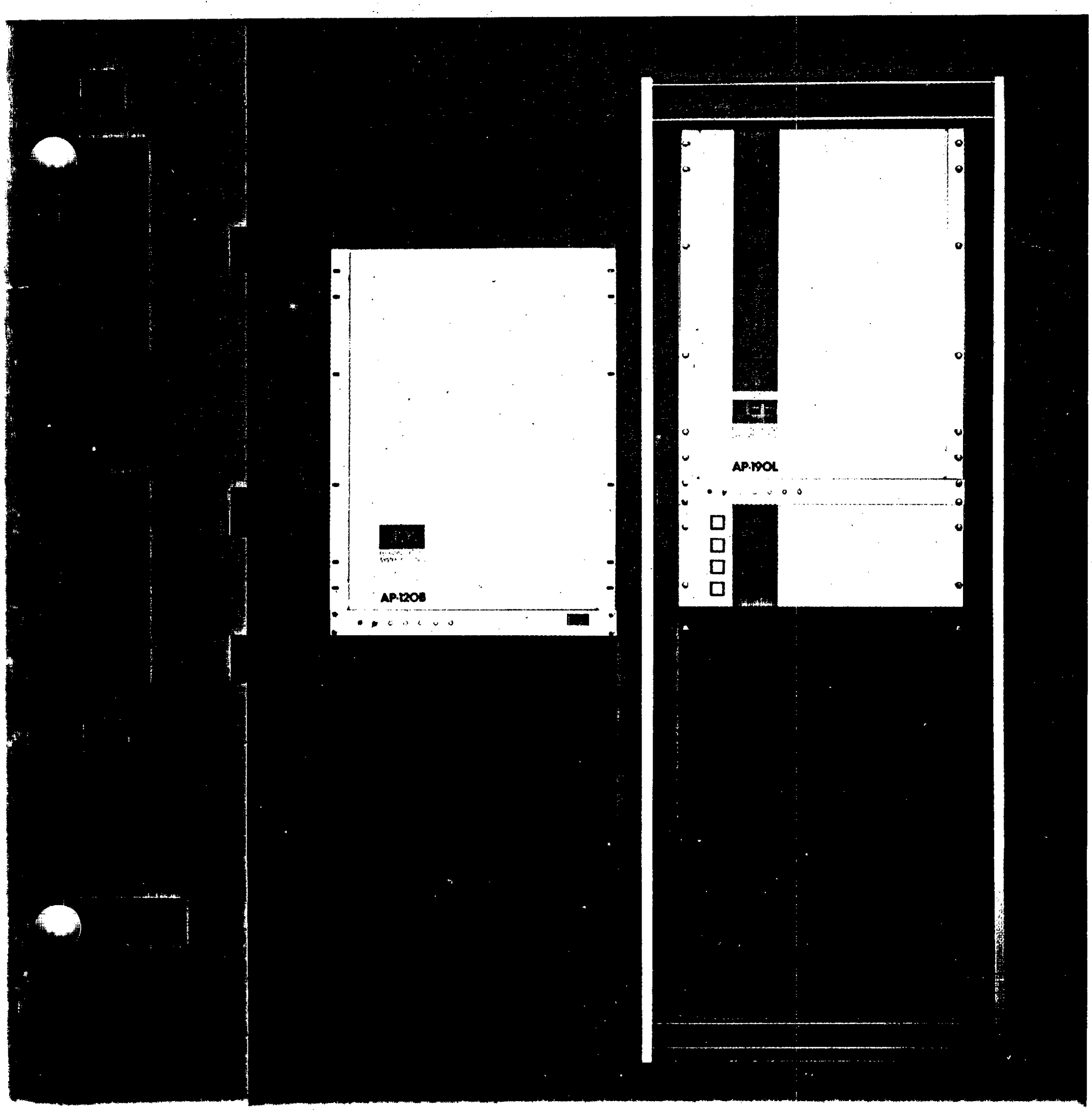
FLOATING POINT
SYSTEMS, INC.

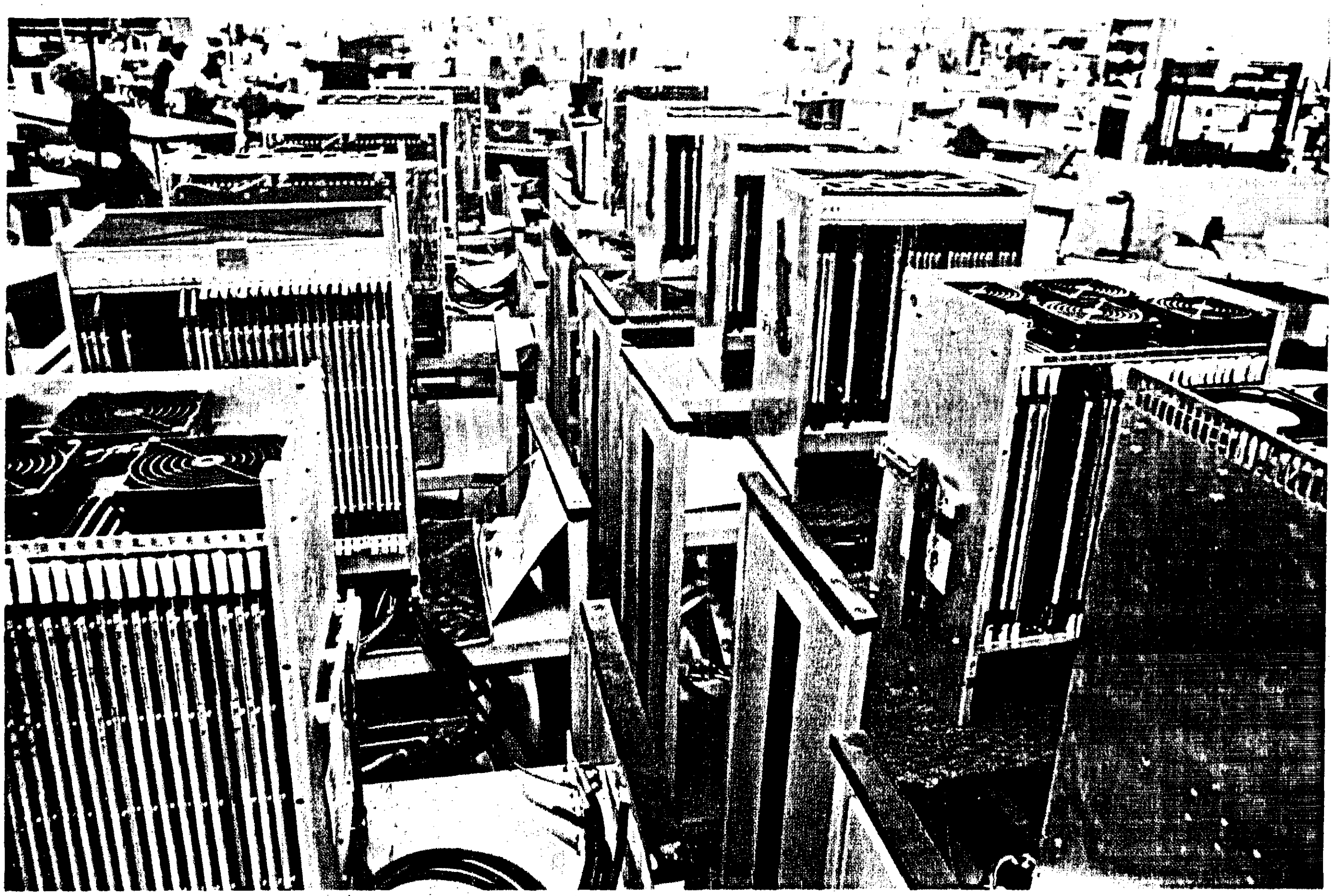
The age of array processing is here.



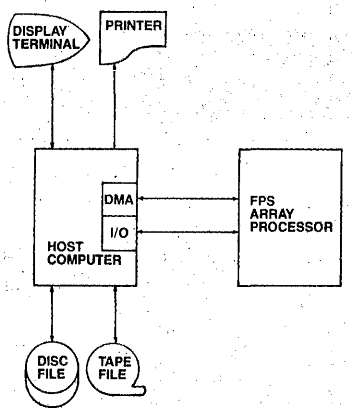
Every day **numerically intensive array processing techniques** are applied to new areas of research and engineering. Since more precise mathematical models are created as data is acquired in greater quantities and expressed for machine processing in arrays, the vectorization of program routines combined with unique architecture allows FPS Array Processors to offer computational speed and precision heretofore available only at great expense.

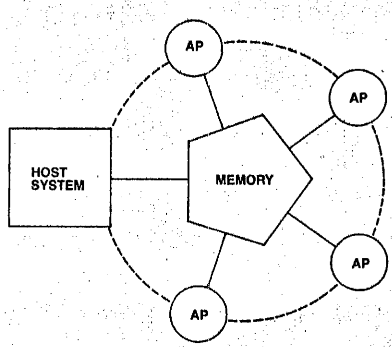
The benefits offered by Floating Point Systems and FPS Array Processors have been demonstrated in numerous areas from research to engineering, some of which include: the analysis of data in **seismic exploration** . . . the calculation, reconstruction, and enhancement of **images** (X-ray, satellite, and seismic) . . . the conversion of **speech** signals to compressed digital data and their subsequent resynthesis . . . the processing of the hundreds of parameters that must be monitored in **nuclear reactors** . . . the composition of **images** in radio astronomy . . . the analysis of the myriad data affecting **economic models** . . . the **simulation** of multi-variant airframes and environments, and more.

Introducing array processors by Floating Point Systems, Inc. Investigate their specifications and you will discover the computational power of mega-dollar mainframes at a fraction of the cost. Join our list of satisfied customers . . . It's growing daily.



Computational power where it's needed.





An array processor is a high-speed arithmetic processor. It takes data and instruction signals from a host computer/controller, performs the mathematical computations indicated by the instructions, and provides for the return of the "processed" data to the appropriate device. Combined with minicomputers, it has increased the computation speed of systems **by factors from one hundred to two hundred.** Combined with major mainframes, it provides computational ability previously available only at tremendous cost.

As original equipment.

The capital investment for computer power has been reduced by more than a factor of ten, so that an economical minicomputer and the Floating Point Systems Array Processor combination is a far better investment in many applications as original equipment than a big expensive mainframe.

The array processor fulfills an urgent need in the demands of today's growing technology. **The age of array processing is here!**

To upgrade.

The investment in original equipment need not be increased significantly to upgrade a system. Adding an FPS Array Processor with extensive software library, documentation, and support to a minicomputer system normally calls for an investment of **less than $50K.** Adding an FPS Array Processor with equivalent library, documentation, and support to the typical large computer system can be accomplished with an investment of less than $100K. Thus, computing power previously found only in large budgets is available to a wide range of individuals.

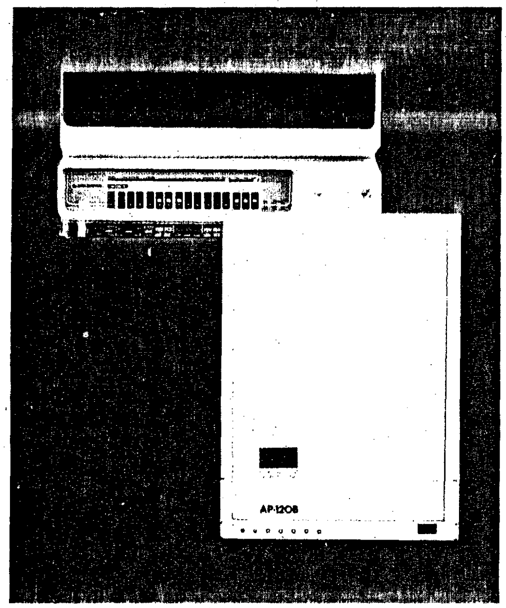
Why vector data processing.

Most algorithms used to implement scientific models and their associated data sets are naturally structured in an array or matrix (vector) form. While the conventional computers of today require restructuring of the models, the architecture and instruction set of the FPS Array Processors have been designed to take full advantage of this natural structure. Furthermore, the use of one or more array processors for a scientific task lends itself to straightforward division and distribution of the task for maximum system throughput.

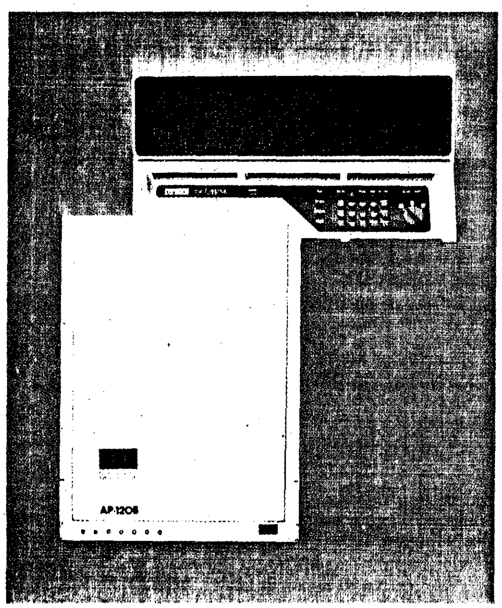
Distributing the task.

Since a conventional general purpose computer must do several jobs well, the task is typically organized to fit the structure of the computer at the cost of programming complexity and time. With today's technology producing lower and lower cost components, more cost effective computer elements dedicated to specific tasks can be built. Utilizing these hardware elements in a specially organized arrangement, as in FPS Array Processors, can eliminate system design problems by allowing the computer system to be tailored to users' problems. Through this concept, **FPS utilizes the most cost effective hardware/software combinations,** thus reducing the overall dollar-for-throughput cost to the user.

The anatomy of an array processor.



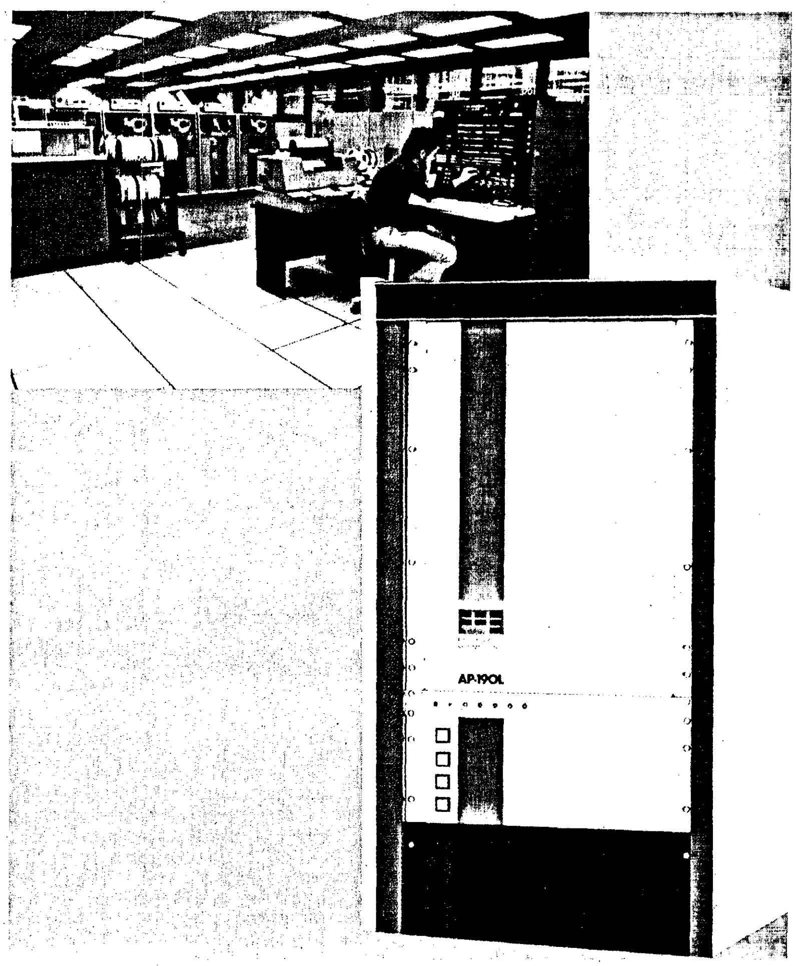
Operating in parallel with the host computer, an FPS Array Processor may increase its computational speed and power by a hundred fold.



When an FPS Array Processor is combined with a minicomputer, the system often exceeds the capabilities of a large mainframe.

FPS array processors are interfaced to all popular computers. They are in use worldwide — performance proven.

Array processors from Floating Point Systems, Inc., are programmable, parallel, synchronous pipelined processors consisting of a number of fast registers, program source memory, data memory, table (or constant) memory, floating-point adder, floating-point multiplier, and an integer address calculator/indexer, all interconnected by multiple data paths.



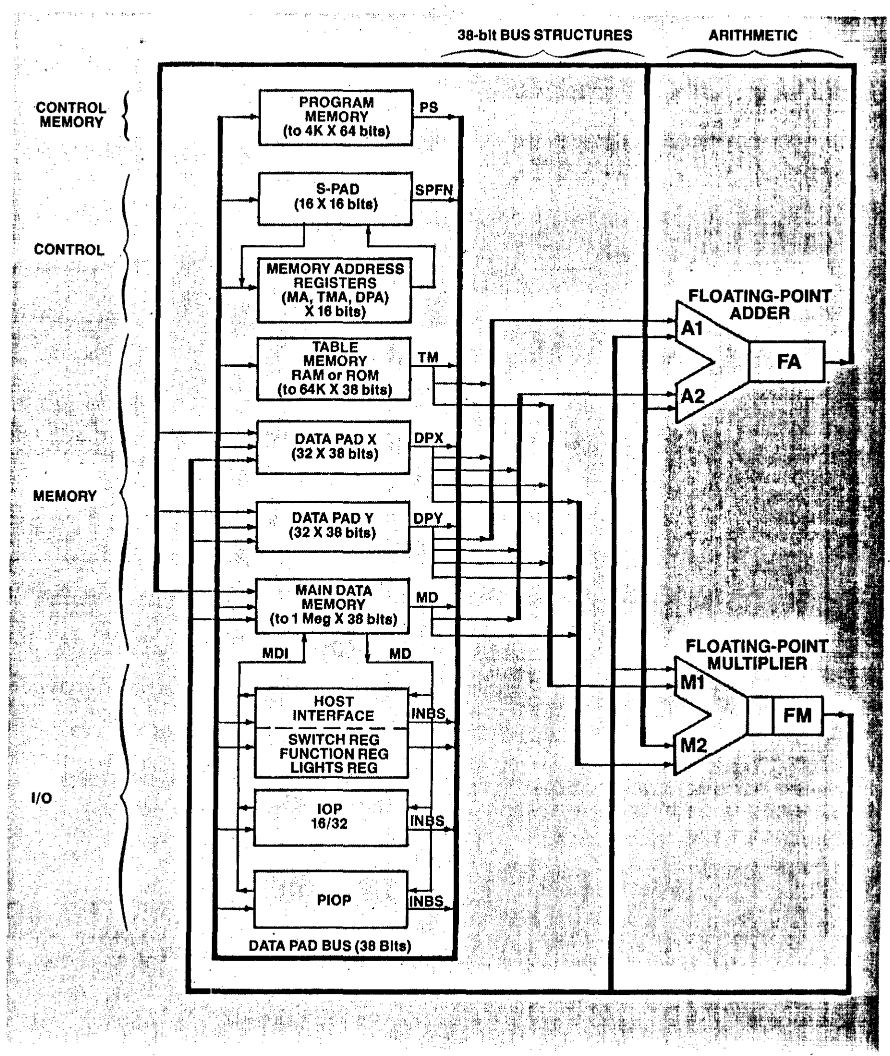
Combined with a major mainframe, the FPS Array Processor brings the user computational ability previously available only at tremendous cost.

The move to floating point.

Previous to the FPS Array Processor, the few array processors in existence were largely integer-arithmetic devices, since the slower floating-point arithmetic of time past was undesirable when working on numerically intensive problems and/or large arrays of data. However, integer arithmetic made programming awkward, due to the limited dynamic range of the word length. Also, array scaling and "block" floating-point techniques allowed human and other errors to creep into the results, and were costly and time consuming. Then, as processing became more sophisticated, even 16-bit integer data words were not sufficiently precise for preserving the accuracy of simple 8-bit analog-to-digital converted input data.

With the advent of faster digital circuit elements, floating-point processing became as fast or **faster than previous integer processing,** allowing users the advantages of easier programming, wider dynamic range and greater precision.

In recognition of this trend, Floating Point Systems, Inc., was formed in 1970 to specialize in floating-point peripheral processors.



FPS simplifies array processor control by using a unique combination of features: (1) all logic elements are controlled by one central clock (synchronous architecture); (2) all logic elements are interconnected with separate dedicated data paths to eliminate handshaking requirements, and (3) a single instruction (64-bits) with command fields controls all processing and/or memory elements.

FPS Array Processors are built for simultaneous operation of all processor elements. Synchronous design assures predictable data flow, which means easier system trouble-shooting. That's good sense in system architecture.

Preserving precision.

As a computational resource in a computer system, the array processor is called upon to compute on different source data formats: the host computer's integer or floating-point format, analog-to-digital integer formats, etc. Consequently, Floating Point Systems became expert in format conversion "on the fly" (as data is being passed to or from the array processor), so processing time would not be used for format conversion. Why convert formats? Simple. Not all formats are mathematically clean. For example, it is unwise to use a 32-bit hexadecimal format for serious number crunching because a hexadecimal normalization can cause as many as three leading zeroes between the binary point of the mantissa and the first significant bit — this reduces precision.

The FPS solution is to use a 10-bit binary exponent, which has more dynamic range than the standard 7-bit hexadecimal or 8-bit binary exponent. FPS also uses a **28-bit mantissa,** plus 3 guard bits, which provide enough bits to not only allow for host hexadecimal formats, but also to carry enough information to permit extensive calculation without significant truncation error when the results are finally converted back to the usual 32-bit formats. The multiplier and adder allow full-width results, and perform post-normalization and convergent rounding at the end of each arithmetic operation in the array processor.

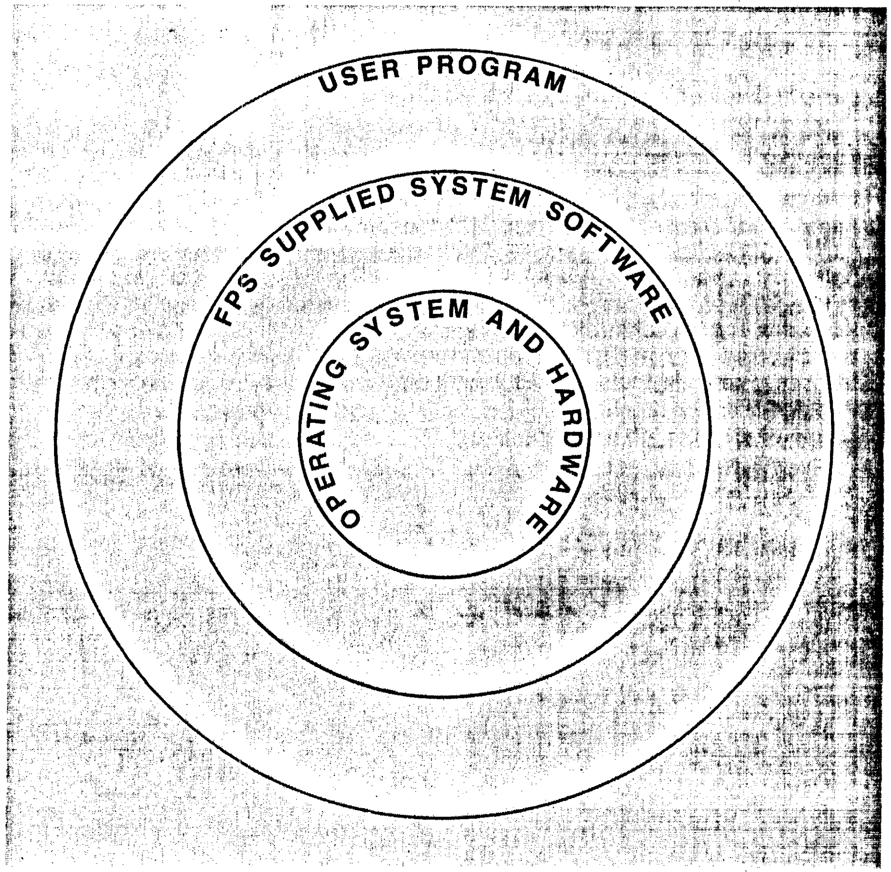
Thus, an FPS Array Processor can receive any reasonable floating-point or fixed format that is desired as the input format, convert it on-the-fly to the FPS format, process it in FPS format with minimal truncation error propagation, and then convert on-the-fly to the desired output format. This procedure allows transparent "no penalty" operation on the data.

Special architecture.

Historically, computations such as fast Fourier transforms (FFT), matrix inversions, and other repetitive calculations required excessive time (and therefore expense) in computer operations, because they were handled sequentially. To speed up these kinds of computations, processors were developed to perform a number of calculations in parallel. The goal was to achieve parallel processing of additions and multiplications simultaneously in separate logic. However, such computer circuitry has proven difficult to manufacture and program because most manufacturers have used an asynchronous multiprocessor design requiring an interaction protocol (handshaking) associated with communication between each internal microprocessor. FPS customers consider this method excessively complex and costly to control.

In addition to the carefully chosen floating-point format, array processors by FPS have **a special architecture featuring a high level of parallelism.** There is a separate bus for each floating-point arithmetic input and a separate output bus from each arithmetic element to the other elements of the system. This parallel multi-bus architecture allows great flexibility in that multiple operands and resultants can be moved simultaneously from any element to any other. It allows the programming of specialized algorithms, such as the FFT, so they execute in times comparable to those achieved by hardwired special-purpose processors, but it also makes FPS machines well suited to less highly organized computations.

FPS Array Processors are **internally synchronous,** and thus have no need for internal handshaking between arithmetic units, memories, and microprocessor; data and results are available at precisely determined times. This synchronous approach has allowed a definitive simulator to be written to support easy program debugging. A further bonus of the synchronous design is the total **predictability of data flow** and timing considerations, which tremendously simplifies programming by the user, and system production and test by FPS. An asynchronous processor has essentially an unlimited number of possible states, each of which should be tested — but in practice cannot be tested. In contrast, the synchronous processor has a finite number of possible states — greatly simplifying testing and enhancing reliability.



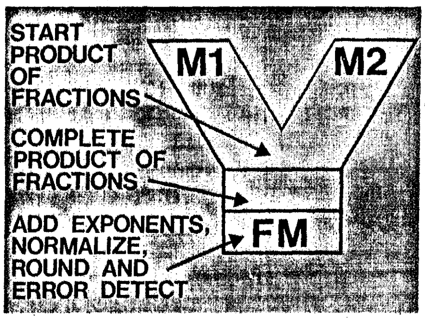
The power of FPS Array Processors can be accessed through the host's FORTRAN, which exercises FPS supplied math routines.

Simple programming.

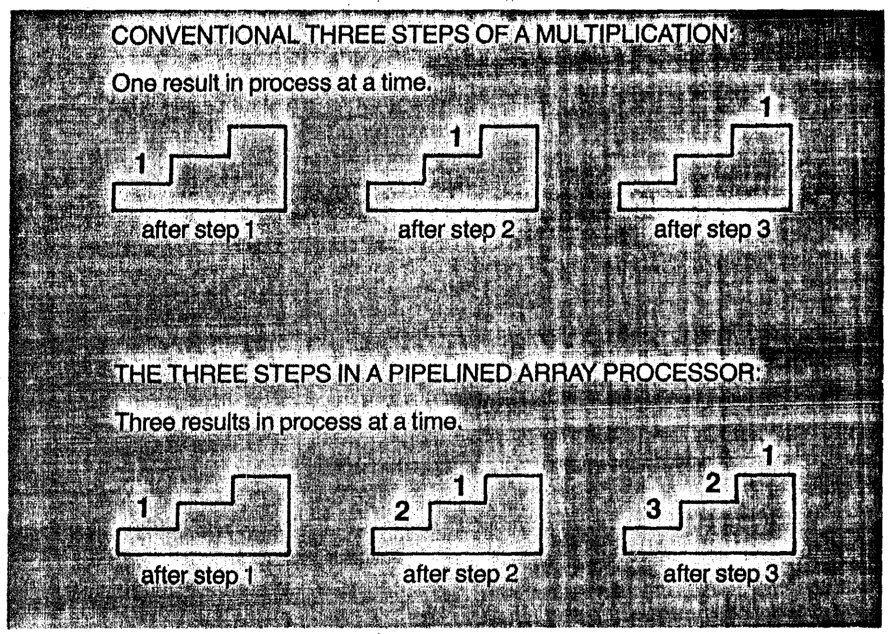
Array processors by Floating Point Systems, Inc., are supplied with a math library of more than 150 program routines, such as vector add, complex vector multiply, FFT, matrix inverse, etc. These routines are callable from FORTRAN, assembly language, or array processor assembly language. Users requiring special routines find FPS Array Processors readily programmable in an easy-to-use assembly language.

What makes a "powerful" array processor.

FPS Array Processors are powerful pipelined, parallel computers. Pipelined parallel processing provides computation rates greatly exceeding conventional sequential computing rates. The floating-point arithmetic elements are pipelined for greater throughput. The two pipelines, as well as the memories and integer elements can all operate together in parallel through independent data paths. These architectural features, combined with a fast (167 ns.) instruction cycle and a large (1 million) floating-point data memory capacity combine to give an extremely powerful, cost effective processor where high-density computation is required.



FPS Array Processors feature 38-bit floating-point arithmetic normalized and convergently rounded to produce eight decimal digit accuracy, not just six. That's big job accuracy!



Pipelined processing.

Most arithmetic computations involve several sequential steps. A floating-point multiply, for example, might require three steps: (1) begin product of fractions, (2) add exponents and complete product, and then (3) normalization and rounding of the answer. To get the correct answer, step #1, then #2, and then #3 must be done. While #1 is being done, the hardware for steps #2 and #3 is idle, and when step #2 is being done, that for steps #1 and #3 is idle, and so forth. **Pipelining enhances computing throughput** by using all the stages at every step. In this case, the three steps of the multiplier hardware are in use at once. A multiply is started by doing step #1 of the add. Then without waiting for the first multiply to complete, step #1 of a second multiply is done concurrently with step #2 of the initial multiply. A third multiply is then started and now all three steps of the multiplier are in use at once.

Once the pipeline is full, a new answer is produced every time step, instead of every three steps — a three times speed improvement. In FPS Array Processors, both the floating-point adder and floating-point multiplier are pipelined. The adder can start a new add every 167 ns., and each add is completed two steps later (333 ns.). The multiplier can also start a new multiply every 167 ns., with the results being completed three steps (500 ns.) later. A floating-point multiply and an add every 167 nanoseconds is **12,000,000 floating-point computations per second.**

Parallel Processing.

Most conventional computers do one thing at a time. Consider the problem of summing the squares of a series of numbers. This loop would typically look like:

1. Increment data pointer
2. Fetch next data point from memory
3. Square the data value
4. Add the squared data value into the sum
5. Decrement loop counter
6. Branch to #1 if loop count non-zero

where each of these six steps is a separate instruction. Note that a floating adder or multiplier is being used in only one instruction out of six, because the conventional processor can do only one thing at a time. The conventional computer instruction word can only specify a single operation, such as multiply, add, or memory fetch, at a time. The conventional computer also has only enough data paths to support a single operation at a time.

Because of their parallel pipelining, FPS Array Processors can do **all of the operations** above in a **single instruction step,** instead of six. The instruction word is wide enough so that a floating-point multiply, add, indexed memory fetch, decrement, and test can all be independently specified in a single powerful instruction.

Independent data paths.

Data flow is the key to computational throughput. FPS Array Processors feature **seven independent data paths** channeling data to, and results from, the floating-point adder and multiplier, minimizing access conflicts. This interconnection of processor elements by distinct data paths gives an unimpeded, synchronized flow of arguments between memory and arithmetic sections and allows the array processor to initiate multiple commands within each 167-nanosecond cycle.

Additional data handling capabilities.

In addition to the host interface, a family of input/output controllers is available for the FPS Array Processors. The one that fulfills the widest range of needs is the Programmable I/O Processor (PIOP). It interfaces the FPS Array Processor to peripheral units, such as data acquisition systems, displays and mass storage devices. The major benefits are speed (3-million 38-bit words per second), independence from a host CPU, and **independent manipulation of data and addresses.** Configurations of array processor and peripherals are readily optimized for a particular application.

The PIOP is a powerful controller for peripheral devices. It features a 38-bit instruction word, 16 registers of 20 bits, 8 independently testable device flags, 4 vectored interrupts, packing and unpacking, and 256 words for writable control store. It supplants the need of specially designed interfaces between the array processor and peripheral devices with an instruction set for device control programmed through the array processor.

The PIOP is one example of FPS recognizing customer requirements and answering with an **innovation in architecture that meets today's and tomorrow's needs.** The resulting product virtually eliminates the need for customer self-support in this area. FPS provides all the support/service you need.

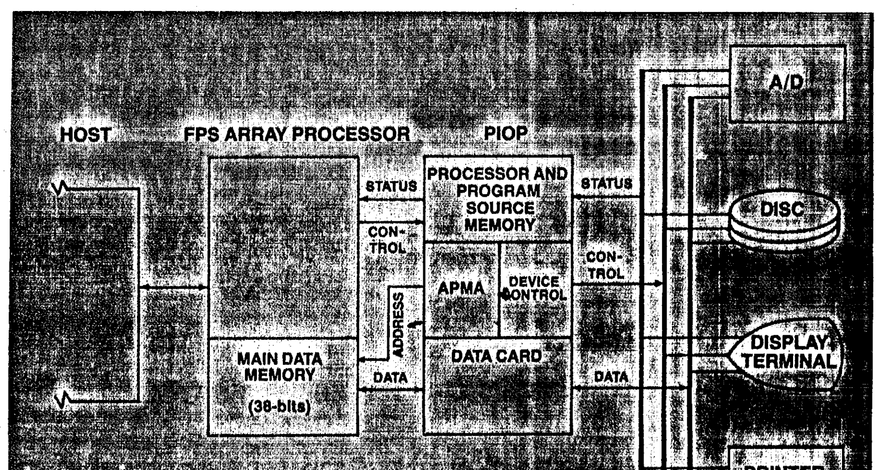
Array processors by FPS give the user the computational power of large mainframes at a fraction of the cost. They are among the most computationally powerful devices available at any price. The age of array processing is here, and **Floating Point Systems, Inc., is the array processor company.**

Conventional Sequential Processor:

One step at a time.
Advance data pointer, then
Fetch data from memory, then
Square data, then
Add to sum, then
Decrement count, then
Branch back if not done.

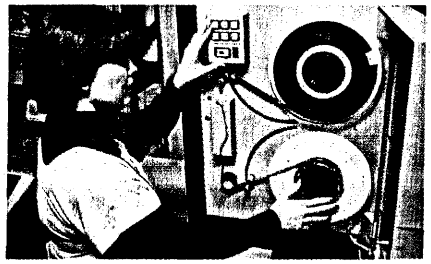
Parallel Array Processor:

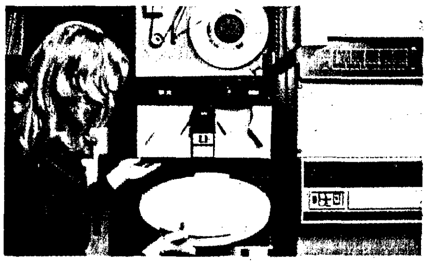
All the steps at once.
Advance pointer and Fetch data and Square data and Add to sum and Decrement count and Branch if not done.

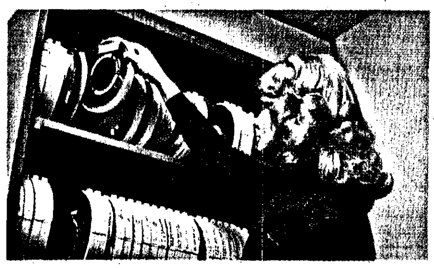


The Programmable Input/Output Processor (PIOP) is an intelligent interface between the FPS Array Processor and peripheral devices.

Standard software.







As an FPS customer, you are provided with the complete software that integrates your FPS Array Processor into your host operating system. You can use the programs from the **extensive FPS math library,** or write your own assembly language programs using our support software, so you can take full advantage of the capabilities we have built into the machine. The support software is divided into packages, which include:

1. APMATH (APMath Library). You get an extensive package of application subroutines. They are FORTRAN-callable algorithms written in the FPS Array Processor's machine language. They handle the vector matrix operations, fast Fourier transforms, and other routines often required of the computer-array processor combination. They are supplied from an extensive library of more than 150 scientific/analysis algorithms.
2. APEX (AP Executive). APEX decodes subroutine calls from your host system's FORTRAN or machine language programs, enabling you to initiate array processor execution with a familiar FORTRAN CALL.

Software development.

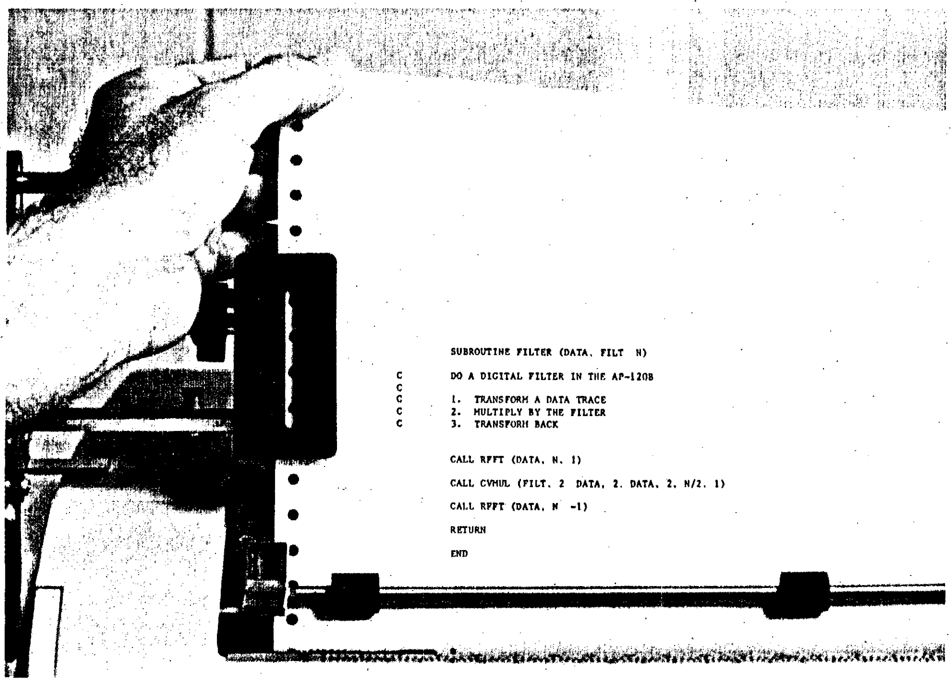
The software development package consists of four FORTRAN IV programs that are compiled on your host computer during installation of the array processor. These include:

1) APAL (AP Assembly Language), a cross-assembler that provides a two-pass assembly of symbolic coding into an object module; i.e., assembles machine code from user source.
2) APLINK (AP Linker) links and relocates separate APAL object modules together into a single load module for execution.
3) APSIM (AP Simulator) simulates all aspects of the array processor on an off-line system. Equivalent runtime characteristics and the floating-point arithmetic (including rounding) are simulated. APSIM lets you develop programs on an off-line computer and get execution times without interrupting array processor production runs.
4) HWDBUG (AP Hardware Debugger) lets you interactively test new programs on the array processor. You may selectively set breakpoints, examine and change memory and register contents and run program segments.

Software diagnostics.

A collection of interactive diagnostic programs test and verify operation of data paths, arithmetic elements, memory units, and the central processor. They provide you with diagnostic readout. The AP Test Programs are:

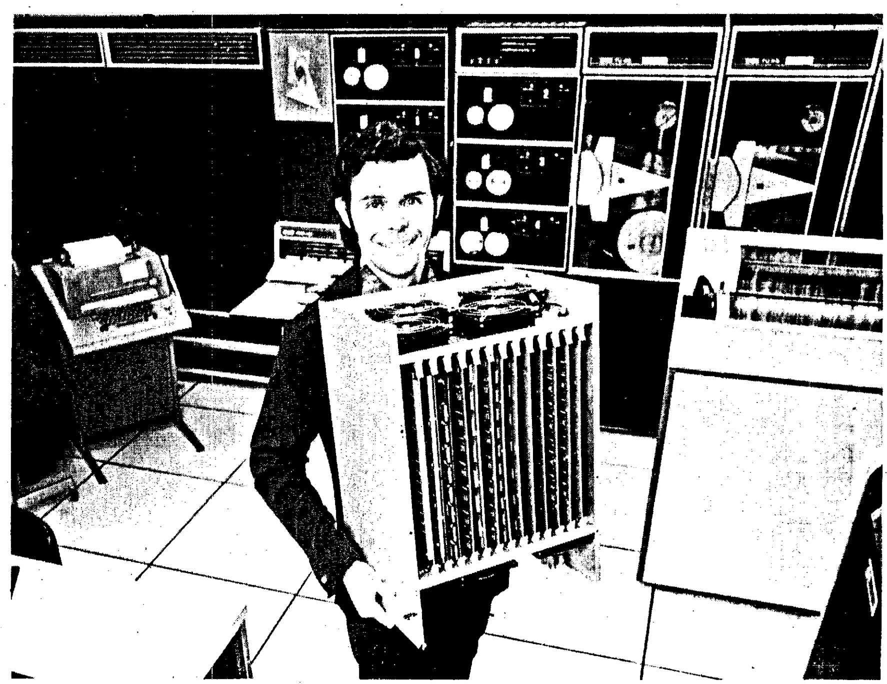
1) APTEST (AP Tester) exercises the Panel, DMA interface, and various internal registers and memories, including the main data memory.
2) APPATH (AP Path Tester) tests the various internal data paths and gives board level diagnostics.
3) APARTH (AP Arithmetic Test) tests the floating-point adder, multiplier, and integer units.
4) FIFFT (Forward/Inverse FFT Test) verifies the correct operation of the array processor by performing forward/inverse fast Fourier transforms.



Efficient programming.

Good program loops harness the power of the machine. The potential of an FPS Array Processor is revealed when you examine the length of the program loop required to accomplish a particular computation. While FPS supplies an extensive math library written **to take full advantage of the machine's capabilities,** you may write your own efficient program loops if you have special needs. FPS provides software manuals to help you. For example, a lengthy but workable dot product program loop might be 14 steps long. But since the FPS Array Processor has a highly parallel structure, each logical unit of the machine may be operated simultaneously and independently (though synchronously) for maximum speed. An array processor programmer (potentially you, as one of our customers) learns to recognize ahead of time how many cycles his loop should contain. The 14 step dot product program can be shortened by combining instructions and overlapping memory fetches. It can actually be cut down to 3 array processor cycles! . . . good loops make an efficient run, and **FPS makes it easy to write good program loops.**

The internal organization of FPS Array Processors is particularly well suited to performing large numbers of reiterative multiplications and additions, such as are required in digital signal processing, matrix arithmetic, statistical analysis, and numerical simulation.



Documentation... everything you need, and more.

Every sale of an FPS Array Processor is backed by a complete documentation package including operation and maintenance manuals, software source and manuals, system schematics, and wire lists. Should you need further material or consultation, all you have to do is ask.

Back in the classroom again.

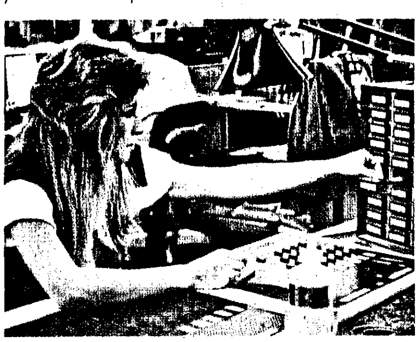
Floating Point Systems, Inc., offers a broad educational resource to train you or your people to the level of expertise desired. We regularly hold classes at FPS. If it is impossible for you to send your people to FPS, we can conduct classes at your location. Contact Floating Point Systems, Inc., for class schedules and rates.

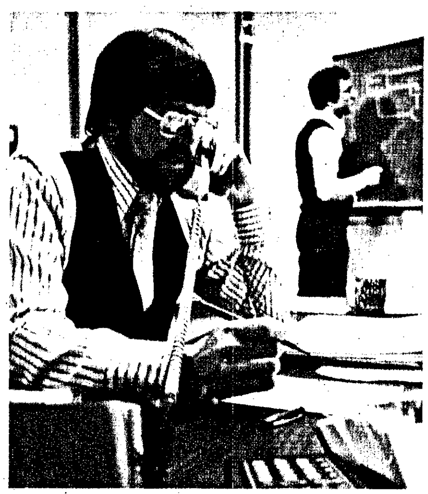
Warranty, installation, and service information.

While FPS Array Processors have been in the field since mid-1975 and have demonstrated a MTBF (mean time between failure) in excess of 3500 hours, FPS stands ready to provide you with service... should you need it. Warranties against defects in materials and workmanship are 90 days to end users and 60 days to OEM customers, covering both parts and labor. Installations are accomplished by specially trained FPS teams, one of which is experienced on your CPU and operating system. Service is available either on a daily rate or by service agreement. Ask your local FPS employee for details on warranty, installation, and service. We at FPS are proud of our product, and we stand behind it.

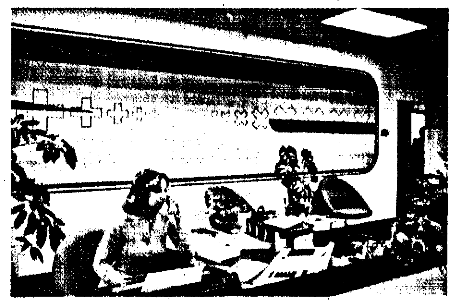
People . . . the resource that ties it all together.

Floating Point Systems, Inc. is a high-technology computer firm with **offices worldwide** — yet it is still a people-oriented company. Founded in 1970 and located near Tektronix, we have grown to be the second-largest computer-related electronics company in the region. Today, FPS maintains equal emphasis between sales and support to end users and response to OEM customers. While several OEM orders have exceeded 200 units, company personnel supply sales support and service to end users through a network of FPS offices that extends nationwide and overseas. Certainly one of the ingredients for our rapid growth has been the close rapport between individuals that allows an idea to become a high-demand, high-technology product. It is this kind of people-to-people contact within FPS and between you and our company that you can depend on.





We want you, as one of our prospective customers, to give us a call. Let one of our specialists discuss your application and define how array processors can tackle your problem with surprising ease. FPS can provide specialized hardware and program routines, as well as an evaluation of your data acquisition and data processing techniques. **We continually develop hardware and software products to set the pace in array processing.** We'll bet we can provide you with a solution to your problem that is faster, more economical in both equipment and dollars, and more dependable.



User Group

FPS sponsors an annual User's Group Conference during which scientific papers are presented and ideas are exchanged in seminars. As an FPS Array Processor User, you are invited to attend these conferences. You also may qualify as a significant contributor to the technology of array processing. Included among the papers that have been presented at the User's Group are:

- "SEMBLANCE CALCULATIONS FOR SEISMIC VELOCITY ANALYSIS IN THE AP-120B," BY PETER BUHL, LAMONT DOHERTY GEOPHYSICAL OBSERVATORY, COLUMBIA UNIVERSITY.
- "A REAL TIME MULTI-CHANNEL DIGITAL FILTER SYSTEM," BY SAM SPARCK, TIME/DATA, DIVISION OF GEN RAD, INC.
- "THE CHEMISTRY MACHINE," BY KENT WILSON, UNIVERSITY OF CALIFORNIA AT SAN DIEGO.
- "A REAL TIME FLOATING POINT VARIABLE FRAME RATE LPC VOCODER," BY RANDY COLE, INFORMATION SCIENCES INSTITUTE, UNIVERSITY OF SOUTHERN CALIFORNIA.

A Message

The importance of providing fast floating-point hardware for the minicomputer user was the impetus for the incorporation of Floating Point Systems, Inc., in 1970. Each year since, we have introduced faster and more compact floating-point processors, spurred on by customers who in turn utilized our hardware in increasingly sophisticated applications — and more demanding hardware environments.

Early recognition of these new requirements led us to consider a revolutionary processor. What users needed was the very heart of a major mainframe — high-speed arithmetic power — but in a small package, and at a small price.

Thus, we have designed processors with general-purpose computing properties, aimed directly at high-speed algorithm execution, and made them easy to program for these tasks.

FPS Array Processors represent a uniquely advanced balance of computing precision, speed, reliability, and economy. They provide an opportunity to acquire original equipment or upgrade computational capacity while lowering investment and usage costs.

We invite all those with complex computational tasks to undertake a detailed appraisal of our array processor systems.

C. N. Winningstad
President
FLOATING POINT SYSTEMS, INC.

Never before has a computer actually delivered so much power, speed, precision, reliability, and programming ease . . . at such low cost.

The exploding growth of technology has created an insatiable demand for extremely high-speed, low-cost computing. FPS has responded to this need by developing a specialized scientific computer. Called an array processor because of its ability to deliver high throughput on large arrays or vectors of data, it has literally created a new era in signal processing and scientific computation. An FPS Array Processor interfaced to a minicomputer or large mainframe has created low cost systems capable of handling the most demanding computational tasks previously achieved by only a handfull of expensive large mainframes.

FPS responds to your total needs.

FPS Array Processors answer technology's continual demands for more computing power.

FPS Array Processors allow systems to be upgraded at a small incremental cost.

An FPS Array Processor and a minicomputer provide the computing power of a giant mainframe at an attractive fraction of the cost.

FPS Array Processors give new capability to major mainframes.

FPS Array Processor Systems offer the best investment in original equipment.

FPS customers continue to get unequaled software and support.

FPS serves the needs of scientific computing technology.