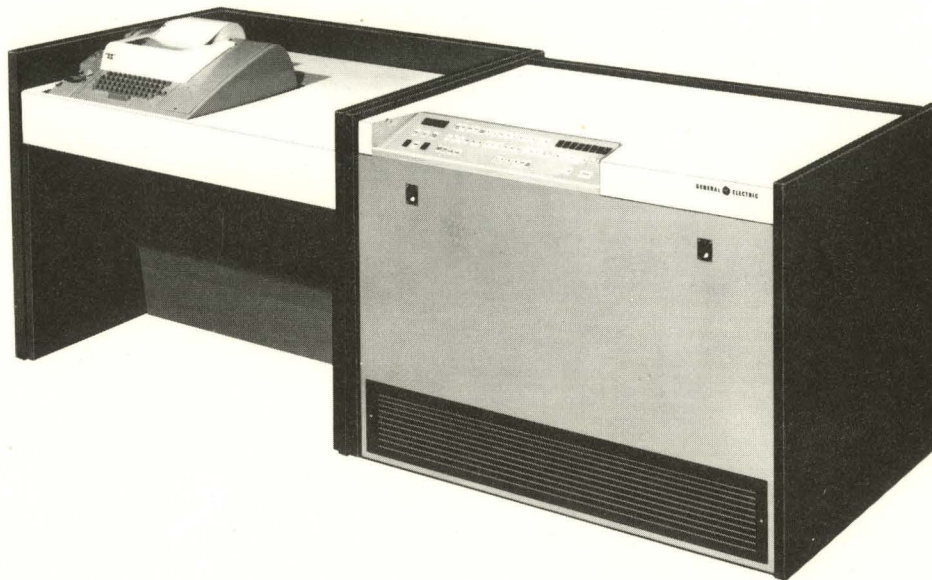


GE PAC 4000*

GENERAL ELECTRIC PROCESS AUTOMATION COMPUTER

FORTY TWENTY main frame



Computer Type: Binary

Circuitry: Solid state, monolithic integrated circuits

Environment: 32 to 131°F; 5 to 95% RH

Memory: Temperature-regulated magnetic core

Capacity: 4096 to 32,768 words

Cycle Time: 1.6 μ s

Mass Memory: Magnetic drum

Capacity: 16,386 to 262,144 words

Access Time: 8.5 ms avg

Speed: 3600 rpm

Type: Magnetic disc

Capacity: $\frac{1}{4}$ million to 4 million words
(24-bit) of expandable storage

Positioning Time: 5 ms/track
Rotational delay 50 ms

Transfer Rate: 163.8K char/sec

Word Size: 24-bits plus parity

Instruction Execution Times:

Add 3.2 μ s Floating Point subroutine

Multiply 12 μ s I/O Word Rate up to 660KC

Divide 13.6 μ s Levels of

Full Shift 7.2 μ s Interrupt to 128

Instructions: 25 independent operation codes, some microcoded to provide up to a total of 88 hardware instructions defined within the assembly language, including shifting, output, bit logic, and testing.

I/O Equipment:

Typewriters	10 cps
Paper tape readers	100/200 cps
Paper tape punch	120 cps
Card readers	70/300/900 cpm
Card punch	100 cpm, 300 cpm
Line printers	120 col-300 lpm 136 col-1200 lpm
Magnetic tape	200/556/800 bpi
Transfer rates	7.5 to 120 kc
Operator consoles	Many standard models available
Digital clock	Memory clock in hours, minutes, seconds
Display devices	CRT, trend recorders, annunciators

Process Communications:

Analog Inputs	8 to 2048 pts/control, 2 & 3 wire, 40 to 200 pts/sec.
Analog Accuracy	.1% of full scale (50 mv)
Analog Range	10 millivolts to 10 volts
Contact Inputs	Groups of 20 at computer execution rates
Pulse Inputs	Any number at computer execution rates
Analog Outputs	To 64 or more of up to 12-bit resolution
Contact Outputs	Groups of 16

Numerous other interface items as required by processes.

*Registered trademark of General Electric Company

IN THE CONSTRUCTION OF THE EQUIPMENT DESCRIBED, GENERAL ELECTRIC COMPANY RESERVES THE RIGHT TO MODIFY THE DESIGN FOR REASONS OF IMPROVED PERFORMANCE AND OPERATIONAL FLEXIBILITY.

8/66 (1M) Litho in USA

GENERAL ELECTRIC

PROCESS COMPUTER BUSINESS SECTION

PHOENIX, ARIZONA

GE PAC* 4020

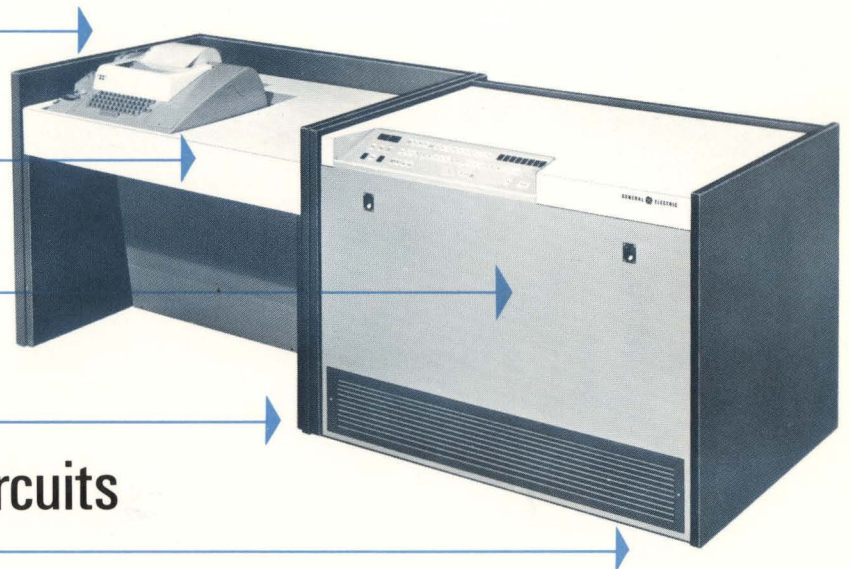
COMPACT COMPUTER FOR PROCESS CONTROL

High speed

24-bit word

Off-the-shelf software

Monolithic integrated circuits



*Reg. trademark of General Electric Co.



GE/PAC 4020...the key to planned growth in process control...gives you highest performance per dollar invested, in a compact and reliable system

Monolithic integrated circuits. Highest performance, reliability, and compactness result from the maximum use of monolithic integrated circuits (shown on Page 4). They are less vulnerable to connection failure and electrical noise. The advanced packaging system for GE/PAC integrated circuits simplifies maintenance, and allows maximum safe utilization of the circuit's high-speed capability.

GE/PAC programs ready to go. GE/PAC 4000 software is available now, *today*. This means your GE/PAC 4020 computer goes on line faster with programming simplified. With FORTRAN to help you talk to the computer in your own language and MONITOR to take the curves out of real time, you get the job done sooner and save money. The software is compatible with other GE/PAC computers.

1.6 microsecond speed. The high speed and low cost of the GE/PAC 4020 are just what many industries have been wanting for new process control applications. Designed for a desk enclosure, GE/PAC starts small. But when it grows up to 32,768 words of core, it can handle big problems. With high speed of over ¼ million instructions per second, it's ready for your toughest jobs.

24-bit word length. Like all GE/PAC process control computers, the GE/PAC 4020 gives you the proved advantages of 24-bit word length. It gives you the precision you need for process control calculations. Better addressability saves programming cost and use of core memory. The 24-bit word also

lets you pack words more efficiently for output logging, reports, and other data. Other benefits: better numeric operations, multiple index register capability, simplified scaling of data, and micro-coding of input/output instructions in a single word.

Direct digital control capability. Basic features of the GE/PAC 4020 give it ideal inherent capability for direct digital control. Among these are high speed, high reliability, a wide range of standard input/output devices, and software which simplifies programming of the many algorithms you want. The GE/PAC 4020's high speed lets you incorporate additional functions such as startup and shutdown sequencing, logging, or process supervisory control, if desired.

Full product line. GE/PAC 4020 is born into a complete family of standard process computer modules. For small systems, the 4020 draws from the complete line — digital inputs and outputs, analog scanning devices with a multitude of sensor conditioning circuits, and all types of digital outputs. Also a variety of amplifiers, converters and controllers; peripheral, bulk memories, and backup power supplies; as well as cabinets, desks, and operator's panels. For larger systems, the GE/PAC 4050 and 4060 are available using the same line of equipment.

Integrated with General Electric's total information systems. Standard interconnection features combine the new GE/PAC 4020 with General Electric's GE-400 and GE-600 business computers. The total G-E systems package also includes: other GE/PAC computers, Directo-Matic* II controls, GE/MAC instruments, and GE/TAC telemetering and control.

*Reg. trademark of General Electric Co.



SG143
4321

Monolithic integrated circuits contribute to maximum reliability

The logic design of GE/PAC 4020 utilizes monolithic integrated circuits to assure highest reliability. Conventional circuitry is used only in those cases where the power requirements for drive capability exceed the present state of the integrated circuit art.

"Monolithic" comes from the Greek meaning "one stone." Monolithic integrated circuits are grown by semiconductor techniques as an integrated logic function on a single chip of silicon. Vulnerability to connection failure is greatly reduced over conventional circuits because single components (resistors or transistors) no longer require soldering or welding to tie them into the circuit. Even some of the "integrated" circuits have micro-welded components on a single, very small base. Monolithic integrated circuits are more reliable even than this type because reliability is a direct result of the number of individual soldered or welded connections in a computer.

Integrated circuits also give the advantages of high computing speed, lower power requirements, and smaller over-all computer size. They provide a high degree of immunity to electrical noise by using a wide voltage swing to perform the switching function. The high signal-to-noise ratio obtained is very critical in process computer installations because of the numerous power system fluctuations possible in industrial plants, especially during emergency situations.

The new General Electric Advanced Packaging System (called "GEAPS") is used for GE/PAC 4020 circuitry. It gives high packaging density for compact design. Epoxy glass printed wiring boards protect against moisture and warping. The circuits can tolerate a wide range of environments. Relatively few different types of circuit elements, together with modular circuit board widths, simplify maintenance and markedly reduce spare parts.

GE/PAC's off-the-shelf, standard software aids give you quicker



Both initial cost and long-term operating expense are materially reduced when programming can be accomplished quickly and accurately. GE/PAC 4020 software packages reduce costs many ways:

- Help you write your own computer programs systematically.
- Offer flexibility for future changes in your processes.
- Provide software designed especially for programming process functions.
- Existing FORTRAN II programs can be altered easily to become on-line routines.

The following paragraphs describe GE/PAC 4020 software packages and their benefits.

PROGRAM PREPARATION AIDS

- Help translate process functions into computer instructions.
- Increase speed and accuracy in preparing programs.
- Aid in documenting and debugging.
- Operate locally on GE/PAC 4020, GE-412, or GE-200 series computer systems.

Process Assembler Language (PAL)

- Enables programmer to code in a systematic and well-documented fashion.
- Operates on-line as well as off.
- Generates single- and double-precision constants to a specified scale factor or in floating-point format.
- Has built-in check features to detect and notify programmer of coding errors.

FORTRAN compilers

- Let you write powerful algebraic and verbal statements with minimum time and effort.
- Operate on-line or off. (For an exclusive off-line application, FORTRAN IV and other scientific programs are available.)
- Permit experienced FORTRAN programmers to make easy transition to GE/PAC 4020 programming.
- Allow previously written FORTRAN II programs to operate on the GE/PAC 4020 after minor alterations.

GE/PAC simulator

Using the GE/PAC simulator as a companion to PAL and GE/PAC FORTRAN, you can write, assemble, compile, and check functional programs at the nearest G-E Information Processing Center — even before your GE/PAC is delivered. Then, system testing can be started as soon as the hardware is available, so your process control computer can be on-line faster.

STANDARD ON-LINE FUNCTIONS

- Common routines suitable for numerous applications.
- Require little or no work by your programmer.

startup...help open broad, new process control application areas

- Routines are pre-checked to eliminate programming and debugging time.

MONITOR & MONITOR-compatible programs

- Schedule and assign priorities to system functions.
- Help you have your system running on-line in minimum time.
- Provide communication between functions and peripheral equipment.

Math routines

- Include commonly used math functions in fixed or floating point, single or double word length arithmetic.
- Available from the General Electric library to all GE/PAC 4000 users.

PROGRAM DEBUGGING AIDS

- Include load-compare, dump, memory change routines.
- Load-compare and dump are available in on-line or off-line form.
- On-line debugging aids are plug-in package to MONITOR system.
- Debugging aids proved by on-site experience provide powerful means of keeping program documentation up to date.

Hardware diagnostic programs

- Minimize delays by rapidly testing computer hardware and indicating areas where trouble exists.
- Cover peripheral devices as well as central processor.

EXPANSION FEATURES

Memory protect

The advanced Quadritect system is exclusive to the GE/PAC 4020. It uses four states of read/write control to protect memory against errors in non-debugged programs. Under hardware control, Quadritect:

- Allows complete protect supervision by MONITOR.
- Expedites program debugging.
- Can confine program to a specific area of core memory.
- Allows complete isolation of a specific core area.
- Protects against incorrect input/output commands.
- Assures no interference with system timing.

Automatic program interrupt

- Expandable up to 128 interrupts (in groups of 8) for small to large systems.
- Protects the process by rapidly directing the computer to the most important task. Search time to any interrupt is less than one-half microsecond.

- Allows all system devices to operate at full speed.
- Facilitates direct memory counting of process tallies.
- Can use interrupts with memory counting for constructing as many programmable time counters as needed.
- Can permit selective interrupts under program control as well as interrupt-on-interrupt.

TIM/TOM

Standing for *Table Input to Memory* and *Table Output from Memory*, this unique hardware design allows block data transfer to and from external devices via arithmetic unit channels in a cycle-stealing mode, independent of the program. Using interrupt control, TIM/TOM offers:

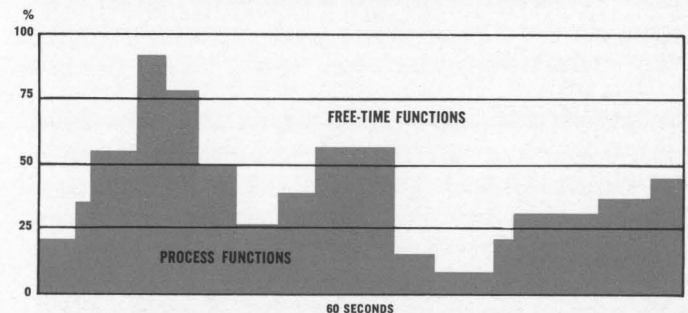
- Low-cost "controller" operation of peripherals.
- Simplified programming.
- Hardware word packing or unpacking of 6-, 8-, and 12-bit characters.
- Faster device and system operation with high-speed data transfer.
- Simple program loading from an input device.
- Device testing under program control.

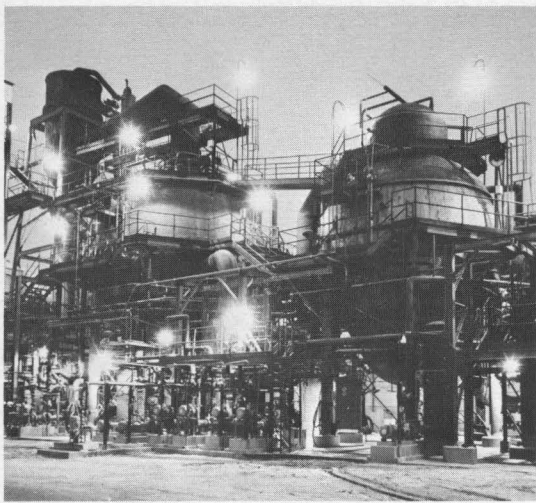
GE/PAC's FREE-TIME SYSTEM GIVES MAXIMUM USE OF YOUR PROCESS COMPUTER

The GE/PAC Free-Time System operates in the white area of the chart, allowing you to realize 100 percent usage of the computer's arithmetic and logic capabilities. Such low-priority functions as production control, stock status, and scheduling programs are done during time increments not used by the computer for its process control functions.

The Free-Time System for the 4020 is controlled by MONITOR, the executive of the GE/PAC software. At any given time, process needs take precedence over free-time functions via Automatic Program Interrupts. As the urgency of process demands decrease, free-time functions automatically increase to fill the unused capacity.

For further details, refer to bulletin GEA-7288.





GE/PAC 4020 brings dollar savings to the process control

. . . through: *Production Control • Inventory Control • Quality Control • Scheduling • Engineering Studies • Yield Accounting • many other areas*

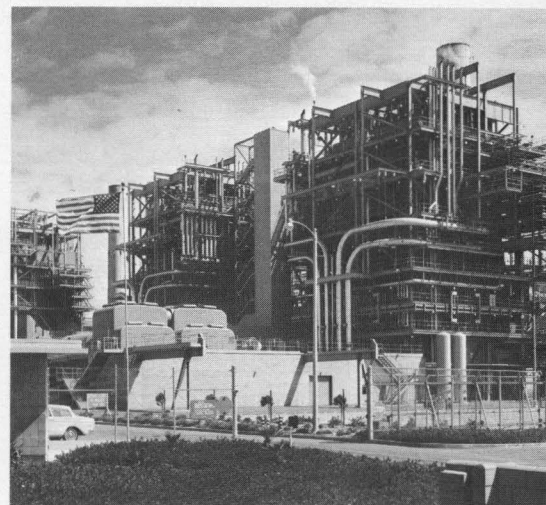
Electric utilities. Process computer applications include monitoring and control in steam and nuclear power plants, system control computers for the economic allocation of generation among various generating units, and the automatic calculation of power interchange between cooperating utilities. Many electric utilities find a process control computer is economically justified when a power plant reaches 150,000-kw capacity. Even smaller capacity plants may have specific requirements which justify a process computer.

Chemical and other process industries. Blending and weighing ingredients for batch or continuous production are used extensively in such industries as chemicals, fiber, plastics, and glass-making. Varying formulation for many different products, close control of uniformity, cost optimizing or formulation tolerances, and product analysis for subsequent processing; these justify the speed, accuracy, and repeatability of GE/PAC 4020.

Petroleum. Refinery optimization and catalytic cracking plants are key applications gaining acceptance for process control computers. A wide range of additional processes are being controlled, including alkylation units, hydrocracking, gasoline blending, and control of a lubricant and waxes plant. Computers are also being applied to petroleum and natural gas pipelines, and process computers are controlling fuel distribution among airlines at key airports.

Steel. Today, no large new hot-strip mill will be built without computer control, and basic oxygen steelmaking, the lucrative replacement for the open hearth, also lends itself to computer control. Other promising areas of application for GE/PAC 4020 include electrolytic tinning lines, annealing lines, power-demand fuel selection, cold rolling mills, electric furnaces, blast furnaces, and continuous casting facilities. With the huge capital investment required in the steel industry, computer control is attractive on a basis beyond direct cost reductions, i.e., ability to increase throughput by more efficient facilities.

Pulp and paper. Impetus to computerization is given by current industry trends toward low alkaline pumping and the rapidly



needs of every industry

increasing demand for specialized papers. The growing shift to kraft pulping by continuous digestion (versus batch) is particularly amenable to process control. Among the benefits: lower maintenance cost, increased output per ton of wood through more precise temperature control, more accurate determination of raw material requirements, and more uniform pulp quality.

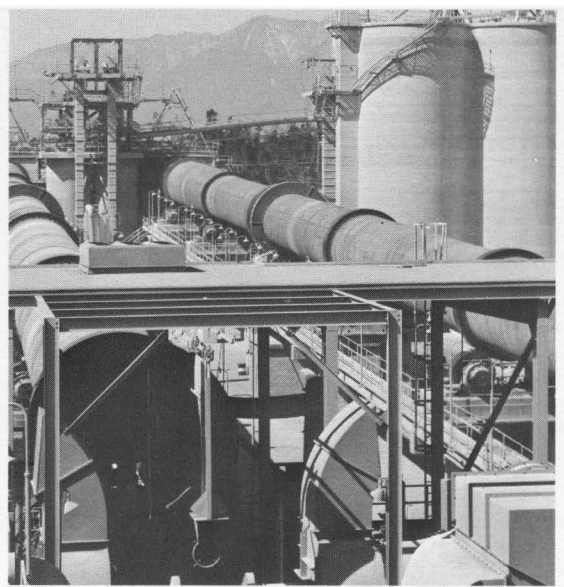
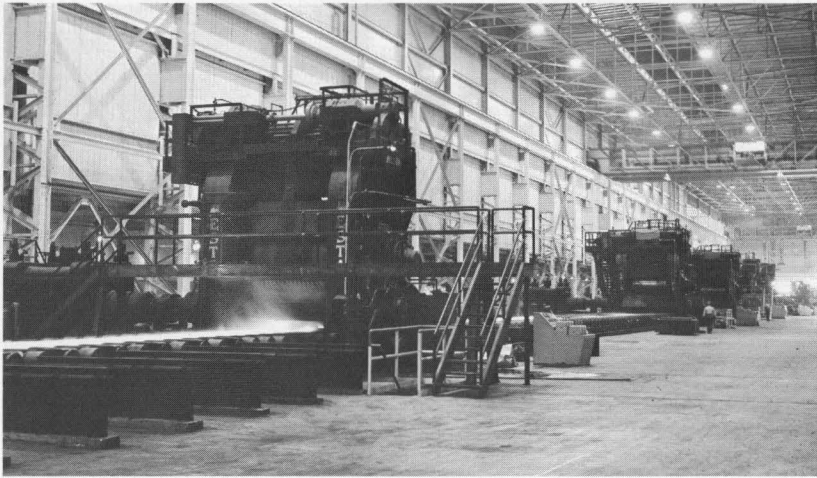
Cement. Process computers are used for raw material mixing, kiln control (including automatic kiln startup), ball mill load control, and over-all off-limit alarming. A typical installation for a 2-million barrel-per-year plant saved \$205,000 annually by reducing power and fuel use, lining maintenance, and additive costs while upgrading product uniformity and extending quarry reserves.

Railroads. Keeping track of foreign cars is an expensive operation. Railroads can use the GE/PAC 4020 with mass memory connected by wire to remote data acquisition centers to keep track of rolling stock and allocate its service. Such computer control systems utilize General Electric automatic car identification products which transmit data on passing cars by wire to the computer.

Mass transit. Municipalities of over 250,000 population face the problem of getting inhabitants into and out of downtown areas efficiently and comfortably. Mass transit systems and electronic traffic controls of the future will use process computers. A GE/PAC computer has demonstrated its capability in the test program of the San Francisco Bay Area Rapid Transit District.

Food Processing. A GE/PAC 4020 can economically control such operations as ingredient storage and handling, mixing, blending, cooking or baking, packaging, and optimized storage and retrieval for fully automated warehousing. Product quality, uniformity, and lower production costs are the benefits of computer control of food processes.

Rubber. The key to product quality is computer control of the polymerization steps to get uniform properties. A computer can decrease the process chemicals needed to promote the reaction, reduce the time required to make process adjustments, and cut the costs of monomer recovery. Dollar savings can be as much as 64% via reduced conversion variations and 45% by reduced plasticity variation. Productivity can increase 3.5% or more.



Discrete product manufacturing. Good production control provides efficiency in the manufacture of discrete items. The industrialized GE/PAC 4020 can be used with large bulk memory storage and high-speed card equipment. This, coupled with its facility for logical decision-making and counting, gives you the flexibility you need for control of production, inventory, and product quality. A GE/PAC 4020 computer system can pace the production line—supplying numerical control data; dynamically dispatching, monitoring, and analyzing machine perform-

ance; and generally controlling and supervising the entire manufacturing cycle, including product testing.

Municipal services. GE/PAC 4020 has the speed and flexibility to handle such multiple and diverse operations as water and sewage treatment, optimized water pumping and dispatching, traffic control, and equipment inventory management. Integrating these functions with an economical GE/PAC 4020 can justify your computer investment.

DATA-EDIT displays visual process information

The DATA-EDIT is an alpha-numeric display system that provides rapid communications with GE/PAC 4020 or other GE/PAC computers from local or remote locations. It consists of a Display Controller and one or more TV-type Display Terminals. Working at a terminal, an operator has clearly visible, up-to-date process information as well as the ability to enter operating data into the computer.

Closed-circuit TV can be added to this display system for extra process monitoring and control capability. Closed-circuit TV of process units or slide-projected diagrams can be mixed with computer-produced data for display on the same screen.



GE/PAC 4020 lets you start your total plant management system at any level

A total plant management system integrates business and process computers to supply fast, accurate management information. The objectives are production control, process control and optimization, yield accounting, and other key functions required on a total plant basis.

The GE/PAC 4020, with its complement of peripheral and process communication equipment, can be easily integrated into a plant management system at any level. It can be used initially for data accumulation on a single unit, then expanded to process control. Later, it can be coupled with GE/PAC Remote Scanners or linked as a satellite process control unit with the larger GE/PAC 4060 central processor to form the over-all plant system for tying into the corporate or business information system.

Small initial investment. With GE/PAC 4020, you buy only the modules to do the functions initially required. The computer operates on standard 230-volt, 50 or 60 cycle a-c power, and requires no special enclosure or refrigeration under normal conditions. It operates in temperatures from 32F to 131F and humidities from 5 to 95 percent. The compact size reduces floor space requirements. The compatibility of GE/PAC components and circuitry eliminates expensive interfacing equipment and facilitates system design and engineering.

Typical functions. You can start with minimum 4096-word core memory in the central processor and a typewriter with integral paper tape reader and punch. This system can perform off-line functions such as data reduction, optimizing calculations, and engineering analysis.

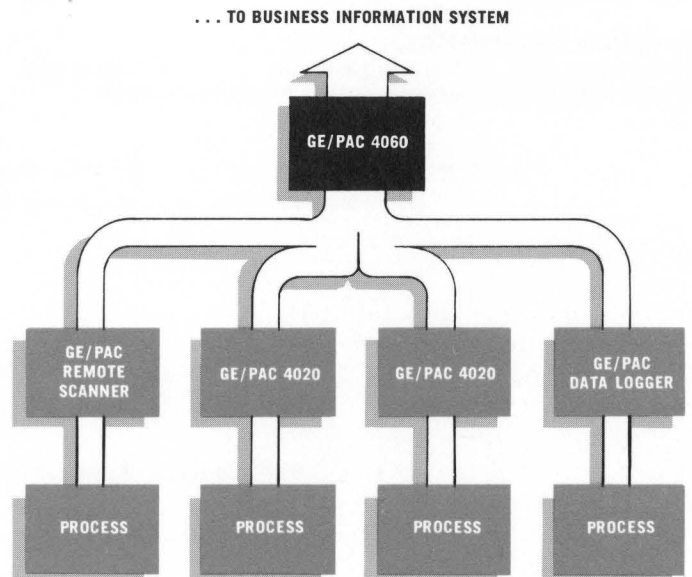
By adding an analog scanner or other process input/output equipment, you can put the computer on-line. On-line functions can include automatic logging, alarming, performance analysis, monitoring, controlling, continuous testing, checkout, and evaluation, as well as providing computer calculated guides for the operator.

Better management reports. GE/PAC 4020 presents accurate, up-to-date process operation data and performs control in real-

time (that is, within time constants of the operation as it takes place). You save money when decisions are based on current information. For instance, productivity is accurately measured and operator efficiency rewarded or improved.

Process sensor signals, scanned automatically by GE/PAC 4020, provide raw data that is converted into useful information by the computer. It can be printed out under computer control to provide complete, factual records of plant operation.

Process supervision and control. The logical and scientific computing capability of the GE/PAC 4020 gives you an ideal tool for process supervisory control. Coupling a GE/PAC Remote Scanner with the GE/PAC 4020 allows supervision over a process with widely separated units. The GE/PAC input/output modules provide a complete assortment of signal measurement and output control devices to handle the various sensors and setpoint control requirements of a supervisory application.



GE/PAC 4020 operating specifications

CENTRAL PROCESSOR

Computer type:

Digital, binary, fixed point

Circuitry:

Solid state, monolithic integrated

Storage, working:

Temperature-regulated magnetic core with memory protect feature, memory cycle time 1.6 microseconds — 4096; 8192; 12,288; 16,384; 24,576; and 32,768 words

Storage, back-up:

Magnetic drum — 16,384 to 262,144 words
Magnetic disc — 250,000 to 4,000,000 words

Parity checking:

Provides for both core and bulk storage

Word size:

24 bits plus parity option

Interrupts:

Up to 128, in groups of 8

Instructions:

Twenty-five independent operation codes, some microcoded to provide up to a total of 88 hardware instructions defined within the assembly language, including shifting, output, bit logic, and testing.

Operating times:

In microseconds, using 1.6 microsecond memory

Memory read/write cycle	1.6
Add full word	3.2
Multiply (average)	10.0
Logical commands	3.2
Memory input/output rate to external registers	667KC
Full length shift	4.0

Operations requirements:

Power 230 volts $\pm 10\%$, single-phase, 50 or 60 cycles per second ± 1 cycle. Other voltages can be accommodated.

Environment:

Temperature range, 32 to 131F; relative humidity, 5 to 95%.

Physical characteristics:

Desk design is standard for central processor. Upright cabinetry is used for system modules and for central processor when desired.

Weight — approximately 400 pounds for typical central processor.

Packaging — rugged industrial construction meets NEMA Type 1 standards. Full access from the front; circuitry mounted on roll-out assembly. Can be installed against wall, in corner, or recessed area. Programmer's console on front of desk.

SYSTEM

Operator communications:

Typewriter — 10 characters per second (available with integral paper tape reader and punch)

Paper tape reader — 100/200 characters per second

Paper tape punch — 120 characters per second

Card reader — 100 cards per minute, option 300 and 900 cards per minute.

Card punch — 100 cards per minute, option 300 cards per minute.

Operator's console — many standard models available

Digital clock — memory clock in hours, minutes, seconds

Display devices — CRT, trend recorders, annunciators

Process communication:

Analog inputs — 16 to 2045 or more at 50 to 200 points per second.

Analog accuracy — 0.1% of full scale

Analog ranges — 10 millivolts to 10 volts

Contact inputs — groups of 20 at computer execution rates

Pulse inputs — as needed at computer execution rates

Terminal equipment for remote communications available

For more information about GE/PAC 4020 process computers and Integrated Process Control, contact your nearest General Electric Apparatus Sales Office.

GENERAL  ELECTRIC

PROCESS COMPUTER BUSINESS SECTION

PHOENIX, ARIZONA