IBM 5100 Portable Computer

MANAGEMENT SUMMARY

If you are presently using data tables to look up values of elliptic integrals of the second kind, hyperbolic functions, present value factors, or chi-square values, be sure to hang onto the books they come in. In a few years, they may have some value as rare curiosities. The IBM 5100 Portable Computer, announced September 9, 1975, for delivery beginning in September, eliminates the necessity for having books of tables by placing a computer on your desk. However, you can buy a lot of books of tables for the 5100's beginning price of just under $9,000. To pay for itself and make it worthwhile to acquire, the 5100 must save you time, allow you to do calculations you could not do manually, and/or replace a more expensive method.

The 5100 brings together an impressive set of capabilities. Built around a one-board microprocessor, the 5100 provides up to 65K bytes of 530-nanosecond MOSFET main memory, an integral 1024-character CRT display, and an integral magnetic tape cartridge drive capable of accessing up to 204K bytes of data. The programming facility is provided by a BASIC or APL interpreter, or both, stored in read-only memory. And that's quite a lot to pack inside a case not much larger or heavier than an IBM Selectric office typewriter.

An 80-cps serial printer and a second magnetic tape cartridge drive can be added, and an optional communications adapter makes the 5100 look like an IBM 2741 typewriter terminal to a remote host computer. No disk or diskette storage is available for the 5100 at this writing.

Details of the internal organization of the microprocessor have not been released to date, but the 530-nanosecond ➢

With the 5100, IBM has entered the personal computer market heretofore dominated by calculator manufacturers such as Hewlett-Packard and Wang Laboratories. Capable of executing BASIC or APL programs or both, the 5100 is built around a microprocessor and features a large main memory and a built-in CRT and cartridge tape drive. Prices begin at $8,975 for a fully functional unit.

CHARACTERISTICS

MANUFACTURER: IBM Corporation, General Systems Division, 875 Johnson Ferry Road N.E., Atlanta, Georgia 30342.

MODELS: 5100 Models A1 through A4, B1 through B4, and C1 through C4.

DATA FORMATS

All access to the 5100 is through the BASIC or APL programming languages, implemented in read-only memory. In general, these languages provide specific facilities for numeric integers, floating-point numeric values, numeric arrays, and alphanumeric strings. Instruction formats are, in effect, the BASIC or APL statements themselves. Apparently, the internal structure is based on a 16-bit word.

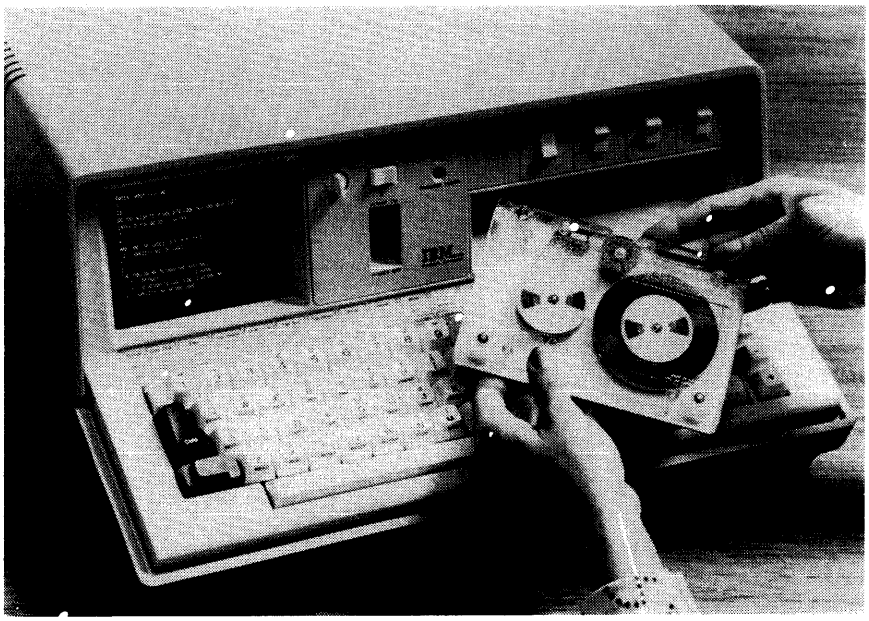
MAIN STORAGE

Type: MOSFET (Metal-Oxide Semiconductor Field Effect Transistor).

CYCLE TIME: 530 nanoseconds per two-byte access.

CAPACITY: 16,384, 32,768, 49,152, or 65,536 bytes.

CHECKING: A parity bit is associated with each byte. ➤



The 3M-style magnetic tape cartridge is featured in this photo of a basic 5100. The cartridge can store up to 204,000 bytes of data or programs. The built-in CRT can display up to 1024 characters; the characters are rather small, but legible at normal working distances. This 5100 is one of the C series models, which give users a choice between the BASIC and APL programming languages.

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memory cycle time mentioned above is based on a two-byte fetch, providing at least the potential for impressive computational speeds. Such speed is highly desirable for the types of applications for which the 5100 is intended, as you well know if you have applied numerical methods to the computation of functions.

Supporting the system are three application libraries: one for business functions, one for scientific/engineering computations, and one for statistical functions. These capabilities are supplemented by the mathematical functions built into the BASIC and APL programming languages. Thus, the basic tools for numerical computation are provided. But any procedures peculiar to specific disciplines will have to be programmed by the user through the facilities of BASIC or APL.

Providing for the computation of specific values for defined functions is, of course, only one side of the story. The basic tools also permit working with observed or empirical sets of data values to determine patterns and relationships existing among the data values. Alternatively, an observed set of data values could be maintained as a table, with intermediate points computed through interpolation, thereby eliminating, perhaps, the need to derive an analytic expression. Many possibilities exist for the productive use of a desk-top computer.

And those possibilities are not limited to technical endeavors, either. The businessman, in planning or evaluating situations, often has the need to handle large numbers of computations to compare costs and expected revenues or make projections. The results of these calculations often fill sizeable worksheets and require substantial time. As a result, the number of alternatives investigated may be few, to prevent the cost of the planning from exceeding the cost of the project. The presence of a small computer with a sizeable internal memory and external storage can permit many more alternatives to be looked at economically.

The 5100, however, is not intended to support conventional business data processing, even at a low level. The absence of a direct-access device and the slow speed of its peripheral devices prevent the 5100 from being used effectively to maintain a file of records, as would be required to process a payroll, for example. It could obviously be used to compute and print business documents such as invoices, paychecks, sales analysis reports, etc., one at a time with manual entry of information, but the inability to effectively maintain a file of records eliminates most of the advantages gained through the use of a computer. Just as IBM carefully configured the System/32 when announced to reduce its impact on the System/3, the 5100 is being controlled to prevent if from having a substantial impact on the System/32.

We have just touched the surface of the possibilities present in most offices, regardless of type, for using an in-house computing facility such as the 5100. The payoff for personnel presently using manual methods, even with

RESERVED STORAGE: A total of 4,400 bytes of main memory is reserved for the BASIC interpreter in addition to the read-only memory; for APL, a total of 6,700 bytes is reserved.

CENTRAL PROCESSOR

GENERAL: The three general 5100 models, A, B, and C, are distinguished by whether the APL interpreter (A series), BASIC interpreter (B series), or both (C series) are implemented. Switching between the two languages is accomplished in the C series models through a front panel switch. Within each series, there are four models corresponding to main memory sizes of 16K, 32K, 48K, and 64K bytes.

The internal structure of the 5100 has not been detailed publicly as yet. It is based on a single-card microprocessor. The basic memory speed is quite fast. This may be compromised by the internal organization of registers and I/O arrangements, but no definite comment can be made at this time.

The instruction repertoire is effectively that of the BASIC and/or APL languages. These high-level languages permit symbolic addressing of data values, loop control, and program flow structuring, along with procedure-oriented facilities for numeric computations. Alphanumeric strings can be handled for display or printing of table heads, interactive prompting, error or condition displays, etc.

Each 5100 computer includes a 1024-character display, a cartridge tape drive, and a keyboard. The keyboard keytops are engraved with symbols corresponding to the elements of the language implemented in each model. For BASIC models, most of the language statement keywords can be entered with a single key depression in conjunction with the Command key. Also on BASIC models, the accompanying 10-key numeric keypad can be used as function keys, with the meanings defined by user programming. On both BASIC and APL models, the top row of keys carries alternate usages for various system and peripheral functions.

The BASIC and APL interpreters are implemented in read-only memory, or, as IBM refers to it, read-only storage (ROS). ROS is implemented in MOSFET technology with 48K-bit chips. Also included in ROS are system control functions and I/O drivers.

PHYSICAL SPECIFICATIONS: The 5100 computer occupies a space 8 by 17.5 by 24 inches; it weights between 46 and 50 pounds depending on memory options. The basic package includes the CRT and built-in tape cartridge drive. It operates on conventional 115-volt, grounded AC power. The optional tape cartridge unit measures 7.25 by 10 by 12 inches and weighs 18 pounds. The optional printer weights 56 pounds and measures 12.25 by 13.25 by 23 inches. Separate power outlets are required for the optional printer and cartridge drive.

INPUT/OUTPUT CONTROL

The processor provides one I/O port for attaching one external cartridge tape drive and one printer. A separate facility is provided for connecting the communications option. However, when the 5100 is used as a communications terminal, user programs cannot be entered. If both the external cartridge drive and the printer are included, the printer is attached to the cartridge drive, which is then attached to the processor. This represents the data flow path; each of the units has to be plugged into a wall outlet. One External I/O Adapter is a prerequisite for attachment of any external peripheral combination.

MASS STORAGE

To date, IBM has not announced a true mass storage device for the 5100. The integral and/or external cartridge tape units can be used to store data and programs. The maximum capacity of a tape cartridge is 204K bytes. Data and programs can be indexed for direct retrieval, but the method of access is necessarily sequential rather than random.

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PERIPHERALS

MODEL	DESCRIPTION & SPEED
INTEGRAL WITH PROCESSOR	
CRT/Keyboard	1024 characters; 16 lines of 64 characters; black on white or reverse, switch selected; spread-out of left or right 32-char. line half, switch selected; data entered on bottom line with automatic upward scrolling.
Magnetic Tape Cartridge Drive	Uses 3M-style tape cartridge containing 300 feet of 0.25-inch tape; data recorded in 512-char. physical blocks with logical records separated by record marks, program interpreted; 40 inches/sec; 2850 char./sec read, 950 char./sec effective write including write with backspace and read/check
MAGNETIC TAPE	
5106	Auxiliary Tape Unit; same specifications as integral unit above
PRINTERS	
5103	Serial, bi-directional, 132 positions, 10 char./inch, 6 lines/inch, full APL/BASIC char. set, up to 6-part forms, 80 char./sec
OTHER DEVICES	
TV Monitor	Multiple CRT monitors can be connected serially; contact IBM for configurational possibilities and prices

electronic calculators, can be seen and evaluated, based on the amount of time currently spent on such calculations and on the value of extending the range of computations that can be performed.

But many offices already have access to a computing facility through an in-house computer system of larger scale than the IBM 5100, or perhaps through a time-sharing service. The capabilities of either of these facilities are generally more extensive than those available with the 5100. To be cost-effective in these environments, the 5100 has to provide more than just convenience. Obviously, having a computer at hand can shorten the turnaround time compared with submitting a problem to an in-house facility. But with the growing use of CRT terminals to replace teletypewriters, a time-sharing terminal shared among a few people is just about as convenient as a 5100 shared among the same people. True, the 5100 can be moved from desk to desk easily, but in most cases having to share a facility is more inconvenient than having to walk to it. Any clearcut advantage of the 5100 over an in-house or remote time-sharing facility has to be based on lower cost. With a printer and a central unit large enough to handle any of the program libraries, the 5100 costs about $16,000. That could pay for a lot of time-sharing services.

Perhaps comparing the 5100 with existing facilities, with direct substitution in mind, is to miss the true value of a personal computer. It has been just a few years since the introduction of the electronic calculator. At that time, $400 for a Hewlett-Packard HP-35 pocket model or a couple of thousand for a desk-top programmable model seemed a lot of money for a "convenience" item. But these units provided more than just convenience. They allowed personnel relatively unskilled in high-speed

INPUT/OUTPUT UNITS

See Peripherals table.

COMMUNICATIONS CONTROL

The Communications Adapter permits the 5100 Computer to communicate with a remote IBM or other computer; the 5100 appears as an IBM 2741 typewriter terminal. Half-duplex, asynchronous transmission at 134.5 or 300 bits per second is supported via a user-supplied modem with an RS-232C interface, such as the Bell System 103. Transmission over a leased line or the public telephone network is possible. Only the EBCDIC transmission code is supported. While in the communications mode, the keyboard and display of the 5100 logically correspond to the keyboard and printer of a 2741. Received data can be simultaneously printed if the optional printer is included. Alternatively, the magnetic tape cartridge can serve as the origin and/or destination of data.

User programs cannot be entered or executed while the 5100 is in the communications mode. The Expansion Feature is a prerequisite for the Communications Adapter. The 5100, operating as an IBM 2741 terminal, is supported by all IBM System/370 configurations that include an Integrated Communications Adapter or a 3704/3705 Communications Controller through standard teleprocessing access methods such as BTAM, TCAM, and VTAM.

SOFTWARE

OPERATING SYSTEM: The system control functions are integrated into the ROS module, with some main memory space required for symbol tables, etc. System control functions are primarily concerned with coordinating the interface between the user programs and the language interpreters and peripheral devices.

In effect, there are three modes of usage: program development, interactive program writing with execution, and interactive execution of a previously written and stored program. Depending on the computer model, the programming language may be BASIC, APL, or either of the two. IBM presently offers three application program libraries for business, scientific/engineering, and statistical problems.

PROGRAMMING LANGUAGES: *BASIC*, for the 5100 B and C series models, is implemented at a level similar to

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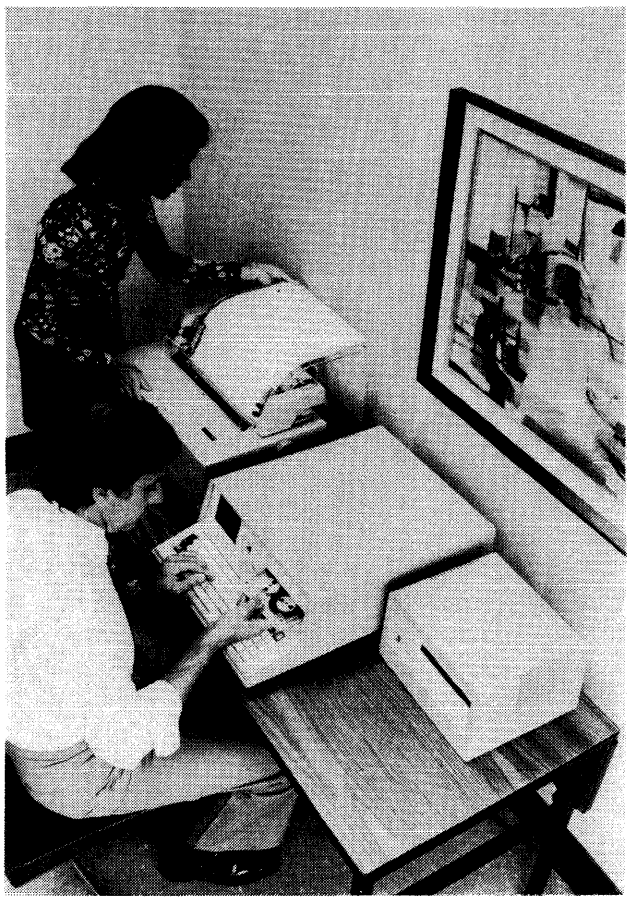
arithmetic calculations to equal the productivity of specialists. They eliminated the need for laborious recalculations because of simple arithmetic errors.

The 5100 can do the same things at a higher level. It can permit increased productivity without the need for highly skilled specialists, who are in increasingly short supply. Computational specialists may not even know the theory behind the computations they perform. They can simply execute the procedures required for specific tasks, as outlined by a person conversant with the theory. This does not eliminate the specialists, however, because they now have a more powerful tool with which to exercise their skills. It seems probable that the success of the 5100 and its competitors will lie in the area just outlined, rather than in replacing existing facilities.

Introducing new personnel to numerical analysis through a personal computer does bring about a problem in interpreting the results of computations. The computer will cheerfully display the results to whatever degree of precision (number of decimal places) it is programmed to produce. The *accuracy* of the result, however, does not necessarily agree with the *precision* of the result. The cause may lie in imprecise input, in the computational algorithm, in using the computational algorithm outside the range for which it was designed, or in internal



Pictured here is a full-blown 5100 with the optional 80-cps printer and second magnetic tape cartridge unit. The price of this configuration could be as high as $25,250.

IBM VS/BASIC for the System/370. It supports stream data files and matrix (two-dimension array) operations. Independent output to the printer of data displayed on the built-in CRT is supported. BASIC includes capabilities for manipulating alphanumeric strings. The statements use English-like forms, so BASIC is the logical choice for first-time users. In addition to ROS, the BASIC interpreter occupies 4,400 bytes of main memory, which is not available to the user. A prerecorded data cartridge containing an instruction program for the BASIC language is available optionally.

***APL*, for the 5100 A and C series models, is implemented at a level similar to IBM APLSV. It supports data files on magnetic tape and arrays of up to 63 dimensions, as well as comprehensive mathematical, logical, and relational operators and functions. Independent output to the printer of data displayed on the built-in CRT is also supported. APL is the logical choice if complex mathematical or logical operations are required.**

APPLICATION PROGRAMS: These program libraries are currently available: Business Analysis, MATH, and STAT. The Business Analysis library is available only for BASIC machines; the other two are available in both BASIC and APL versions.

The general manner of using these program libraries is similar. Parameters describing sizes and options are entered in response to displayed questions, which typically include a short description of available options. Data values are also entered in an interactive, prompted fashion. Results are displayed and/or printed according to parameters previously entered. The level of prompting is sufficiently clear for a person who is familiar with the computational procedures and generally familiar with the operation of the 5100. Each of the three libraries is supplied on two magnetic tape cartridges and comes with a user's guide. All of the program libraries will receive IBM central programming support through September 1976.

The *Business Analysis/Problem Solver Library* includes 30 BASIC routines specifically oriented to problems in spread sheet, investment, depreciation, break-even, and time series analysis. The spread sheet analysis is a general report preparation tool that permits tabular presentation of data with line arithmetic (e.g., multiple line 2 by line 3) and cumulative column presentations. Data values can be input from the keyboard or from a previously recorded magnetic tape cartridge file. Some routines include the capability to insert your own algorithm if the standard facilities provided do not include the operation you need. The investment analysis series of programs permits computation of return on investment, discounted cash flow analysis, multiple and single loan analysis, lease versus pruchase analysis, and make versus buy analysis. Included in the depreciation analysis series of programs are straight line, sum-of-years digits, declining balance, and equipment units methods. The break-even or cost/volume profit analysis series permits computation with definite or probablistic assumptions. The time series analysis group of programs provides a wide range of computational capabilities for time-oriented data for compound growth rate projection, moving average, and seasonal or cyclical analysis, as well as for simple statistical problems such as auto or cross covariance and correlation, exponential smoothing, and simple regression.

Generalized routines also provided in this library permit a user to construct and display histograpms, create and update user files, resequence or rearrange records in files, and print data files. The Business Analysis Library requires a 5100 Model B2 or C2. The optional printer is recommended for the spread sheet analysis program group.

The *MATH/Problem Solver Library* includes a comprehensive set of numerical analysis routines. There are 37 programs in the APL library and 44 programs in the BASIC library, but essentially the same capabilities are provided with each library. The facilities provided can be broadly grouped into calculus, including integration, differentiation, and solution of ordinary differential equations; linear equations and matrix analysis, including eigenproblems, least squares solutions, linear programming, and solution of linear equations; approximations to functions and zeroes of functions, including several interpolation and approxima-

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round-off and truncation. In purchased algorithms, such as those in the IBM program libraries, normal practice includes identifying the applicable range of each procedure in the supporting documentation accompanying it. This can sometimes be overlooked. But the real problem is with user-generated procedures. Calculation of the applicable range for a given error level is a taxing mathematical procedure that is often ignored because of the time it adds to the programming task. Widespread use of desk-top computers such as the IBM 5100 may well lead to increased interest in providing the user with improved methods of estimating error ranges for his programmed procedures. In any case, prospective users should be made aware of the old precision/accuracy problem, which has been faced by data processing personnel since the early days of computers, but which may be entirely new to people just acquiring a desk-top computer.

The concept of a desk-top calculator/computer that can be programmed in a higher-level language is not new. Both Hewlett-Packard and Wang Laboratories have marketed such units for several years, and in the same price range as the IBM 5100 for equivalent configurations. However, the 5100 is distinguished by the capacity of its main memory and in the provision of two programming languages.

Memory sizes range from 16K bytes to 65K bytes in 16K increments. For each memory size, there is a corresponding 5100 model for the BASIC language, for the APL language, and for a combination of BASIC and APL. Switching between the languages in the combined models is accomplished through a front panel switch.

The BASIC language is widely known and used. Its English-like statement keyword structure makes it an easy language to learn and a logical choice for first-time users. BASIC also provides convenient facilities to handle alphanumeric strings for annotating tables. The APL language is more suited to expressing complex mathematical relationships.

The 5100 is also novel in the way IBM is supporting it. The support is similar to that provided for the company's typewriters. No customer engineer shows up when you install the 5100. You read the instruction book that comes with it and set it up yourself. Lease plans are not available for this unit; it is offered on a purchase-only basis. Maintenance agreements are available, naturally, just as with typewriters. IBM has set up a separate staff to handle the 5100 within the General Services Division.

IBM's entry into the field of personal or desk-top computers, timed as it is at the beginning of the wide availability of microprocessors, may herald the start of a highly competitive market segment. If that is the case, you can expect to see many specialized models announced by many vendors, each tailored to a specific type of computational problem. Software houses will no doubt get into the act as well, with specialized program offerings for the IBM 5100 and similar computers. The prospect of this may make one want to learn what all of these exotic-sounding functions–such as Bessel functions of the first kind and fractional order, multivariate analysis, and discounted cash flow–are all about. □

tion methods, function smoothing, minimums and maximums of tabulated functions, etc.; and evaluations of advanced mathematical functions such as the Gamma function, Bessel and modified Bessel functions, elliptic integrals and functions, orthogonal polynomials, etc. The complete MATH library can be run on a 5100 A2 (APL), B2 (BASIC), or C2 configuration. A majority of the routines in the BASIC library can be run on a 5100 B1.

The *STAT/Problem Solver Library* includes 40 (APL) or 41 (BASIC) routines for the analysis of numerical data through commonly used statistical techniques. The routines can be broadly grouped into elementary statistics, including histogram, cross-tabulation, moment, tally, and Chi-square and T test; regression and correlation analysis, including simple, stepwise, multiple, and polynomial regression; multivariate analysis, including discriminant analysis, canonical correlation, and factor analysis; analysis of variance; time series analysis, including moving average, seasonal and cyclical analysis, auto and cross covariance and correlation, and triple exponential smoothing; nonparametric statistics; and biostatistics, including survival rate and profit analysis. Four routines in the library provide capabilities to enter and display/print, correct, modify, generate, or smooth data. The BASIC library can be run on a 5100 B1 or C1; the APL library requires a 5100 A2 or C2.

PRICING

POLICY: The 5100 Portable Computer is available only on a purchase basis, although an installment purchase arrangement can be made. A separate maintenance contract is available. No installation assistance is provided with this product; the customer sets up the system from step-by-step instructions packaged with the unit. The warranty period extends from the date of shipment from the plan for a total of 10 days plus 3 months.

A separately priced set of magnetic tape cartridges furnishes instructions in the BASIC ($225) or APL ($295) programming language. Two source-code data cartridges and a user's guide accompany each program library and include instructional material. The program libraries are furnished for a one-time license fee. The user is expected to maintain duplicate, back-up copies of the data cartridges.

The standard 10 percent educational discount applies to the basic computer and peripherals.

EQUIPMENT: The following prices include all attachment features required, but do not include any program libraries.

MINIMUM BASIC SYSTEM: Consists of BASIC 5100 Model B1, which includes integral CRT display, magnetic tape cartridge, and 16,384 bytes of main storage. About 12,000 bytes of main storage is available to the user. The only programs available that can be run on this configuration are STAT and portions of MATH. The BASIC interpreter is included. The purchase price of this system is $8,975, and the monthly maintenance cost is $55.

MINIMUM BUSINESS-ORIENTED SYSTEM: Consists of BASIC 5100 Model B2, which includes integral CRT display, magnetic tape cartridge, and 32,768 bytes of main memory, plus the optional 5103 printer. About 28,400 bytes of main memory is available to the user. The Business program library, the MATH library, and the STAT library can be run on this configuration. The BASIC interpreter is included. The purchase price is $15,950, and the monthly maintenance cost is $95.

LARGE SCIENTIFIC SYSTEM: Consists of APL 5100 Model A4, which includes integral CRT display, magnetic tape cartridge, and 65,536 bytes of main memory, plus the 5103 printer and 5106 Auxiliary Tape Unit. About 58,800 bytes of main memory is available to the user. The MATH and STAT program libraries can be run. The APL interpreter is included. The purchase price is $25,250, and the monthly maintenance cost is $125. ■

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EQUIPMENT PRICES

		Purchase	Monthly Maint.
PROCESSORS AND MAIN MEMORY			
5100	Portable Computer; includes 1024-character display, magnetic tape cartridge drive, ROS for language processor, and main memory as detailed below:		
	APL Language Interpreter—		
A1	With 16,384 bytes of main memory	$ 9,975	$65
A2	With 32,768 bytes of main memory	12,975	70
A3	With 49,152 bytes of main memory	15,975	75
A4	With 65,536 bytes of main memory	18,975	80
	BASIC Language Interpreter—		
B1	With 16,384 bytes of main memory	8,975	55
B2	With 32,768 bytes of main memory	11,975	60
B3	With 49,152 bytes of main memory	14,975	65
B4	With 65,536 bytes of main memory	17,975	70
	APL and BASIC Language Interpreters—		
C1	With 16,384 bytes of main memory	10,975	70
C2	With 32,768 bytes of main memory	13,975	75
C3	With 49,152 bytes of main memory	16,975	80
C4	With 65,536 bytes of main memory	19,975	85
OPTIONS			
1524	Expansion Feature; required for Communications Adapter	300	6
1525	Communications Adapter	600	10
3601	External I/O Adapter; required for 5103 Printer or 5106 Auxiliary Tape Unit	300	6
1501	Carrying Case, soft	125	—
MAGNETIC TAPE DRIVES			
5106	Auxiliary Tape Unit	2,300	10
	Tape Cartridges, per package of five	100	—
PRINTERS			
5103	Printer, 80 cps	3,675	29

SOFTWARE PRICES

		License Fee
5721	Problem Solver Libraries—	
-XM3	Business Analysis, BASIC	$500.00
	User's Guide	19.00
-XM1	MATH, BASIC	500.00
	User's Guide	23.00
-XM2	MATH, APL	500.00
	User's Guide	17.50
-XA1	STAT, BASIC	500.00
	User's Guide	22.50
-XA2	STAT, APL	500.00
	User's Guide	22.50