CALCULATOR USERS GUIDE AND DICTIONARY

by
Charles J. Sippl

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including:
An Index of Calculator Products and Manufacturers

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FIRST EDITION, 1976

ACKNOWLEDGEMENTS: Basic reference source for many of the terms and definitions in this dictionary is "Computer Dictionary and Handbook" published by Howard W. Sams & Co., Inc., 4300 West 62nd Street, Indianapolis, Indiana 46268. It is available through book stores, electronic parts distributors, or directly from the publisher. Approximately 15% of the more fundamental microcomputer definitions are excerpted from "Microcomputer Dictionary and Guide," Matrix Publishers, Inc., 1976. Many of the communications-oriented definitions can also be found, with significant elaboration, in the large volume, "Data Communications Dictionary," published in 1976 by Van Nostrand-Reinhold Company, New York.

How To Use This Book

The dictionary section of this book follows the standards accepted by most, but not all, modern lexicographers. All acronyms and terms of more than one word are treated as one word and abbreviations are also treated alphabetically. The letters "I/O" follow "Input-output" rather than appearing at the beginning of the I's.

For ease in quickly locating a specific term, the first and last entries on each page appear as reference words at the top of each page.

Extensive cross-referencing has been used as an aid in locating terms which you might look for in more than one place. For example, "ECL" may also be located as "emitter coupled logic." If you are not sure whether you want "memory" or "storage," check both; CMOS is filed as it would read as a word; commas and hyphens are disregarded. Again, think of each group of letters or words as a single word, including "ings" and "eds," then follow strict alphabetization to facilitate location efforts.

The author expresses his appreciation to all calculator manufacturers who forwarded photos, operation details, and other materials.

"This pocket calculator is far more than a revolution in technology . . . it is a revolution in individual management capability." "I believe the calculator will soon become as common as a pen. It will be difficult to locate many students, managers, scientists, business people, professionals . . . who do not carry one or do not have one very near by . . . ". "It can be said that the microprocessor (the heart of advanced calculators) is the bridge between the impossible and the possible. Certainly it is the link between today's challenges and tomorrow's realities. Coupled with human imagination and concern, the microprocessor can undoubtedly propel us to a better world. We need only the inspiration and opportunity to explore the microprocessor's possibilities." . . . . . These are random, anonymous quotes from Calculator Industry people.

Preface

Throughout history man has designed and built tools to extend his physical capabilities such as wheels to move his person and products faster and more conveniently, agricultural implements to increase his output and gathering of food and countless other extensions of his brawn but not his brain. Machines to count, measure, perform simple arithmetic and mathematics have remained few and relatively primitive for thousands of years. None of these are analytical, control or decision-making tools. The computer of the mid-twentieth century — our age — is the first tool that actually extends man's mental capabilities. The computer similates sets of circumstances, uses data it has electronically gathered, and develops conclusions, problem answers and decisions based on programs that man or the computer itself has designed and predetermined. And due to the power of its programs, the computer can control countless other machines, processes and procedures and do so with speeds calibrated in minute fractions of seconds. Truly, the computer is one of man's greatest marvels and more than a tool, it is a masterful servant, and indeed, for many — also man's job-substituting competitor.

But today's computers still have many problems and inconveniences for most users. The complexity of most larger systems, the cost of the equipment, difficulties of computer programming techniques, etc. continue to preclude its use by the great majority of the world's citizenry. Where computers are installed the cost of computer time, the inconvenience of waiting for a turn and the problems of having to learn and remember special computer languages and rules almost prohibit their widest and best use by managers, teachers, researchers, and myriads of professional people who should be their most immediate and hardest users. But the ever-industrious and ingenious designers of calculating devices have evidently solved most of these problems, and this very sudden turn of events has taken place within the past three to four years.

The central processing unit (CPU) is the heart of all computers. It performs the arithmetic, procedural and processing control and communication to and from memory units within computer systems. Computer engineers have reduced the size of this powerful electronic unit to about the space occupied by one of the printed 'O's on this page. This is the microprocessor — a maze of electronic connections and switches on a 'chip' of silicon. Together with some input-output 'pins', a few thousand transistors and discrete semiconductor devices, all almost invisibly tiny, used as memory to store coded (1s and 0s) data, information and programs, a complete microcomputer can be built which in total can be held on the tip of one's finger. Perhaps the greatest miracle of all of this, however, is that microprocessor chip powerhouses are being mass-produced at rates of up to one million a month by large semiconductor and computer companies around the world. The cost for the majority of them is less than a hundred dollars — and the simplest ones, which still have the power and versatility of the huge vacuum tube computers of 30 years ago, sell for $10 and even less in quantities of 20,000 to 50,000.

These microprocessors, and their input-output plus memory attachments are now being used as the controllers of advanced calculators, replacing more than 70 million "older" calculators. Microprocessors are now appearing in countless electronic games, watches, appliances, computer terminals, communication devices, automobiles, medical and scientific instruments and devices — and the industry is only in its infancy. In this book we are concerned with how the microprocessors and microcomputers can function as mass-user calculators — from the simple $30 to $100 four-to-six function (+, −, ×, ÷, %, $\sqrt{\ }$) with memory and special function keys to the very masterful 'computing' calculators that have peripherals attached such as big-screen terminals, graphic plotters, voice-input and answerback, and scores of others. The latter are 'programmable' calculators that function almost exactly as computers but without the problems of complexity, big expense, special language programming headaches, waiting in line for service, etc. Programmable calculators are "personal" computers that are very easy to operate, simple to program by almost any user or to operate with insertable program strips, cards, cassettes, etc. They are available as hand-held, pocket-size calculators or small typewriter-size low cost number crunchers and processed information distributors on the desks of immediate users, such as, clerks, managers, students, grade-schoolers — anybody, really. How much are these 'programmable' calculators — in their simplest, most easy to use but very versatile form? The book opens with the analysis and explanation of the 'below $30' units.

Unfortunately, however, many current calculator users and potential purchasers are totally confused when they attempt to make the decisions concerning what type, model, brand, capacity, capability, etc. calculator to purchase. In the calculator marketplace there are hundreds of different models and makes with sales personnel making claims (and proving them) of rather fantastic utility for practically any type of customer . . . and at near unbelievable low prices for the many sundry and also really great services. The confusion (and often frustration) results, as with most new technologies, from a bewildering array of strange terminology. Almost without warning, terms such as: stacks, loops, registers, ROM (Read Only Memory), RAM (Random Access Memory), LED (Light Emitting Diode) and scores of other strange words and acronyms are thrown out to customers as though they were as common as "See Spot Run" of first-grade days.

This book has as its primary purpose to (1) help take most of the confusion out of the judgement of the types and capabilities of the calculators in the marketplace by analyzing the products available, (2) explain the criteria and procedures required to evaluate many of these machines for proper selection of the type of calculator unit or system best suited for individual application, and (3) to offer a rather complete dictionary section to assist the reader in unraveling the mysteries of the new and rapidly growing importance of modern calculating, processing, communicating terminology. The dictionary section is broad, comprehensive, tutorial. The design of the dictionary section (Part III) is multipurpose: for use as specific 'lookup' of a single word or phrase or as a reference for a conceptual search or for an analysis of a single concept, technique, product or procedure. Perhaps its greatest value for many is its 'browsing' characteristic. If the reader determines he or she desires to learn more about 'advanced calculators,' for example, *several pages* are available to offer the opportunity to study or explore the full range of capabilities, adaptations, developments, applications, etc. — all in one section. This type of topic grouping reflects the effort of the author to provide a concise encyclopedic aspect to assist the true enthusiast for a quick and convenient quest to gain succinct knowledge in larger distinctly pertinent 'subject areas' in contrast to brusk, curt non-explanatory tight phrasing of many dictionaries. In designing the dictionary section in this way, a few of the rules of strict modern lexicography have been 'bent' a bit. The reader is advised to carefully read the 'How to Use' section to facilitate his 'search and find' adventure into calculating and electronics. A companion text is available from Matrix Publishers, Inc. entitled, "Programmable Calculators:" How to Use them in Business, Science and Industry — At Home and On the Job". For those interested in the microcomputer per se, the publisher offers a 704-page "Microcomputer Dictionary and Guide" and several lively pragmatic applications and technical design professional and college level texts.

The programmable calculator is now a major 'consumer computer.' A few years ago calculators were basically for mathematicians, who compute complex formulas; statisticians, who evaluate models and project values and events; engineers, who need instant answers in design work; educators, who teach math, computer and other sciences, and research specialists, who reduce large amounts of statistical or control data and information. Now programmability provides 'custom design' for professionals, managers, and practically every type of worker to input and resolve problems of all ranges and nature. The machines have outstanding characteristics and permit immediate personal problem-solving "by the person with the problem when he or she has the problem." They are not 'remote' or difficult to use. Properly programmed, they practically *automatically* solve the problems *where* they happen, *when* they happen and provide analysis as to *why* they happen. The slight strain to learn to master especially the more advanced models of calculators is well worth the effort for any and every type of worker with a progressive, alert mind.

It must be remembered, however, that we all must make the assumption that whatever the manufacturers are offering in the calculator lines of today, something better will be available tomorrow. Neither the designers nor the manufacturers can specify for any set length of time what they intend to do . . . this year, or even this month. Using calculators for fun and profit is an adventure and a challenge that carries with it a very personally satisfying reward of continuous self-accomplishment and contentment.

Charles J. Sippl

INTRODUCTION

Calculator industry specialists estimate that another 50 to 70 million calculators will be sold to North Americans from mid-1976 to mid-1978. The rate of sales jumped from a few million per year in the early 1970s to about 20 million in 1975. Exports of Japanese calculators to the U.S. in December, 1975 alone totalled 1,550,521, according to the Japanese Finance Ministry. The Japanese shipments to the U.S. for 1975 totalled 11,074,779 (of the 32 million Japan and the Far East produced). The U.S. produces and sells about 7 to 9 million, the majority of them being the more expensive or 'high-end' of the market. The retail prices of all units range from $5 to $10,000 — from shirt-pocket simple arithmetic units to very large calculator systems with practically all the power, peripherals, and versatility of medium-to-large computer-communications systems. Users range from 5-and 6-year-olds to atomic and space scientists — and practically everybody in-between.

Astronauts used them in outerspace; ocean bottom 'dwellers' use them as lifeline system controllers. Their real potential as sophisticated, customized personal processing and control instruments and expandable systems is now only being approached. As their range of cost-effective advantages becomes larger, their physical size and their costs become smaller. A scientific and commercial phenomenon unheard of in the annals of technological history. This remarkable achievement by the computer and calculator industry is causing both 'first-time' users and calculator veterans to 'trade-up' for ever-more capability — and the significant side-effect is a subtle reduction in the formerly almost all-pervasive 'fear of computers.' The problem of each user selecting the 'right calculator' for his specific range of tasks becomes more difficult as each new 'miracle' model emerges and the costs of 'unlimited — anybody can do it' programmability fall drastically. Excellent 'programmables' are available for under $30, and convenient and 'beautiful' hand-held machines that can accept 'pocketfuls' of 'miracle' programs for near-automatic operation are available for less than $400. The successful search and the purchase of just the right one that fits specific users job, hobby, or challenge can be a joy of personal fulfillment. The 'quick' buyer who fails to seriously evaluate and mentally digest the latest information of low cost available functions and capabilities will return to demonstrate his 'electronic brain' to his peers and associates only to become terribly dejected in frustration and depleted of funds that could have otherwise been well-spent. The information required and the 'understandability' knowledge desired relates to: 'preprogrammed' functions; internal and peripheral memories, alternate logic manipulation, and it goes on. The new terminology might be a little difficult at first, but it reflects the new nomenclature — new phrases and concepts that quickly become very standard, day-by-day conversational, common words of the computing, processing, communicating language of our new electronic world.

LIST OF ILLUSTRATIONS

TABLE OF CONTENTS

CALCULATOR CLASSIFICATION SYSTEM

The maze of the calculator marketplace can be organized into a relatively basic structure of calculator types, their components and capabilities. On a rather primitive but functional basis the classifications fall into groups of threes — three general *classifications* of calculating instruments; three *types of operating units* in each classification; three primary characteristics of each type of unit, three types of memory; three types of logic; three types of software (programs) and 3 general classes of peripherals. This organization system hopefully will provide a pathway for the eager calculator purchaser — whether he or she is a high school student, a manager of a large bank or industry, or an ivory-towered superbrain about to solve man's toughest problems. Calculators are a blessing and a sound investment for each and all of them. They're fun — and they pay off in both the short and long run. How does one tell which are which? Let's try!

Practically all calculators are: Hand-Held (pocket); Desk-Top (display or printing, or both) or computing (control systems). These are the basic and broad classifications, and within *each class* the calculator will either be: (A) Basic — Four-to-Six Function; (B) Preprogrammed (Basic or Advanced) and (C) Programmable (Basic or Advanced).

CALCULATORS: CLASS AND FUNCTION STRUCTURE

CLASS

I. HAND-HELD	II. DESK-TOP	III. COMPUTING
A. Four-Six Function	A. Four-Six Function	A. Prompting/ Peripherals
B. Preprogrammed	B. Preprogrammed	B. Exterior Memories/ High Level Languages
C. Programmable	C. Programmable	C. CRT Computing Systems

TYPE

A. FOUR-SIX FUNCTION	B. PREPROGRAMMED	C. PROGRAMMABLE
1. Arithmetic	1. Slide-Rule/Scientific	1. Keyboard/Temporary
2. Memory	2. Business/Financial	2. Card, Tape, ROM (Permanent)
3. Special Function Keys (SFKs)	3. Professional/Specialist	3. Language/Interactive

MEMORY TYPES

1. Intermediate Storage
2. Addressable Storage (direct/indirect)
3. Automatic Input-Output Storage

LOGIC TYPES

1. Arithmetic
2. Algebraic
3. Reverse Polish Notation (RPN)

SOFTWARE (PROGRAMS)

1. Simple Formula
2. Decision-making
3. Interactive/microprogrammable

PERIPHERALS

1. Input-Output
2. Communication
3. Control (Remote)

The Hand-Held, Preprogrammed, and Programmable Classes all carry subgroups as either: Basic or Advanced.

Thus a Desk-Top (Class) Type B-2 would be a: Desk-Top Preprogrammed Business/Financial Calculator. Because its preprogrammed and not programmable, it would have no exterior software capability. But, it could have Memory Type 2, Indirect Addressable Storage, and Type 3 Logic, RPN, and Type 1 Peripherals, i.e., Input-Output (printer, or voice output).

It will be difficult to discover any calculator that does not fall within these three Broad Classes, Functional Types, or Memory, Logic, Software or Peripherals groups.

The Sections of Part I and Part II are organized within this Classification Structure — and the products and capabilities are related competitively, generally — as of late '76.

EVALUATION OF HAND-HELD CALCULATORS: THE BASIC TYPES AVAILABLE

The calculator selected should have individually desired capabilities and conveniences — the built-in functions, memories and other features required to solve many specific problems quickly, easily, accurately and without confusion. In most cases the simple unprogrammable or unprepreprogrammed calculator will not suffice — even providing it can handle the required number of digits and may also include "%" and constant keys, i.e. special function keys or SFKs. Usually problems extend beyond basic arithmetic. The hard user needs a professional pocket calculator — designed and manufactured for day-in, day-out professional use.

Professional calculators are designed with the specific capabilities required to quickly and easily solve problems intrinsic to a specific discipline or application. The preprogrammed nomenclature on the keys give users a quick insight into the types of problems the calculator can help solve. Broadly speaking, there are four main types of professional pocket calculators: Those designed for the Scientific and Engineering disciplines, Statistics units, Business units for broad ranges and those units for more exacting Financial disciplines.

Scientific Preprogrammed and Key Programmable Pocket Calculators — Professional "scientific" calculators generally provide the standard log and trig functions, so users don't have to refer to tables or interpolate from those tables. They just press the keys to get their answer — an answer far more accurate than any slide-rule can give. These "full scientific" calculators also provide exponential, square root and reciprocal functions. But these are only SFKs.

For handling more advanced types of scientific, engineering, business, mathematical or statistical problems, users need an "advanced business, statistics, financial or scientific" calculator. These have all the built-in functions found in the preprogrammed machines, plus the SFKs for a variety of others, depending upon which models are selected. These may include: mean, standard deviation, linear regression (trend line), and U.S./metric conversions, and many others.

These advanced models also offer more memory power . . . more sophisticated trig functions, such as rectangular coordinate/polar coordinate conversion . . . selectable modes (degrees, radians and, possibly grads) . . . conversion between decimal angle and angle in degrees/minutes/seconds . . . and others.

This added fixed capability facilitates the handling of complex problems and can drastically reduce the time and effort necessary to solve them. For example, polar/rectangular coordinate conversions let users add or subtract vector components in seconds, simply by pressing one or a few keys. The fixed functions are programmed.

The more proficient type of low cost professional scientific pocket calculators are key programmable. When solving complex, repetitive or iterative problems, programming can be invaluable. Users enter their specific problem-solving sequence of keystrokes just once . . . then, with just one keystroke initiate the entire sequence — as often as they wish.

But whatever scientific calculator one chooses, the more functions and features it has, the more capability it has to solve more types of problems — even the most complex — faster and easier, reducing the work users have to do. And the less chance for errors. Users should compare functions and features carefully before they make their final selection. At $100 or less: 4-function with SFKs ("scientific"), preprogrammed or key programmable, are all true bargains.

Business Pocket Calculators — Pre- or Key Programmed — Although a scientific calculator may be used for solving the more basic types of business problems, Key Programmable calculators especially designed for business and/or financial problems can soon pay for themselves in terms of time and effort saved — because they are made to solve specific business problems — giving users the exact answer they need when and where they need them.

A business calculator should provide all of the fundamental financial functions to solve problems involving interest rates; rates of return and discounted cash flows; extended percent calculations; remaining balances, amortization and balloon payments. But in addition, a business calculator should help the modern business manager in planning, forecasting and decision analysis. For these problems, a business calculator should provide advanced statistical capability, mathematical functions, and extra memory power, i.e. be preprogrammed.

In addition to business pocket calculators, there are also "advanced business" or "financial" calculators. These usually have all of the functions found in business calculators, but will also have more specialized capabilities to solve problems involving depreciation, bond prices, yields, etc. And because the latter require a calendar, these types of calculators will have one "built-in," as part of the group of programs designed and fixed within the operating capability of the specialized machines — either hand-held, desk-top or computing calculating tools.

For the solution of many types of specialized business or financial problems, involving extended calculations or unique and complex formulas, a key programmable calculator can be a tremendous time-saver. Since users enter their problem-solving sequence of keystrokes just once — and then with one keystroke start an entire sequence — they reduce their error ratio and as a result, have confidence in their answers.

Another point to consider when selecting a business calculator, is the basic financial concepts a user works with daily as a decision maker handling business transactions. The calculator selected should help in making decisions, then users save far more than the calculator costs, the first week they use it. And this, applies to a basic business 4-function or pre- or key programmable type for a very nice return on investment.

Four Criteria (Features) for Determining Problem-Solving Capabilities — Before users make their final selection of a pocket calculator, they should take a close look at four features that can make their problem-solving easier and more reliable. These are programmable capabilities, memory power, the logic system, and peripherals.

Programmable Capabilities — To reduce the number of keystrokes, and keystroke errors, even low-cost hand-held calculators can be programmed

— directed to initiate the desired keystrokes automatically. A sequence of keystrokes is used to automatically solve a problem or series of problems. Once a calculator is programmed, all users have to do is key in the data — the numbers for the specific problems they are solving — and press one key to run the entire program. Other preprogrammed capabilities can be 'wired-in' also.

A pocket calculator may be either "key" programmable or "fully" or use exterior programmability. A key programmable machine can usually be key programmed up to 100 steps by pressing the keys. (Then the program is temporarily stored in the program memory, where it remains until removed or changed by the calculator operator or until the calculator is turned off.)

With a fully programmable pocket calculator, that same program can also be permanently stored on an external device (such as magnetic "strips" or cards) and re-entered in the program memory when needed. Programming can be an extremely useful feature, saving time and energy and helping to avoid keystroke errors. Depending on the model, a fully programmable calculator may have provision for editing a program (adding, deleting or changing steps) and such computer-like operations as branching — choosing between two alternate steps depending upon the outcome of a relational test. A fully programmable calculator can actually make logical decisions for users.

For occasional key programming, a "programmable" machine (i.e., one with temporary storage capability) should suffice. But if users frequently handle problems that can be permanently programmed, they should consider a "fully programmable" calculator, and record their programs on program cards, strips, cassettes, etc. Then their specific and general applications are already programmed for multiple users . . . amateur or professionals.

Memory Power. — Every pocket calculator should have at least one addressable memory — to store constants or other numbers used more than once in a calculation. The more memories a calculator has, the less writing down of numbers that users have to do. With certain calculators having addressable memories, users can do register arithmetic — they can directly add to, subtract from, divide into or multiply the contents of a register. This makes data manipulation exceptionally easy, even when working problems involving three simultaneous linear equations (or other 3 x 3 matrix inversions).

Besides addressable memories, certain pocket calculators have an automatic memory (also called an operational stack, a four-memory stack, etc.). Entries and intermediate answers are stored automatically, then re-entered into the calculation at the appropriate time. Obviously, this eliminates the need for users to write down and re-enter numbers, which could lead to errors, and it speeds the work.

Logic Systems. — A logic system is the "language" used to communicate with a calculator — the way in which users key in problems and the way the calculator is designed to handle the problems. One logic system may require users to restructure an equation to conform to the system; another may not.

The three most common types of logic systems used in professional pocket calculators are algebraic, arithmetic and RPN logic. Users may wish to check out these systems, and determine for themselves which is the easiest to use (especially important when solving complex problems) . . . which is the least confusing (so they can have confidence in their answers) . . . and which is the best to use for solving the kinds of problems they face regularly.

Peripherals Availability. — In addition to everything mentioned so far, users should also — before selecting a specific type calculator — consider peripherals of the physical units for fast input and output of calculator data and instructions . . . cassettes, printers, readers, and the availability of accessories and wide-ranging applications books . . . and, of course, one must remember, a good value in an adequate calculator that's capable of solving specific problems today . . . may not help for tomorrow's problems. Programmables are best.

With all this in mind, users should study descriptions of each calculator type, compare the models, and select the one machine that comes closest to filling future needs. And those evaluating fully programmable calculators must carefully consider the types, quality and future programs (software) available or planned.

The Direction of Today's Calculator Buyers quests — A typical user today is a problem solver (and usually a multi-discipline problem solver). Users now expect more capability in the same package at a significantly lower cost. Pocket calculators have increased in number and complexity of functions and memory storage size. The gap between computer and calculator has gotten narrower and narrower. The alphanumeric input-output calculator, which has become a true computer by any definition, is now a reality in less than four years from the invention of the microprocessor. But these computers now remain in the form of a calculator. They sell better that way.

The user has grown in sophistication. Today's users have reached new skill levels and have mastered their present machines. They now want more capability, more memory, faster execution speeds, and more complex firmware (fixed programs). As long as there are more and more users experimenting with their machines, trying to solve their problems, there will be a need to share 'discoveries' and techniques. Through clubs, newsletters, and magazines, most calculator owners can become aware of applications information directly related to their job, hobby or specific calculator. Most want to acquire that information to stay ahead. Calculator user sophistication has become like various professional degrees. Alert and eager users continue to reach for levels of complexity and capability that represent new technical and mathematical vistas.

Today's pocket calculators are far from a complexity level that only a relatively few 'experts' can use them. Users are challenged, but they win. A few years ago the electronic slide rule that replaced volumes of mathematical tables was considered complex. Today every college campus has a large percentage of students using far more complex calculators like any other tool. Programmability rules today. Hundreds of thousands of 100+ step scratch-pad programmable machines that cost less than $100 are being sold. The straightforward four-function calculator has broken the $10

price barrier. Successful users of scratch-pad programmable machines now want to move up to machines with editing and conditional branching capability. Many manufacturers are providing these machines and also provide "free" many applications programs to attract customers. Most new users will transcend the scratch-pad programmable storage and purchase fully programmable (looping and editing) machines without much hesitation. And the emphasis of this book attests to this. A majority of users now want units with program recording capability. And they also now or soon will want units which have larger 'mass' storage capability made possible by magnetic tape cassettes. The general trend will be toward plug-in ROM programs and programmable machines with more exotic firmware functions.

The user of today primarily applies his calculator to personal and business affairs. Data handling capability must be enough that the machine will take on such tasks as record keeping and measurement. Complex analysis of data is now possible because of the extensive firmware functions built into the machines. The capability of the machines will become so great that the challenge of calculating will consume considerable time. The longer run times of complex programs will upset the owners and a keyboard interrupt capability will be an expected feature; this will allow a short, quick keyboard, time or register inspection operation to be performed. And the previously executing program can wait and then continue with great user satisfaction. The complex, current high technology society is spawning whole new generations of users applying calculators not only to time and money problems, but to such problems as optimizing the route to take in going to work. Measurement and numbers will continually take on a greater meaning for people. The hardware and firmware are being made ready, only the dissemination of calculator progress information seems to be lagging.

Calculators for Elementary School Students — In education the calculator plays roles both subtle and obvious. Users can press keys in seconds. They can 'test' their answers faster than they can ask the question. When they make some rather dumb mistakes, there is no reprimand; no one to tell them how stupid they are, only a flashing display or other indication alerts them to improper operations. With instant, logically perfect responses from their machines, the users quickly refresh their basic math. Great numbers of teenage and business users have reported that they were previously uninterested in mathematics, but now find themselves very involved because the mathematics gives them the answers they want — painlessly, precisely and fast.

Other educational uses for a programmable calculator are obvious. One popular program converts the HP-65 reverse polish into the algebraic logic of other machines — including second argument constant. This demonstrates and contrasts the two logic systems. The most spectacular and fun aspect of calculator education is games.

Recreation. — The kids and adults who 'play around' with numbers find this both recreational and educational. People who enjoy recreational math now spend hours experimenting with numbers. The fun and challenge pastime of devising words or expressions to be read from the display held upside down or to a mirror is well known; 'alphabets' and dictionaries have been published. Catalog houses and retailers have discovered that a surprising number of people buy pocket calculators for their amusement. Many popular types of programs are really games. The value of other games is becoming more and more recognized, as specifically designed by computer people as a means of teaching and, equally important, humanizing the computer. Games programmed for programmables cover a wide field.

Calculator to Develop Math Skills — One of the first calculators specifically made for developing individual mathematical computational skills has been introduced by Monroe, called Classmate 88. The machine uses an individualized instruction approach to generate unlimited drill and practice exercises for more than 70 computational skills. The calculator is used in conjunction with Operation Achievement, a skills program developed three years ago in Monroe's education center. The combination of the computer system and the skills program provide an innovative approach to developing a capability in addition, subtraction, multiplication, division, fractions, decimals and number concepts.

Classmate 88 comes with survey and diagnostic testing to determine exact competence levels for individual students. With a flick of the switch, the system generates random exercises in any of the 70 skill areas. When a skill area is selected and entered on the keyboard, the Classmate 88 prints a problem for that specific skill on a tape. The student works it manually on scratch paper, enters his solution into the machine and presses a "go" button.

The machine either accepts the answer as correct and automatically prints another problem or prints the student's answer and a red error indicator. The student then may do the problem again until he gets the correct answer or he may press a key to ask the machine for the right answer. Problems and student's answers are printed on the tape, providing the teacher with a record of the student's work.

SPECIAL COMBINATION CALCULATORS-WALLETS, WATCHES, VOICE ANSWERBACKS, BIORHYTHM

Texas Instruments Portable Electronic Hand-Held Printing Calculator, The TI-5050 — The TI-5050 performs chain calculations with all four functions. Users simply press a desired function key to use any result in the next problem. Repeated addition and subtraction is completed without reentering the number. Number entries are cleared with the CE key. A # key (non-add) prints reference numbers. The ↑ key feeds extra paper for easy tearoff. The unit sold for less than $130.00 in mid 1976.

Its dimensions: 8.7 × 3.9 × 2.7 inches; weight 28 ounces. Includes carrying case, 2 inch thermal paper, adapter/charger, manual. High level buffering lets users make multiple entries while the calculator is still printing. Two-key rollover lets users press a second key even before their finger leaves the first. Familiar business machine entry sequence.

It's a decided improvement over Casio's printing ¼" tape machine . . . but, other competition is expected.

Texas Instruments TI-5050 Hand-Held Prining Calculator — The TI-5050 pictured above is a popular unit for those users who require only simple calculations. It has very little sophistication for engineers, businessmen, statisticians, or scientists, as do other Texas Instruments models. It is one of the best of the hand-held printers, however. Its competition, in 1976, was from the under $100 Casio, "Mini Calculator/Printer" using a narrow ¼" tape horizontally mounted within the case, and the Facit-Addo, Inc. unit model 1140 (1½ pounds), which uses a 2¼ inch tape (thermal) and has 8-digit capacity, floating decimal, automatic constant and percentage keys, permitting discount and markup calculations.

Shirt Pocket Calculator Users — For novelty and purpose there's a calculator that does fit in a users pocket. The Hanimex weighs only 3½ ounces. So users can keep it in their pocket comfortably all day long — at lunch, on the airplane and during all those times when they wish they had a calculator with them. The Hanimex is an eight-digit, 4-function, percentage calculator. There's an automatic constant on all four functions. The unit features algebraic logic (users perform functions exactly as they think), and the LED display has overflow indicators and a floating negative sign. The clear key doubles as a clear entry key, and the unit measures 11/16" × 2⅛" × 4⅜" — convenient for any pocket.

Calculators Vocalize Data Entries and Results — Master Specialties Co. (MSC's) ARC 9500 audioresponse calculator talks to users with its solid-state natural-sounding synthesized voice. It announces each entry and the results of every calculation in a loud, clear voice, according to the manufacturer in Costa Mesa, CA. Talking calculators are used in the vocational education of the blind and in the reinforcement of basic math concepts for sighted students. In addition, sighted users find that it permits them to concentrate full visual attention on the input figures being entered without having to shift attention back and forth to look at the visual display. The ARC 9500 is an eight-function calculator and also has an eight-digit visual display.

A "Speech Plus," talking calculator was developed by Telesensory Systems, Inc. There are NO tapes in the calculator. Rather, the 24-word spoken vocabulary is electronically synthesized by a custom LSI microcontroller in conjunction with a single 16-k ROM. The firm specifically ruled out the use of tapes from reliability and cost considerations. The speech synthesizer is expandable to 64 words and is entirely contained on a single 4 in. × 6½ in. PCB, includes batteries, volume control, and loudspeaker.

Calculator/Wallet — Some manufacturers offer desk-top calendar-calculator combinations for business gift giving. Rockwell offers a combination wallet and built-in ultra-thin five function calculator, priced at $40. The unit includes a ballpoint pen, check or notebook pocket, and transparent credit card inserts. The calculator has a full four-key memory and functions include percent with automatic add-on and discount, square root and change sign. The 24K operates in algebraic logic and maintains trailing zeroes in add and subtract for monetary calculations. It positions the decimal point automatically and also performs chain calculations. Fairly impressive for a product that weighs less than half a pound and measures 5½ x 2¾ x ½-inches.

Calculates Biorhythms — The BIOLATOR is a dual function machine. It is an 8-digit, four-function calculator. Plus, it calculates a users biorhythm status for the day. They key in their birthdate, and the machine will automatically compute their physical, emotional, and intellectual condition for the day. A built-in 99-year calendar does it, can also be used for computing loans and interest. Made by Casio.

Mostek Calculator for Check Accounts — A semiconductor manufacturer, Mostek Inc. has introduced a purse-size, two-function calculator which is designed for computing checking account balances and is aimed at the female consumer market. Called the Checkmaster, the $39.95 unit, with a keyboard and six-digit LED display, automatically adds deposits and subtracts checks. The machine features a memory which retains the correct checking account balance even after the unit is turned off.

The battery-powered Checkmaster incorporates a single modified P-channel MOS chip and LSI circuitry. Also, the unit is designed in a case which opens and closes and holds a checkbook. The system automatically shuts off when the case is closed.

Initially, the unit was marketed by the JS&A National Sales Group, a Northbrook, Ill., mail-order distribution firm. In addition, the Checkmaster was marketed under the Corvus trade name by banks as a bank account premium and by retailers. Mostek, a Dallas-based firm, expected to sell about 250,000 units during the year 1976.

Here's how it works. — Users open their checkbook holder and turn on the built-in computer. Press the "Balance" key, and their bank balance is recalled on the display. The CheckMaster memory never forgets their balance — even months after they last recall it.

They enter the amount of their check, and press the "Check" key. The check amount is automatically deducted from their balance, and their new balance is displayed — and all with just one key stroke.

Or they enter the amount of a deposit, and press the "Deposit" key. Their deposit is automatically added to their balance, and again, their new balance is displayed.

Watch/Calculator — A hit of the 1975 Christmas season, Time Computer Inc. introduced a solid gold Pulsar watch-calculator combination with a six-digit LED display. The calculator has five functions, plus memory, floating decimal, and display overflow. Originally priced at $3,950, it's designed around two C-MOS chips, one each for time and calculation. The watch uses four battery cells that should last for a year for 25 calculations and 25 time readouts a day.

The big drawback to the Pulsar calculator — in addition to its price — is that users have to use a special plastic stylus to key in information. Even though Time Computer supplies the retractable stylus mounted on the top of a ballpoint pen, the fact that the calculator can't be operated with an ordinary ballpoint tip means a user's $3,950 calculator isn't usable if the wearer forgets the stylus. But this problem probably will be overcome with later models, and certainly by competitors.

The Optel I Calculator/Watch — Multiplexed circuits connecting the display segments have helped cut the size of a calculator/watch combination so that it fits on the wrist. The all-electronic calculator/wristwatch was exhibited by Optel Corp., Princeton, N.J., in Switzerland at the Basel watch and jewelry fair in 1975. Prototypes were ready for sampling and small production quantities were scheduled. Called the Optel I, the calculator/watch is designed around complementary-MOS circuits and a field-effect liquid-crystal display. It uses multiplexing to wire the display segments, simplifying the design. The display has eight digits, six of which are used in the normal time-keeping mode to show hours, minutes, and seconds. All eight are operable when the device is switched by pushbutton to the four-function calculating mode.

Succeeding versions will have memory and calculator functions for scientific applications. Prices for the first two models were between $500 and $550 for the standard version and $975 for the fancier one. The Optel I packs three C-MOS chips into its case, measuring 3.3 by 4.57 by 0.953 centimeters. One chip contains the countdown circuitry for time-keeping, the second integrates the calculator circuitry, and the third the buffer and driver stages for the display. The 1-second time pulses are derived from a 32-kilohertz crystal oscillator whose frequency is counted down by a 15-step divider network. The power pack consists of four 1.5-volt silver-oxide batteries, each about 15 millimeters in diameter and 4 mm thick.

Wrist-Watch Size Calculators — Below is a handy calculator, it is a 17-key unit. Its tiny keys and readout use a layer of conductive rubber. The trend toward micro-miniaturization in electronics has been pushed ever further by the watch industry. Chomerics Inc. of Woburn, Mass. responded by introducing a keyboard measuring only ¾ x 1 inch with 17 keys of 5/32-inch centers. The key array includes a moving decimal point, constant, clear, multiply, divide, add-equal, and subtract-equal keys that are as easy to read as a watch face. The full calculator would probably have either a four-digit liquid-crystal display or a six-digit light-emitting-diode (LED) readout.*

This pencil tip or stylus keyboard makes use of Chomerics' materials technology in conductive elastomers, paints, and inks, and its capability in full-size keyboards. The miniature keyboard uses the same materials as the large subassemblies, but they are put together differently. The keyboard consists of a tiny printed-circuit board, screened with a silver paint that provides a permanently conductive contact surface. Over this is laid a 0.005-inch-thick Mylar spacer with holes directly under the keys. A layer of conductive rubber, and a Mylar legend sheet has the keys on it. When the Mylar is deflected, an electrical impulse that is set up in the conductive rubber travels through the holes in the Mylar spacer to the printed-circuit board. The keyboard was developed as a result of inquiries from watch companies, and samples were supplied to at least 10 of them in mid-1974. In volume the manufacturer says the keyboards could sell for less than $2 each.

Calculator-Watch for Men Offered — Maybe! — A calculator-watch combination that can be worn on a man's wrist has been developed by Fondiller Corp. Called Calcron, the product is a scientific calculator and a man's digital wrist watch combined in a 1.5-inch-square case and less than 0.5-inch thick. The 40 functions of the keyboard — including trigonometric, logarithmic, exponential functions, square root, memory, chaining degrees and radian — use 20 buttons and operate by the use of a shift key like a typewriter's. Rechargeable nickel-cadmium batteries supply power for about 20,000 calculations. Retail price of the system is $500, including a battery charger. The calculator portion is priced at $300. The unit is said to have 40 functions in a 20-button keyboard through use of a shift key. Buttons on right give hours, minutes, seconds and data in the same 9-digit LED display used in calculators. The company also began working on a wrist watch for women to be called Femcron. It is not known if either unit is yet on the market.

* Slightly larger readout areas could accommodate several 'answer' lines, using an attached magnifier for improved clarity.

PART I — Section One

HAND-HELD CALCULATORS — HOW DO THEY WORK? WHAT ARE THE DIFFERENCES?

"My Calculator is Fine — But, I Want a better One." Now almost anyone can enjoy the speed, efficiency, accuracy, and computational power of personal programmability with a $30 Litronix, a $50 Sinclair, a $90 Corvus. Hewlett-Packard hand-held calculators and those from Texas Instruments, Monroe, Compucorp, others are a "tradeup" from these.

Programming is simply the ability of a calculator to learn, remember, and execute automatically a series of steps necessary to solve a particular problem. This is "real" calculating power, and it does not end. Once a user has taught the calculator the formula for any problem, all he must do is supply the known variables and start the program running.

But this is the "short" story. Programmable calculators give users much more. Their calculators can become a full computer . . . with:

- Full editing capability. Users can add or change steps at will . . . from a one-line to a 16-line display. (see: Advanced Desk-Top Computing Calculators, Part II, Section 4.)
- Direct branching. Users can solve problems requiring iterative routines. Can control machines and communicate around the world.
- Conditional testing. Users can program the calculator to make decisions or change conditions based on the data . . . decisions to jump to another program and another.
- Easy-to-understand keystrokes or programming languages . . . keyed in or entered by cards, tapes, cassetes, etc.

Before one buys a calculator, he or she must take a look at the programmable calculators from at least three to five sources.

One advanced scientific programmable pocket calculator offers eight addressable memories, full editing, and branching and conditional test capability . . . the stepup from the less than $100 models.

Another low-cost advanced scientific programmable calculator provides 20 addressable memories, editing, branching and conditional test capability, and also a 100-hour digital timer. These are KEYBOARD programmable units. The program must be keyed in when it is to be used. Others can be "automatically" programmed.

The best are fully programmable pocket calculators for scientists or business executives, etc., that let users prerecord their programs on magnetic cards for future use. The HP-65, for example, has nine addressable memories, full editing, and nine conditional tests. In addition, Application Pacs containing pre-recorded magnetic cards for many specific business and scientific disciplines are available which save users much time and effort. Attractively priced, the HP-65 and Texas Instruments SR-52 are only two of many bargains.

Programmable calculators take most of the repetition out of often used repetitive problems. If users want to save $ and frustration, they should take time to read about the specific advantages and price ranges on the following pages. Programmability is the "magic" word of calculators. The majority of the book is devoted to this capability — and the 'dictionary' section is designed to help the reader unravel the mysteries of "computing" calculators.

But to understand the calculator first . . . and programmable calculators next, it is necessary to start at the beginning — with the simple, straightforward four-to-six function machines often called "the adders". They add, then subtract by 'adding' algebraically — and multiply and divide by successive addition and subtraction — in split seconds.

HAND-HELD BASIC 4- TO 6-FUNCTION MACHINES

The Typical Pocket Size Four-to-Six Function Electronic Calculator with Memory Performance — The typical unit enables users to carry out calculations silently and accurately anywhere . . . in the home, office, plane or train . . . because it's battery operated. Its calculating capabilities include addition, subtraction, multiplication, division and arithmetic combinations. All keys of the unit are logically arranged according to their function, and conveniently located. Memory keys are color-coded. Most low-cost units have a standard 10 key keyboard with decimal point key. The nine function keys are self-explanatory and based on universal arithmetical language. A typical unit has a capacity of 8 digits, which is ideal for solving complex calculating problems. It includes full floating decimal point with automatic roundoff.

The operator can select the decimal placing of the result between 2 and 4 places.

Memory System, Constants and Clearing — The flexibility of the typical memory system allows the operator to work individual problems and store the results in memory until grand totals are required to complete calculations. When carrying out a series of multiplications and divisions the multiplier and divisor can be held constant. When switching on the calculator, the display is cleared automatically. Newly entered figures clear the display panel of any previous figures. The CLEAR (C) key clears the calculating register at the end of the calculation.

Standard Performance Highlights are:

Modern MOS-LSI technology.
8 digit capacity.
Addition, subtraction, multiplication and division.
Automatic percent calculation.
Constant in all four arithmetic functions.
Direct access independent memory.
Chain multiplication and division.
Choice of full floating or fixed 2-4 decimal system with underflow.
Leading zero suppression.
Mixed and chain calculations.
Automatic round-off.
Credit balance.