and if we do this directly on the Wang Calculator we will wind up with .000. . . However, if we use X^n *Using Scientific Notation,* No. 320.23 – MA, by following the operating procedure, we will be able to determine the answer.

OPERATING PROCEDURE

1. CLEAR ALL
2. Index X = 986.5; push START
3. Index n = 36.5 CHS; push CONTINUE

The display reads –5.193500110. The first five places of the display contains the number; the last five places contain the power of 10; and the sign indicates the sign of power of 10. Thus, $986.5^{-36.5}$ = 5.1935 X 10^{-110}.

Also, we can multiply and divide extremely large and extremely small numbers by using Program No. 320.23 – MA. The program is written to find the answer to the expression

$$\frac{A.B.C. \ldots .N_1}{X.Y.Z. \ldots .N_2}$$

Thus, if we want to calculate

$$\frac{111{,}111 \text{ X } 222{,}222}{999{,}999{,}999 \text{ X } 888{,}888{,}888 \text{ X } 777{,}777{,}777}$$

we simply follow the operating procedure.

OPERATING PROCEDURE

1. CLEAR ALL
2. Key in A = 111 111; push START
3. Repeat step 2 for B,C,. . .N_1
   N_1 = 222 222; push START
4. Key in X = 999999999 CHS; push START
5. Repeat step 4 for Y,Z,. . .N_2
   Key in Y = 888888888 CHS; push START
   Key in N_2 = 777777777 CHS; push START
6. After all numbers in the denominator are entered; push CONTINUE

The display reads –3.571400017, which means
(3.5714 = number; 00017 = power of 10)

the answer is 3.5714 X 10^{-17}.

CALCULATOR PROGRAM

No. 320-24-MA   Date: May, 1968

MULTIPLICATION AND DIVISION SCIENTIFIC NOTATION

A . B . C . . . . N
X . Y . Z . . . . N

1. CLEAR ALL
2. KEY IN A PRESS START
3. REPEAT STEP 2 FOR B, C . . . . N
4. KEY IN X, CHANGE SIGN PRESS START
5. REPEAT STEP 4 FOR Y, Z . . . . N
6. PRESS CONTINUE
7. FIRST 5 PLACES OF DISPLAY CONTAIN NUMBER, LAST 5 PLACES CONTAIN POWER OF 10. SIGN INDICATES + OR – POWER.

No.	Cmd	Code	Comment	No.	Cmd	Code	Comment
00	$\text{LOG}_e X$	42		40	0	60	
01	X =	46		41	$\text{LOG}_e X$	42	
02	+AR	52		42	ENTER	41	
03	STOP	01		43	RECALL AR	51	
04	.	75		44	X =	46	
05	0	60		45	e^x	43	
06	0	60		46	CLEAR AR	50	
07	0	60		47	ENTER	41	
08	0	60		48	.	75	
09	1	61		49	0	60	
10	X^2	45		50	0	60	
11	+AL	56		51	1	61	
12	1	61		52	X^2	45	
13	0	60		53	ENTER	41	
14	$\text{LOG}_e X$	42		54	.	75	
15	÷ =	47		55	0	60	
16	ENTER	41		56	0	60	
17	RECALL AR	51		57	0	60	
18	X =	46		58	0	60	
19	CLEAR AR	50		59	0	60	
20	ENTER	41		60	1	61	
21	1	61		61	÷ =	47	
22	X =	46		62	+AR	52	
23	+AR	52		63	RECALL AL	55	
24	.	75		64	ENTER	41	
25	5	65		65	.	75	
26	–AR	53		66	1	61	
27	ENTER	41		67	ENTER	41	
28	RECALL AL	55		68	.	75	
29	X =	46		69	0	60	
30	ENTER	41		70	0	60	
31	RECALL AL	55		71	0	60	
32	÷ =	47		72	1	61	
33	CLEAR AL	54		73	X^2	45	
34	+AL	56		74	$\text{LOG}_e X$	42	
35	–AR	53		75	e^x	43	
36	.	75		76	+AR	52	
37	5	65		77	X =	46	
38	+AR	52		78	STOP	01	
39	1	61		79			

Code Listing for Program Control

PROGRAM CODE	300-360 OPERATION	362 OPERATION
01	Stop	Stop
10	Store Reg 0	Store Half B
11	Store Reg 1	Store Half A
12	Store Reg 2	Add Full
13	Store Reg 3	Store Full
14	Recall Reg 0	Recall Half B
15	Recall Reg 1	Recall Half A
16	Recall Reg 2	Subtract Full
17	Recall Reg 3	Recall Full
41	Enter	Enter
42	$\text{Log}_e X$	$\text{Log}_e X$
43	e^x	e^x
44	$\sqrt{x}$	$\sqrt{x}$
45	X^2	X^2
46	X =	X =
47	÷ =	÷ =
50	Clear Right Adder	Clear Right Adder
51	Recall Right Adder	Recall Right Adder
52	+ Right Adder	+ Right Adder
53	– Right Adder	– Right Adder
54	Clear Left Adder	Clear Left Adder
55	Recall Left Adder	Recall Left Adder
56	+ Left Adder	+ Left Adder
57	– Left Adder	– Left Adder
60	Numeral 0	0 and Reg 0
61	Numeral 1	1 and Reg 1
62	Numeral 2	2 and Reg 2
63	Numeral 3	3 and Reg 3
64	Numeral 4	4 and Reg 4
65	Numeral 5	5 and Reg 5
66	Numeral 6	6 and Reg 6
67	Numeral 7	7 and Reg 7
70	Numeral 8	8 and Reg 8
71	Numeral 9	9 and Reg 9
75	Decimal .	Decimal .
76	Clear Display	Cl. D. and Reg 10
77	Change Sign	Ch. S. and Reg 11

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CALCULATOR PROGRAM

No. 320-23-MA

Date: May, 1968

X^n

SCIENTIFIC NOTATION

1. CLEAR ALL
2. KEY IN X
3. PUSH START
4. KEY IN N
5. PUSH CONTINUE
6. FIRST 5 PLACES OF DISPLAY CONTAIN NUMBER, LAST 5 PLACES CONTAIN POWER OF 10. SIGN INDICATES + OR – POWER.

TEST

$986.5^{-36.5}$

DISPLAY NUMBER	READS POWER OF 10
–5.1935	00110

or

5.1935×10^{-110}

Code Listing for Program Control

PROGRAM CODE	300-360 OPERATION	362 OPERATION
01	Stop	Stop
10	Store Reg 0	Store Half B
11	Store Reg 1	Store Half A
12	Store Reg 2	Add Full
13	Store Reg 3	Store Full
14	Recall Reg 0	Recall Half B
15	Recall Reg 1	Recall Half A
16	Recall Reg 2	Subtract Full
17	Recall Reg 3	Recall Full
41	Enter	Enter
42	Log_eX	Log_eX
43	e^x	e^x
44	$\sqrt{x}$	$\sqrt{x}$
45	X^2	X^2
46	X =	X =
47	÷ =	÷ =
50	Clear Right Adder	Clear Right Adder
51	Recall Right Adder	Recall Right Adder
52	+ Right Adder	+ Right Adder
53	– Right Adder	– Right Adder
54	Clear Left Adder	Clear Left Adder
55	Recall Left Adder	Recall Left Adder
56	+ Left Adder	+ Left Adder
57	– Left Adder	– Left Adder
60	Numeral 0	0 and Reg 0
61	Numeral 1	1 and Reg 1
62	Numeral 2	2 and Reg 2
63	Numeral 3	3 and Reg 3
64	Numeral 4	4 and Reg 4
65	Numeral 5	5 and Reg 5
66	Numeral 6	6 and Reg 6
67	Numeral 7	7 and Reg 7
70	Numeral 8	8 and Reg 8
71	Numeral 9	9 and Reg 9
75	Decimal .	Decimal .
76	Clear Display	Cl. D. and Reg 10
77	Change Sign	Ch. S. and Reg 11

No.	Cmd	Code	Comment	No.	Cmd	Code	Comment
00	LOG_eX	42		40	ENTER	41	
01	+AR	52		41	RECALL AR	51	
02	.	75		42	X =	46	
03	0	60		43	e^X	43	
04	0	60		44	CLEAR AR	50	
05	0	60		45	ENTER	41	
06	0	60		46	.	75	
07	1	61		47	0	60	
08	X^2	45		48	0	60	
09	+AL	56		49	1	61	
10	1	61		50	X^2	45	
11	0	60		51	ENTER	41	
12	LOG_eX	42		52	.	75	
13	÷ =	47		53	0	60	
14	ENTER	41		54	0	60	
15	RECALL AR	51		55	0	60	
16	X =	46		56	0	60	
17	CLEAR AR	50		57	0	60	
18	ENTER	41		58	1	61	
19	STOP	01		59	÷ =	47	
20	X =	46		60	+AR	52	
21	+AR	52		61	RECALL AL	55	
22	.	75		62	ENTER	41	
23	5	65		63	.	75	
24	–AR	53		64	1	61	
25	ENTER	41		65	ENTER	41	
26	RECALL AL	55		66	.	75	
27	X =	46		67	0	60	
28	ENTER	41		68	0	60	
29	RECALL AL	55		69	0	60	
30	÷ =	47		70	1	61	
31	CLEAR AL	54		71	X^2	45	
32	+AL	56		72	LOG_eX	42	
33	–AR	53		73	e^X	43	
34	.	75		74	+AR	52	
35	5	65		75	X =	46	
36	+AR	52		76	STOP	01	
37	1	61		77			
38	0	60		78			
39	LOG_eX	42		79			

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SECTION 5

ITEM COUNTER OPERATION

5.1 GENERAL

Item counting capability, added to any 300 series calculator, provides the user with the means for tallying many of the keyboard operations (refer to p. 1-6). Primarily used for statistical applications, many other uses warrant the addition of this accessory.

5.2 OPERATING INSTRUCTIONS

Operation of the Item Counter is controlled by a series of selector switches. To count a desired function, set the appropriate switch by pushing it to the upper position. The counter is "zeroed" by depressing the black knob located directly below the readout window.

Example 1

Count the Number of Items in an X^2 operation:
Set the Counter $\mathbf{X^2}$ selector switch to the upper position. Set all other selector switches to the lower position. Set the counter readout to zero. Operate the keyboard for all values of X to be squared. The IC-1 will indicate the number of calculations of the $\mathbf{X^2}$ function.

Example 2

Count the Number of Multiplications:
Set the **X=** switch of the IC-1 to the upper position. Place all other switches to the lower position. Set the counter readout to zero. Perform multiplications on the keyboard as usual. The IC-1 will indicate the number of multiplication operations performed.

Example 3

Count the Number of Divisions:
Set the **ENTER** switch of the IC-1 to the upper position. Place all other switches to the lower position, and set the counter readout to zero. Perform divisions on the keyboard; the IC-1 will indicate the number of division operations performed.

SECTION 6

WARRANTY, SERVICE AND MAINTENANCE

6.1 WARRANTY

Wang electronic equipment is warranted to be free from defects in workmanship and materials for 90 days from delivery to the original purchaser; parts only are warranted for one year, exclusive of labor. Readout tubes, transistors, and fuses are subject to the RETMA guarantee (substituted tubes should be returned to Wang Laboratories). This warranty is in lieu of all other warranties expressed or implied, except as specifically modified in writing by a document signed by an officer of WANG LABORATORIES, INC. Except for such a document, no representative or other person is authorized to represent or assume for WANG LABORATORIES, INC. any warranty liability beyond that set forth herein. Use limits and time between overhaul hours may be specified for mechanical and rotary elements of a Wang system. During the warranty period, Wang equipment is serviced free of charge except for occasional freight cost to and from a service center.

6.2 POST-WARRANTY SERVICE AVAILABILITY

Wang Service Centers are located in many major cities throughout the world. It is a product service policy to restore the operation of a customer's unit within 24 hours of the service call. For remotely located users, equipment turnaround is normally within one day after arrival at the center. Spare parts, as well as circuit board repair capability are available at all service centers.

6.3 ANNUAL MAINTENANCE CONTRACT

An annual maintenance contract is available that consists of adjusting, replacing parts when required and keeping the equipment in first-class operating condition. The contract includes all necessary service calls. It does not include repair necessitated by accident, current fluctuations, fire, abuse, or negligence.

6.4 POST-WARRANTY SERVICE CALLS WITHOUT MAINTENANCE CONTRACT

All service calls made to customer's facilities not having a service contract will be charged on an hourly basis point to point between the Wang Service Center and equipment location. Automobile charges per mile and material costs will also be included.

NOTE:

Users who attempt to repair Wang equipment, without receiving prior Wang equipment training, run the risk of causing further damage to their equipment. Also, and more important, internal equipment voltages are present that could cause severe electrical shock.

6.5 IN-HOUSE MAINTENANCE CAPABILITY

Wang Laboratories offers free product familiarization lessons for customers that desire to build up an in-house capability for maintaining their equipment. The customer, of course, is expected to defray the travel and living expenses of his service representative while in training at Wang Laboratories, Tewksbury, Massachusetts.

Appendix A1

REVIEW OF EXPONENTIALS AND LOGARITHMS.

Logarithms and exponentials (anti-logs) are most commonly encountered as simple methods of facilitating multiplication and division. We shall review the salient points in these concepts. Excellent detailed treatment can be found in good high school algebra texts such as Dolciani.

A1.1 EXPONENTIALS.

For convenience in writing and manipulation, numbers are often expressed as factors of appropriate powers of 10.
For example:

4,587,000, may be written as 4.587×10^6,
4587 " " " " 4.587×10^3,
4.587 " " " " 4.587×10^0,
.4587 " " " " 4.587×10^{-1},
.0004587 " " " " 4.587×10^{-4},
$.001 = \frac{1}{1000}$ " " " " 10^{-3}.

We notice that with the exponential notation, multiplication and division of numbers of the form 10^n are reduced to addition and subtraction. For example:

$$100 \times 1000 = 10^2 \times 10^3 = 10^5 = 100{,}000,$$

$$\frac{1}{100} \times \frac{1}{1000} = 10^{-2} \times 10^{-3} = 10^{-5} = \frac{1}{100{,}000} = .00001,$$

$$\frac{1}{100} \times 1000 = 10^{-2} \times 10^{+3} = 10,$$

and,
$$\frac{1}{10} \times 10 = 10^{-1} \times 10^1 = \underline{10^0 = 1.}$$

This can naturally be generalized:

$$2^2 \times 2^4 = 2^{2+4} = 2^6,$$

$$3 \times \frac{1}{3^4} = 3^{1-4} = 3^{-3},$$

and
$$(a^{y_1}) / (a^{y_2}) = a^{y_1 - y_2}.$$

This is the motivation behind the use of logarithms for multiplication and division.

A1.2 LOGARITHMS.

The logarithm of a number X is defined with respect to a base δ. The notation is $\mathrm{Log}_\delta(X)$, and it is an exponent for the base δ. A number y is the logarithm of X with base δ if,

$$X = \delta^y \quad (\text{or, } X = \delta^{\mathrm{Log}_\delta(X)}).$$

A1.2 (Continued)

In accordance with this definition,

$Log_{10}100 = 2$, since $100 = 10^2$,

$Log_{10}.001 = -3$, since $.001 = 10^{-3}$,

$Log_2 8 = 3$, since $8 = 2^3$.

What is $Log_2 64$? $Log_3(1/27)$?

Suppose we wish to multiply two numbers X_1 and X_2. If we can find the logarithms y_1 and y_2 with respect to a base δ, then

$X_1X_2 = (\delta^{y_1})(\delta^{y_2}) = \delta^{y_1+y_2}$,

i.e., $Log_\delta(X_1X_2) = y_1 + y_2 = Log_\delta(X_1) + Log_\delta(X_2)$.

Let $y = y_1 + y_2$.

The answer X_1X_2 can be found easily if the inverse process (sometimes written as anti-log (y) or Log^{-1} (y)) of finding the exponential δ^y is easily performed. Normally, the log of a number is found by looking in a table. The anti-log, or, inverse process is formed by going the other way in the table. Division can be similarly performed:

$X_1/X_2 = (\delta^{y_1})/(\delta^{y_2}) = \delta^{y_1-y_2}$,

or,

$Log_\delta(X_1/X_2) = y_1 - y_2$.

We have considered the general case of base δ. In practice, a fixed base is chosen, and tables of y published to correspond to values of X. Common logs use the base $\delta = 10$, whereas natural logs use the base $\delta = e = 2.718281828\ldots$* Extensive tables for both bases have been published in the past few centuries. The advent of these tables in the 17th century provided a happy thrust to the volume of calculations which paved the way for scientific theories formulated during the age.

The usage of log tables reduces multiplication to addition, and division to subtraction. However, table search and interpolation can also be prone to errors. The Wang 300 System can generate natural logarithms or anti-logarithms at a single keystroke. We shall again resort to numerical examples. Thus, to find $Log_e 10$, simply key in [1] [0] [$Log_e X$]; the result +2.30258509 is displayed in the Work Register. Likewise, to find $e^{2.3}$, key the sequence [2] [.] [3] [e^x] to read +9.974182454.

Aside from saving time and reducing error, the log and exponential features facilitate the computation of expressions like X^Z where Z is not necessarily an integer. This can be performed simply on the 320 as follows:

1. Compute $Log_e(X)$ or $Ln(X)$ by the [$Log_e X$] key as described above;
2. Multiply result of 1 by Z
3. Compute X^Z by using e^x key as above.

* There is no mystery to the number e. Like π, it is a number often found in calculations related to physical phenomenon. A non-terminating decimal, or an irrational, e can be calculated to any desired accuracy, by the formula $e = 1 + 1/2! + 1/3! + \ldots$

A1.2 (Continued)

Consider the following numerical examples.

1. $2^{2.3}$

[2] [$Log_e X$]	$Log_e(2)$ in Work Register
[Enter] [2] [.] [3] [X=]	2.3 $Log_e(2)$ in Work Register
[e^x] Read: +4.924577651	$2^{2.3}$ in Work Register

2. $\sqrt[3]{2}$

[2] [$Log_e X$]	$Log_e(2)$ in Work Register
[Enter] [3] [÷=]	1/3 $Log_e(2)$ in Work Register
[e^x] Read: +1.259921049	$\sqrt[3]{2}$ in Work Register

3. $Log_{10}(2)$

[Clear All] [1] [0] [$Log_e X$] [+ (Left)]	$Log_e 10$ in Left Adder
[2] [$Log_e X$]	$Log_e(2)$ in Work Register
[Enter] [Recall (Left)] [÷=]	$Log_e(2)/Log_e(10)$
Read: +.3010299957	Log10(2) in Work Register

Note: $10 = e^{Log_e(10)}$

If $Z = 10^Y = e^{Y \log_e(10)}$

$Log_e(Z) = Y\ Log_e(10)$

$Y = Log_e(Z) / Log_e(10)$

Since Y is $Log_{10}(Z)$, we have $Log_{10}(Z) = Log_e(Z)/Log_e(10)$

Exercises: Perform on the keyboard.

1. $(37.4)^5$ = (Answer: 73174 204.55)
2. $(.00479)^{1.4}$ = (Answer: .00056 55483)
3. $(26400)^{1/8}$ = (Answer: 3.5702 65315)
4. $(46.3)^{1/4}$ = (Answer: 2.6085 26468)
5. $Log_{10}(100)$ = (Answer: 2)
6. $Log_{10}(1000)$ = (Answer: 3)
7. $Log_8(100)$ = (Answer: 2.2146 18730)

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