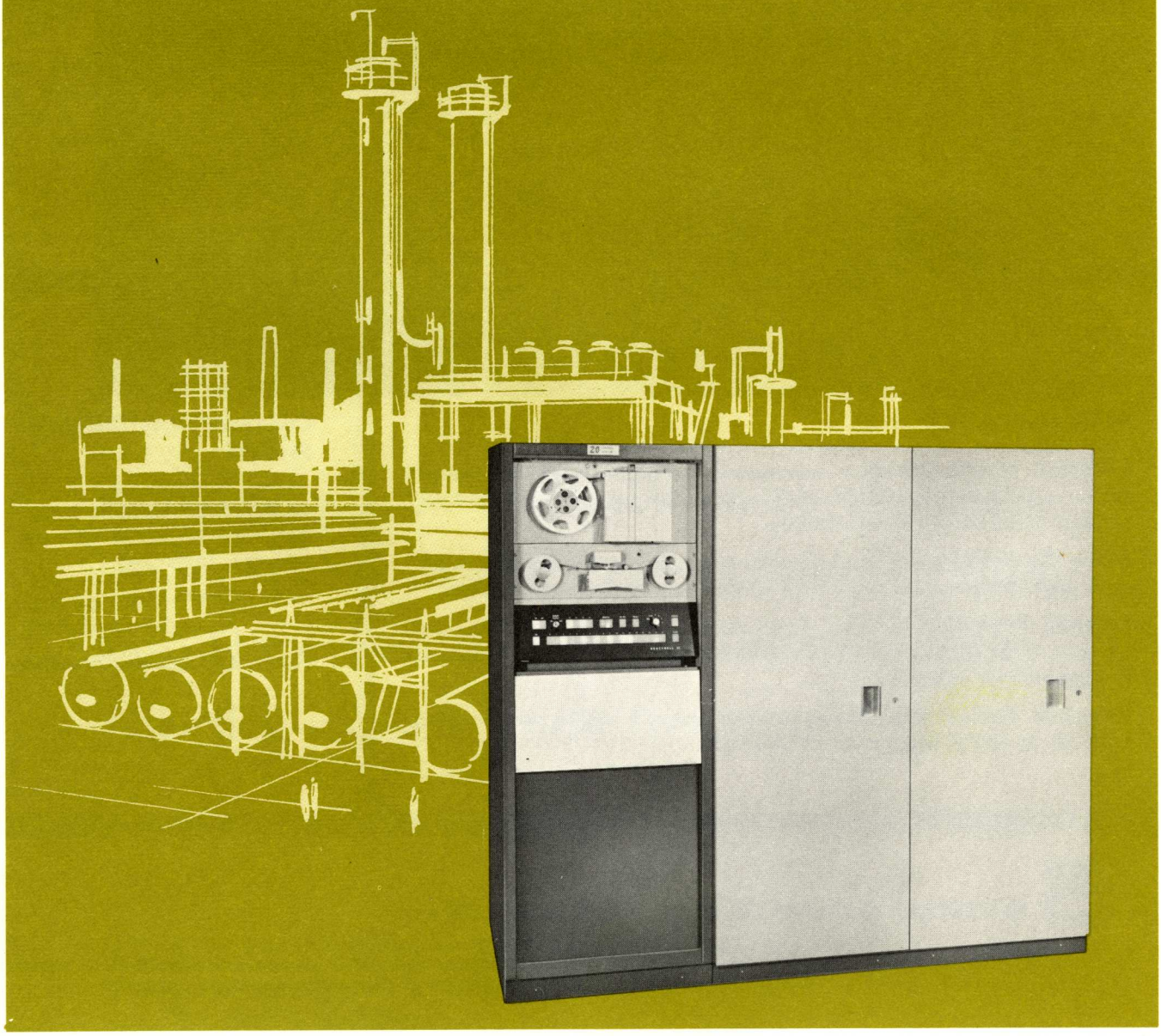
Process Control with

The Honeywell 20 Digital Control System



FEATURES

1 PERFORMANCE

High Internal Speeds—complete core memory cycle time of 1.75 microseconds on the H22 Central Processor and 6 microseconds on the H21 permits average execution rates of 220,000 and 80,000 instructions per second, respectively.

Analog Inputs—low-level multiplexer provides scanning of up to 200 points per second. Overall accuracy for 0 to 50 millivolt range is to within ±0.05% of full scale. High-level multiplexer scans at rates up to 8KC.

Multi-Level Priority Interrupts—up to 32 hardware levels available; up to 144 process interrupt lines per level.

2 GROWTH

System Flexibility — Honeywell's *MagnetiK* Coupler provides universal interface for a wide variety of analog and digital input-output signals. Digital inputs and outputs, digital-to-analog converters, typewriter control buffers, counters, and other modules can be plugged in interchangeably.

System Modularity — core memory field expandable to 16,384 words; analog inputs to 1,024 points, analog outputs to 720 points; digital inputs and outputs to 1,440 points.

3 RELIABILITY

Advanced Circuit Design — microcircuit techniques, exclusive use of silicon semiconductors, and extensive use of passive components contribute to high Mean-Time-Between-Failure.

Parity Checking—parity is checked or generated on all memory, character input/output, and high-speed direct memory access operations.

Program Protection—memory guard feature allows any core memory location to be "padlocked" against alteration by unauthorized programs or input/output operation.

Industrial Environment Design—system operates within specifications from 32 to 120°F without air conditioning.

4 PROGRAMMING AIDS

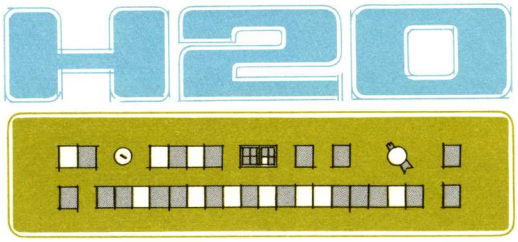
CONTROLWARE — industry's most advanced software package, featuring

CONTRAN*—the new language of real-time control.

*CONTRAN—*Control Translator*

5 SINGLE-SOURCE RESPONSIBILITY

Honeywell's experience in manufacturing and applying computer systems and process instrumentation assures full loop capability, including application assistance, system engineering, programming and installation.

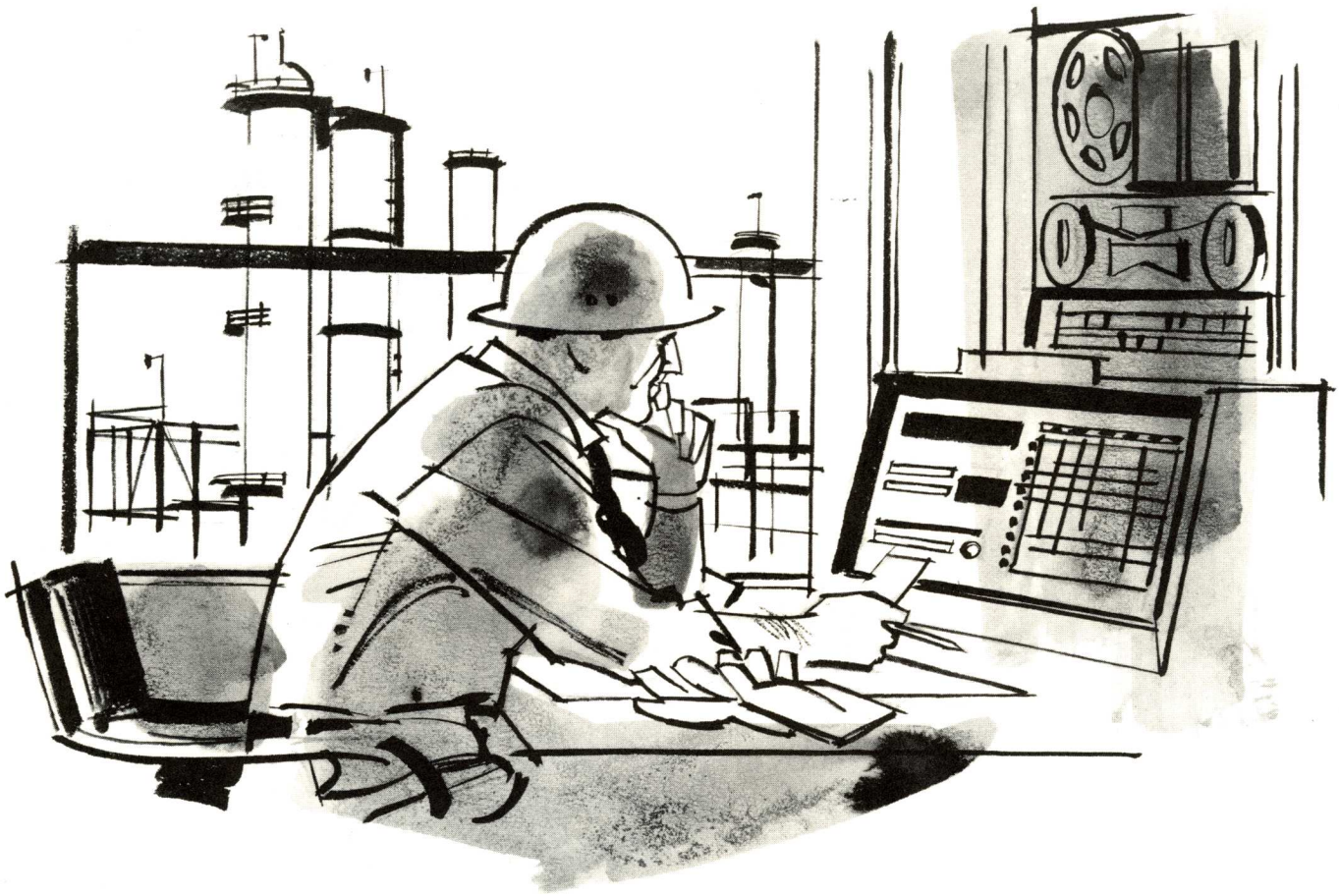


The Honeywell 20 Digital Control System offers you new opportunities for advanced industrial automation. With either the H21 or H22 Central Processor, the H20 System is the first computer system to combine high performance and ease of use with attractive low costs.

Because of its speed, accuracy, and flexibility, you can apply the Honeywell 20 System to control problems considered too difficult for control computers of earlier generations. And because of its low cost, you will find advanced digital techniques wholly practical and economical for an entirely new range of industrial applications. The H20 system has high reliability, essential for successful control of industrial processes. Modular construction and built-in expansion potential enable you to carry out your plant automation programs in steps, either as part of a planned schedule, or as you gain additional experience through system use.

Advanced software features of CONTROLWARE greatly simplify system programming, enabling process engineers with a minimum of training to write programs that put their systems on-line efficiently and quickly. Honeywell-pioneered CONTRAN is a prominent part of CONTROLWARE. A highly significant addition to existing industrial programming aids, CONTRAN is a new concept in real-time control languages.

The superior hardware design of the Honeywell 20 System gives you a powerful, easy-to-use control tool at a price you can afford. Accompanying software advances, particularly CONTRAN, significantly reduce the time and cost of complex programming, freeing you to concentrate your efforts and the power of advanced digital techniques on the mainstream problems of your process.



APPLICATIONS

The low cost, high performance, and flexibility of the Honeywell 20 Digital Control System greatly extend the role of the computer in industrial operations. Of primary importance is a two-way extension of the control computer's potential. For so-called "small" jobs — those now implemented by wired-in static logic, special purpose analog computers, conventional control devices, or electro-mechanical data loggers — the H20 System's low cost means that a computer control system can often be economically justified. At the opposite extreme, many control and monitoring jobs considered too difficult for even the largest of other present generation computers are well within the technical capability of the H20 System.

Input-output equipment, with a design based on years of experience in the building of process control computers, provides excellent interface with all classes of industrial instrumentation and control devices. The accuracy of conversion operations is equal to the most demanding data acquisition and control requirements.

Since overall system reliability is considerably above that of previous generations of control computers, the Honeywell 20 System opens up many new possibilities for direct digital and logical control.

Because of its flexibility and field expansion capability, the H20 System offers an ideal "starting" point for the newcomer to computer technology. A relatively simple monitoring or data logging system can be gradually expanded to include the most complex control functions.

Since the Honeywell 20 System can communicate directly with remote business and scientific data processing systems, it can simplify the integration and streamlining of the manifold tasks of large manufacturing and processing operations. Timely and accurate real-time process data from the H20 System will increase the effectiveness of management information systems. At the same time, the H20 System can receive instructions from central supervisory computers. This means that desired changes to production levels and processing operations will be carried out accurately and tirelessly.

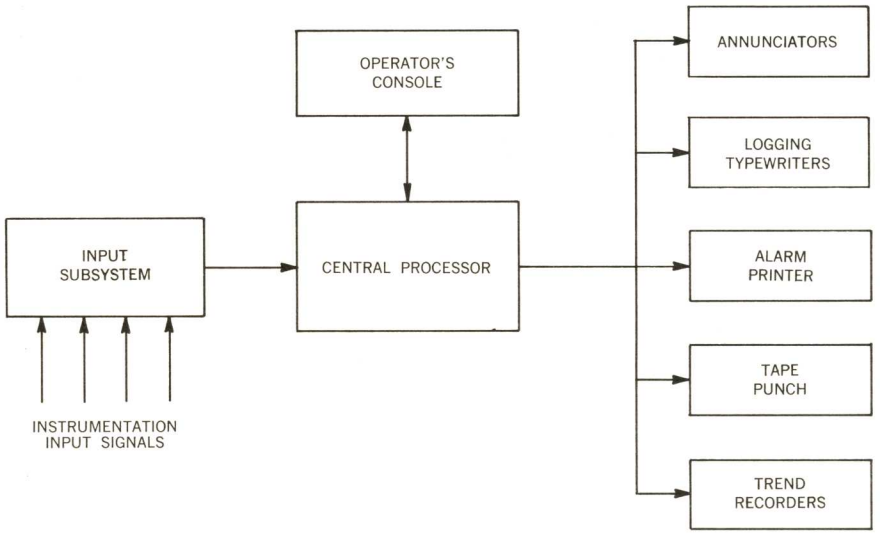
Illustrated on the following pages are several typical applications of the Honeywell 20 System. In actual practice, a number of these different applications might be handled by a single Honeywell 20 System. Supervisory process control, for example, will often be combined with data logging and direct digital control; data acquisition could be combined with production monitoring.

MONITORING AND DATA LOGGING SYSTEM

The Honeywell 20 System, through standard plug-in modules, accepts all types of conventional process instrument signals—including millivolts, resistances, pulse counts, and contact closures. Reference junction compensation is provided for thermocouple signals. These inputs are scanned under program control, checked for alarm limits, and converted to engineering units. Summary logs are printed and punched at designated times or on demand. Alarm conditions are immediately printed and/or displayed.

The cost of an H20 System tailored to this application? . . . frequently no more than that of an electro-mechanical data logging and alarming system. Moreover, additional, more sophisticated, tasks can be accomplished by the same Honeywell 20 System at little extra cost. For example, performance and efficiency calculations and material balances can be included in the log. Advanced data reduction capabilities give operating, accounting and engineering personnel genuinely useful information.

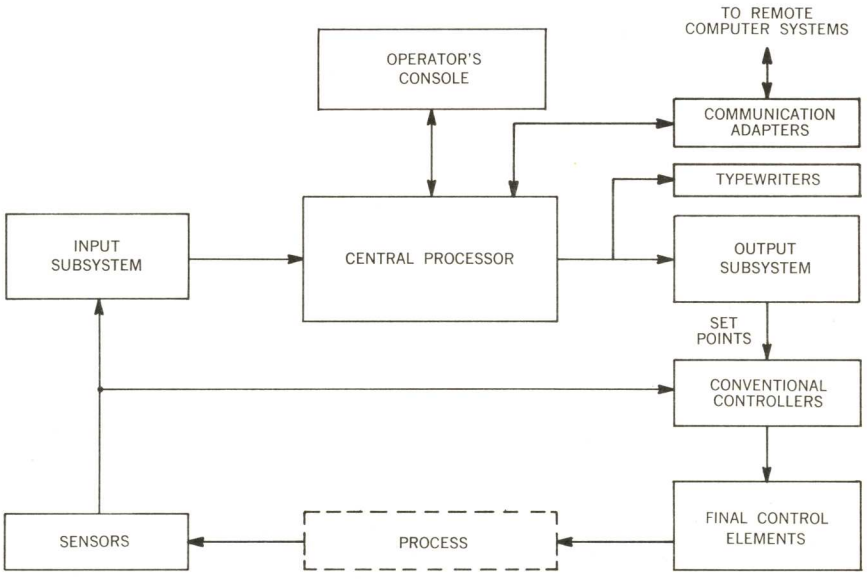
Data gained through this basic system is often a prerequisite for—and a stepping-stone to—more advanced direct digital and setpoint control.



Monitoring and Data Logging System

PROCESS SUPERVISORY CONTROL SYSTEM

It is often possible to increase process efficiencies once you have obtained and evaluated reliable information on process functions and dynamics. Frequently the most effective way to realize these increases in efficiency is through a computer-directed supervisory control system. Signals from instruments and process analyzers are scanned and fed to the computer which performs heat and material balance calculations to determine the state of the process. The computer then calculates any needed adjustments to controlled variables and sends these adjustments out in the form of setpoint signals to conventional controllers. This technique compensates for changes in raw materials and other uncontrolled variables, keeps the process stable, and efficiently produces the desired product at optimum rates. Through communications adapters, the supervisory control system can be tied to both higher and lower level computers, providing a vital link in advanced management information systems.



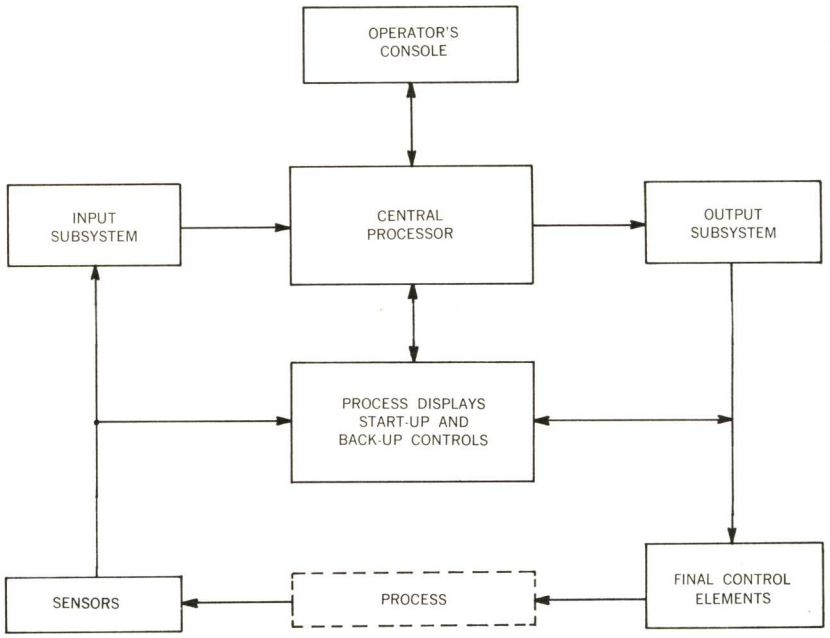
Process Supervisory Control System

DIRECT DIGITAL CONTROL

The reliability, internal speed, and instrumentation input/output capabilities of the Honeywell 20 System equip it ideally for direct digital control (DDC). In DDC, the H20 System can be used to perform the functions of conventional controllers by making the set-point vs. process variable comparison, computing the proportional, reset and rate corrections, and transmitting the result to the final control element. Since this is done on a time-shared basis under program control, a large number of loops can be handled. The internal speed of the system (particularly its multiply speed), as well as its speed and accuracy of scanning process inputs, is of great importance in DDC applications.

The DDC program, moreover, allows additional flexibility and the use of sophisticated control techniques which are not possible or practical with conventional controllers. Advanced ratio and cascade as well as feedforward control can be performed. Process loops with dominant lag-times or transport delays, which provide severe problems for conventional controllers, can be handled easily and with greater stability. Logical and sequence control can be introduced to provide for automatic cut-in of auxiliary process units.

Direct digital control systems must be engineered to consider the startup needs as well as the contingency or backup control requirements of the specific process. Often it will be technically and economically advisable to use the DDC system to perform additional tasks such as report preparation and supervisory control.

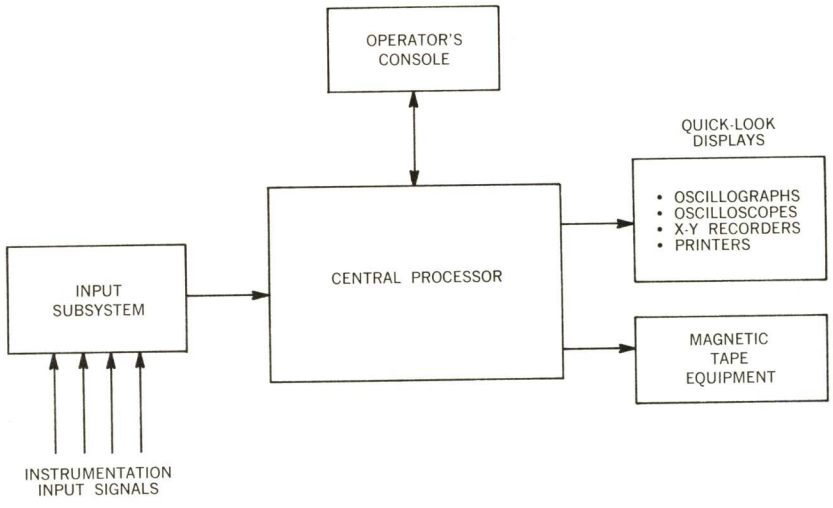


Direct Digital Control System

HIGH-SPEED DATA ACQUISTION SYSTEM

Testing of motors, rocket and jet engines, air frames, system components, etc., frequently demands accurate and rapid acquisition of data for permanent records and/or later evaluation by large off-line computers. With an H20 System, input signals (usually in the 1-to-10 volt range) from on-line sensors or from off-line playback of FM instrumentation tapes are normally scanned, checked, formatted and recorded on magnetic tape. Analog scanning takes place at rates up to 8,000 inputs per second; digital scanning, at 330,000 points per second. Checking of limits and conversion to engineering units are easily programmed. Quick-look information can be made available to the operator via convenient scope and recorder displays. An operator's console allows the test operator to insert data, make format changes, and modify internal operations.

The stored program of the Honeywell 20 System allows you to incorporate additional tasks. For example, considerable evaluation and editing of data can be done in real time, greatly reducing the amount of recorded data produced and off-line analysis required. Complex parameters can be displayed in simplified form to operators. Increased automation of testing can be achieved through output of sequencing and test-stimuli signals.

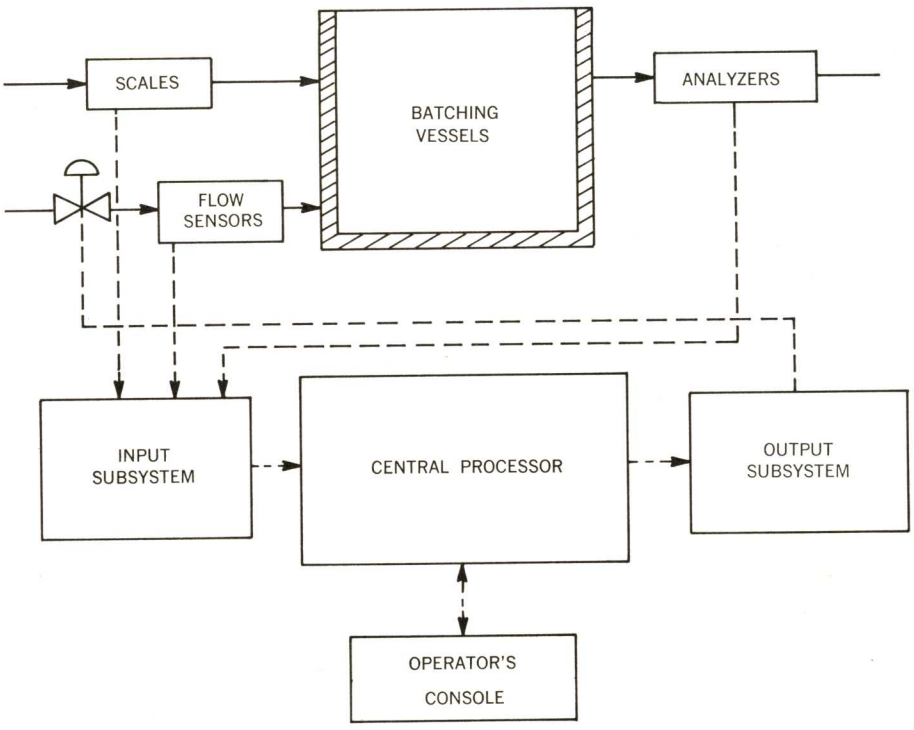


High Speed Data Acquisition System

BATCH PROCESSING CONTROL SYSTEM

Batching and blending are widely used operations in the chemical, food, petroleum, fiber, and steel industries. They require reliable and highly repeatable control to ensure batch-to-batch uniformity. Some applications involve the use of empirical formulas. On others, qualitative data describing the conditions of raw materials and/or the finished product must be factored into the batching formula. Control of batch scheduling is often necessary to make the output of multiple-batch units compatible with downstream continuous processes.

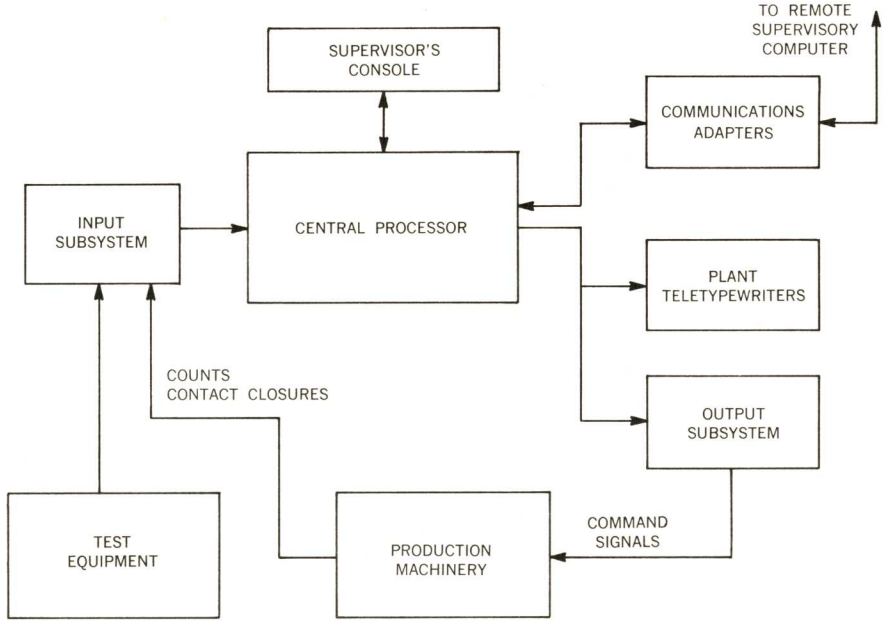
The stored-program capabilities of the Honeywell 20 System provide highly repeatable—yet flexible—control under all of these circumstances. Inputs are accepted from scales, turbine meters, constant displacement pumps, conventional flow meters, and process analyzers. Control outputs automatically operate motors, scale hoppers and valves. Where batch equipment is used for multiple products, the formulations and processing information for all products can be stored in the computer and recalled for use as required. The logging of operating and accounting information as well as complex batching formulas is easily incorporated into the H20 System's program.



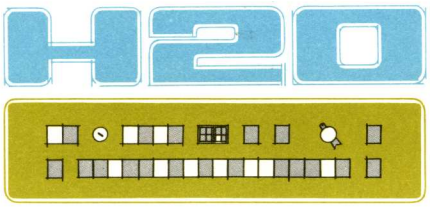
Batch Processing Control System

PRODUCTION CONTROL SYSTEM

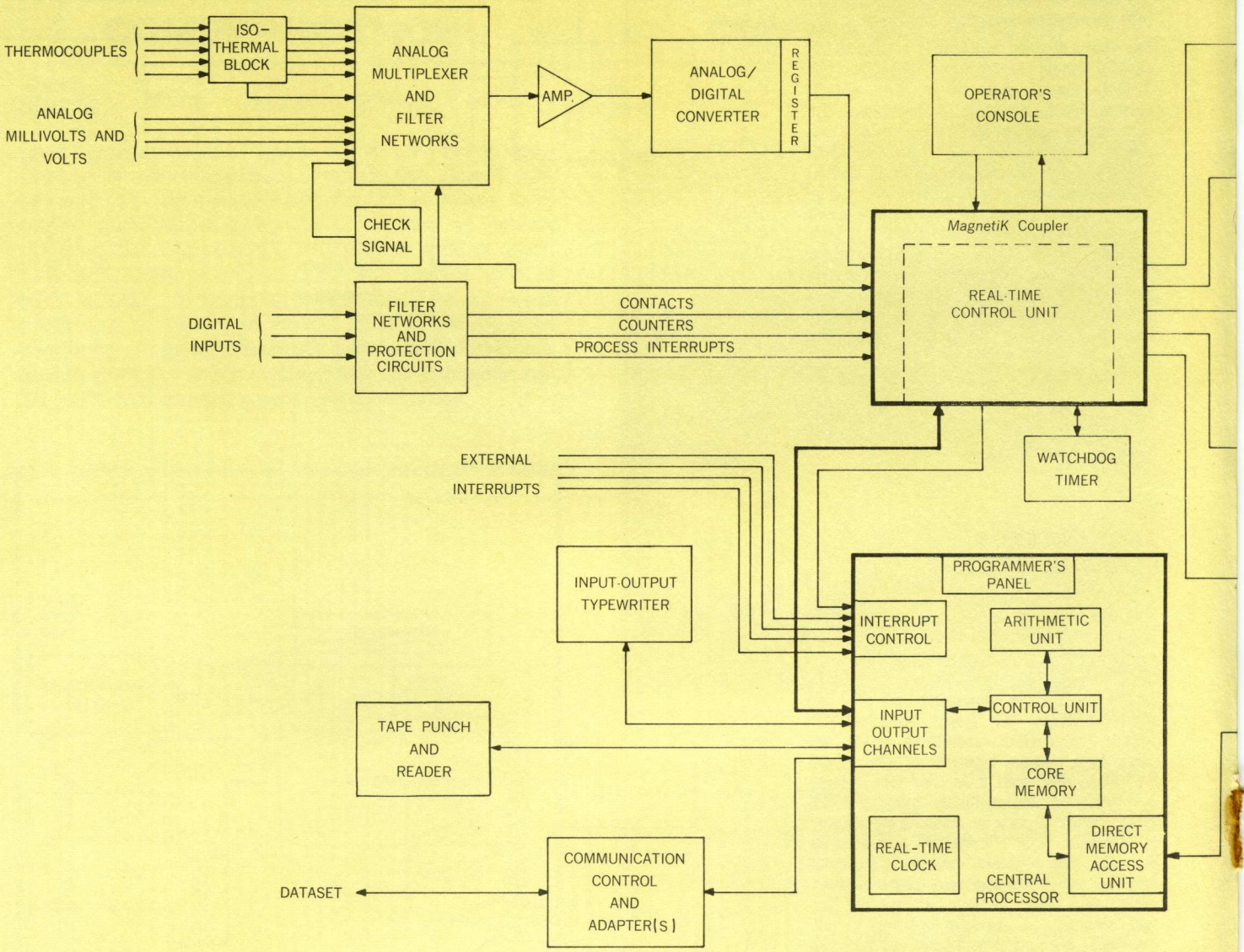
Efficient manufacturing of discrete products requires accurate up-to-date information in order to provide accurate control of inventory levels, production rates, and product quality. Selected portions of this information must be rapidly conveyed to appropriate personnel and plant equipment for proper response. The flexible input/output capabilities, speed, and large bulk memory capacity of the Honeywell 20 System make it an ideal tool in these manufacturing and materials handling situations. Counts of parts or products are accumulated on-line from a multitude of production and packaging machines; material is traced on conveyor lines, and machinery status is transmitted by a series of limit switches and contact closures. In advanced systems, control commands are sent to machinery and materials handling equipment to control operation, unit scheduling, and material movement. Since production testing equipment is monitored, the system can pinpoint drifts in product quality, and provide supervisors with current statistical information. Communications adapters enable the system to receive and transmit information over telephone lines, thereby making accurate and meaningful source data on overall operation immediately available to remote business computers. The Honeywell 20 System can thus bring to production operations many improved efficiencies.



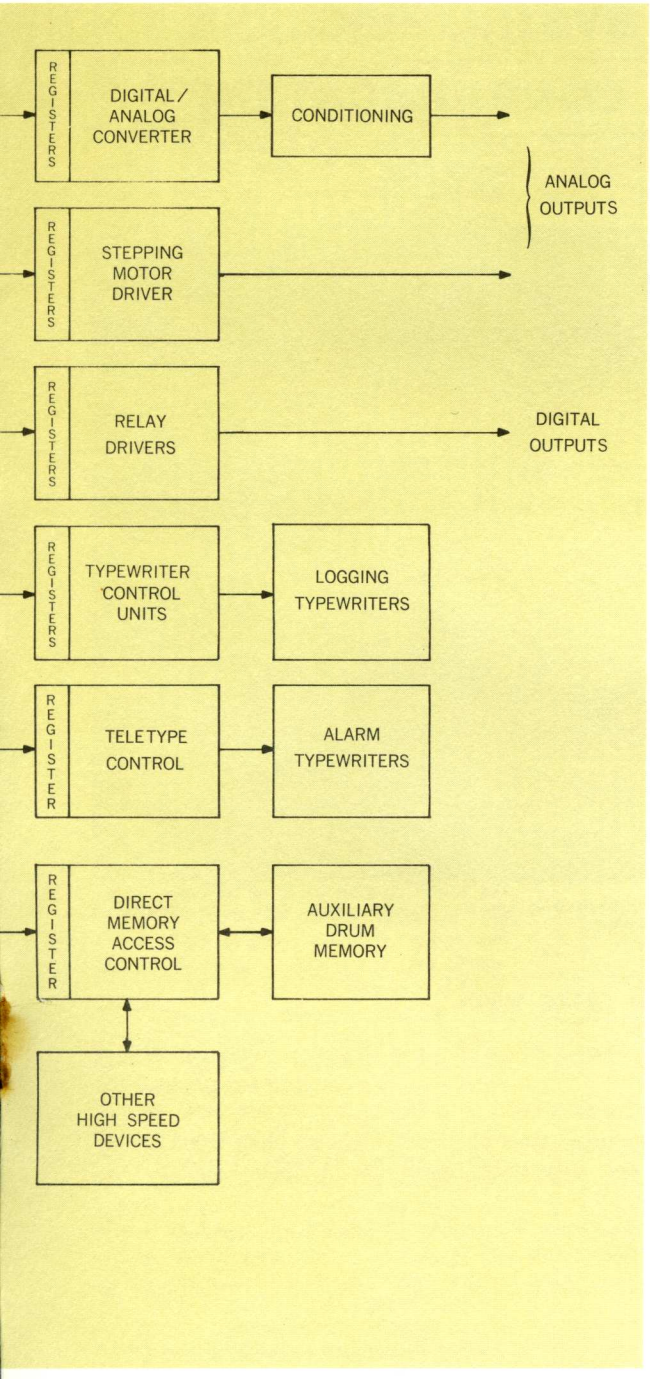
Production Control System



DIGITAL CONTROL SYSTEM



HONEYWELL 20 DIGITAL CONTROL SYSTEM
BLOCK DIAGRAM



SYSTEM DESCRIPTION

The Honeywell 20 Digital Control System represents a large forward step in the art of real-time data acquisition and control.

The heart of the Honeywell 20 System, the H21 or H22 Central Processor, incorporates the working memory and the computing and control circuits involved in all system operations.

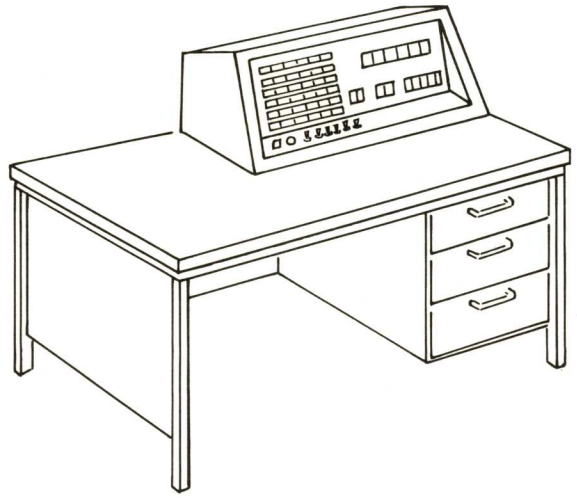
Two basic classes of input/output (I/O) furnish multiple communication paths to and from the central processor. Standard I/O channels provide programmed, real-time communication with the process, the operator, and various peripheral devices. At the same time, optional Direct Memory Access channels (as many as eight in the H22) offer fully buffered communication — on a cycle steal basis and without program intervention — with drum memory and other high-speed devices.

Process data and control signals enter and leave the central processor through the Real-Time Control Unit. Standard plug-in modules tie Honeywell's unique *MagnetiK* Coupler to all classes of process sensors, final control elements, and operator displays, assuring ease and flexibility in establishing system configuration. The use of magnetic core logic in the *MagnetiK* Coupler's select and decode circuitry provides increased reliability and complete electrical isolation of input-output circuits.

Buffering of slow-response real-time circuits is accomplished with data registers, timing circuits, and priority interrupts. Data transfer thus requires an absolute minimum of central processor time.

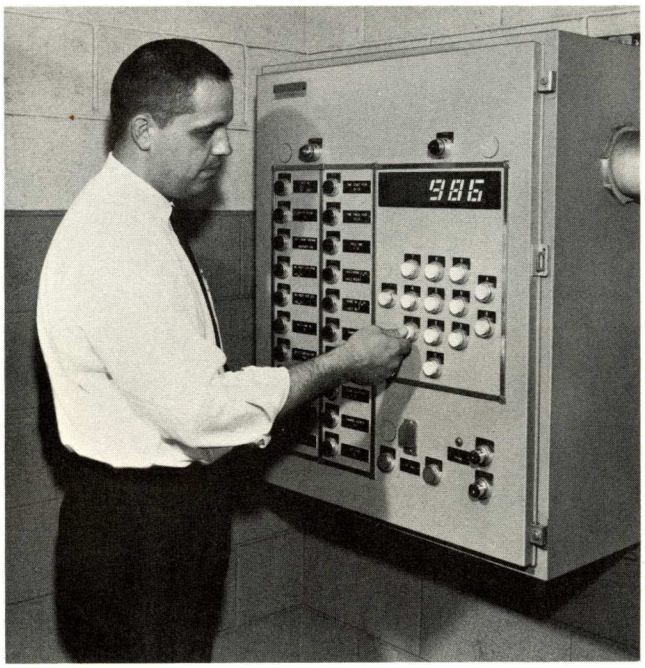
OPERATOR-PROCESS COMMUNICATION

An optional operator's console affords convenient operator-process communication. Through this console, the operator can request such information as alarm summaries, performance calculations, displays of process variables, and demand logs. Information such as alarm limit and setpoint changes and lab analysis data is easily entered. If required, many small input/output panels can be located in remote areas of the plant to coordinate process operations. Honeywell also supplies complete control centers, integrating the computer system with conventional process instrumentation.



Standard and custom operator's consoles provide 2-way communication between operator and process.

SYSTEM-PROCESS COMMUNICATION



Remote input/output panels provide on-the-spot operator-process communication.

Low-Level Analog Inputs

Scanning Speed: 200 points per second (random access) is standard.

Number: Up to 1,024.

Noise Rejection: Common mode—greater than 1,000,000 to 1 at 60 cps. Transverse mode—greater than 1,000 to 1 at 60 cps.

Overall Accuracy: To within ±0.025% of standard input range at 200 points per second.

Resolution: 0.006% of standard input range (one part in ±8192).

Input Range: —50 to 0 to +50 mv is standard. Other ranges up to 50 volts full scale available.

Signal Conditioning: Thermocouple reference junction. Current input conversion. Voltage dividers.

High-Level Analog Inputs

Scanning Speed: 8,000 points per second.

Input Range: 0 to ±1 or 0 to ±10 volts.

Accuracy: To within ±0.025% of reading, ±1.5 mv for 10 volt range.

Digital Inputs

Transfer Speed: Up to 330,000 contacts per second.

Protection and Noise Rejection: each input individually filtered, fused and transformer-coupled.

Number: up to 1,440 inputs.

Pulse Inputs: up to 240 solid-state counters per system.

Analog Outputs

Digital-to-Analog Converter: solid-state, 10-bit (1 part in 1,000) resolution. Output available in standard process current or voltage transmission levels.

Stepping Motor Driver: solid-state drive and timing control for up to 720 external motors; 5-wire, 48-volt output.

Digital Outputs

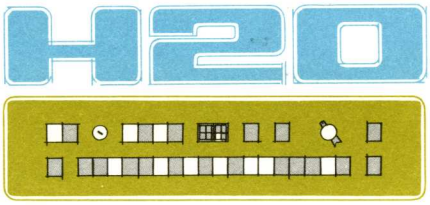
Transfer Speed: 330,000 output operations per second. Each output individually buffered. Operations performed at computer speeds.

Types: On-off (latching), and pulse duration (10 milliseconds to 1 second): solid-state or mercury-wetted relays.

Output Rating: Solid-state: 48 volts at 250 ma (non-inductive). Power supply included in standard system.

Mercury-wetted contacts: 100 VA is standard.

The Honeywell 20 System, rack-mounted in from 2 to 7 cabinets for industrial installations, is fully operational from 32 to 120°F. Cabinets are 70″ high, 27″ wide and 27″ deep. Typical small system requires 117 volts ±10%, 60 ±2 cps at 30 amps nominal. 50-cycle operation is also available.



PROGRAMMING THE HONEYWELL 20 SYSTEM

THE PROGRAMMING OF REAL-TIME CONTROL APPLICATIONS has traditionally called for a compromise by system users. Those demanding the most of their system's capabilities have generally approached programming with assembly-level coding techniques. This method requires the talents of highly-skilled programmers for extended periods. It frequently results in lengthy startup delays, and produces programs that, although efficient, are individualized and cryptic. This approach can easily double the cost of system programming.

Other users have tried to get around this problem with somewhat makeshift alterations to off-line scientific programming aids. Dollars and days, they hope, will be saved with this technique. Such savings are frequently illusory since off-line compilers by themselves are seldom adequate for real-time control applications. Consequently, these users must still resort to assembly-level programming for large portions of the program. The highly-skilled programmer is again called for. And the resulting hybrid program is invariably less efficient than the pure assembly-level approach.

In the past, there just hasn't been any easy way to economically program control computers for industrial applications.

Using their experience in *both* the computer and industrial control fields, Honeywell has developed the most advanced programming system available for industrial applications. We call it CONTRAN. With CONTRAN, the user can get both high system efficiency *and* low programming costs.

CONTRAN—Developed by Honeywell explicitly for industrial control applications, CONTRAN combines the ease and simplicity of compiler-level programming with the efficiency of assembly-level coding. The CONTRAN language permits control programs to be written in English language statements and straightforward mathematical expressions. Engineers can learn CONTRAN techniques with a minimum amount of training.

CONTRAN, in addition to providing a compiler-level translator, also contains a system scheduler and interrupt linkage. Effectively, this means that the system programmer—now the engineer—need no longer be concerned with long and cumbersome executive routines, with the problems involved in sharing primary core memory with bulk memory, and with responses to random external interrupts. All system programs are automatically linked to the CONTRAN scheduler as they are compiled. CONTRAN thus represents the first effective means of programming an entire system in compiler-level language.

With CONTRAN, compilation of both related and unrelated programs is accomplished effectively and safely while the system is simultaneously engaged in on-line control. System tasks can be added, deleted or modified on-line, presenting to the process engineer many new possibilities in the form of "live" studies.

CONTROLWARE—For those desiring to remain with older techniques, Honeywell's complement of programming aids, called CONTROLWARE, includes an extensive library of process control, diagnostic and mathematical routines, as well as provisions for special programming functions (CAP) and for hybrid assembly-compiler level control programming (FORTRAN II).

CAP—The Control Assembly Program (CAP) permits programs to be written in mnemonic codes and symbolic addresses. It also contains several pseudo-operations to aid the programmer when special assembly-level coding is desired. CAP's sub-routine call capability permits integration of the process control program library with system functions, allowing additional flexibility and modularity.

FORTRAN II—An expanded version of FORTRAN II is also available for the Honeywell 20 System. Process control statements and statements linking the process control library to FORTRAN II are included. The FORTRAN II compiler with on-line capability can accept assembly-level (CAP) coding intermixed with its own statements. Statements linking FORTRAN II to the executive program are written in CAP. Off-line engineering studies can also be accomplished with FORTRAN II, as can compilation and execution of the user's existing FORTRAN II programs.

CENTRAL PROCESSOR

Either of two central processors can be included in the Honeywell 20 System: The H21—with a basic cycle time of 6 microseconds, and the H22—with a 1.75 microsecond cycle time. Except for this difference in operating speeds, the two central processors are functionally identical.

A powerful instruction repertoire is tailored to the requirements of on-line control systems. In addition to the normal commands found in control computers, the H21 and H22 central processors incorporate commands for extended operations in the arithmetic registers and commands for comparing and testing internal and external data. Advanced programming features such as indexing, indirect addressing, and extended operation codes provide the base for the highly efficient CONTROLWARE programming aids.

Memory

Magnetic core.

2,048 to 16,384 word capacity, prewired for convenient field expansion.

Data not lost on power failure.

Typical Operating Speeds (in microseconds, including accessing and indexing)

	H22	H21
Add	4.8	12.0
Load/Store	4.8	12.0
Multiply	25.0	54.0

Word Length

18 bits plus parity and memory guard bits; a single instruction word may directly address any one of 8,192 core locations.

Parity Checking

Parity is automatically checked or generated on all memory operations, character input/output and DMA transfers.

Program Protection

Memory guard feature provides "padlocked" protection against accidental modification of guarded magnetic core locations.

Multi-Level Priority Interrupt

Up to 32 hardware levels on the H22; 16 on the H21; up to 144 process interrupt lines per level.

Direct Memory Access

This optional feature permits direct transfer of data between core memory and external high-speed devices. Once initiated, block transfers are accomplished automatically and without further attention by the program. The H21 provides one 83-KC data channel to which eight devices can be connected under program control; the H22 provides eight channels through which simultaneous transfers of data can be made at rates up to 71 KC per channel. Thus, at maximum rate, transfers of 568,000 words—or 1.7 million characters—per second are possible.

Power Failure Interrupt

Provides automatic program shutdown and re-start on power transient or failure.

Auxiliary Drum Memory

Access Time: 16.6 milliseconds, max.; 8.3 milliseconds, average.

Average Transfer Time (including access): 12 milliseconds for 256-word block; 24 milliseconds for 1,024-word block.

Transfer Rate: 60,000 words plus parity (1.2 million bits) per second.

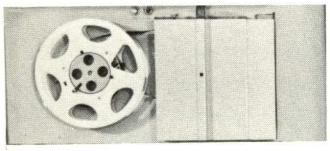
Capacity: 64,000 to 512,000 words in groups of 64,000.

Program Protection: write capabilities can be selectively disabled.

Central processors (H21 shown above) can be optionally mounted in attractive lowboy consoles.

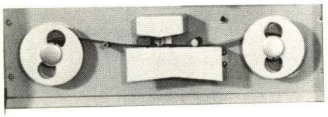
PERIPHERAL DEVICES

PAPER TAPE PUNCH



60 characters per second; 8-level ASCII code.

PAPER TAPE READER



Photoelectric; 200 characters per second; 8-level ASCII code.

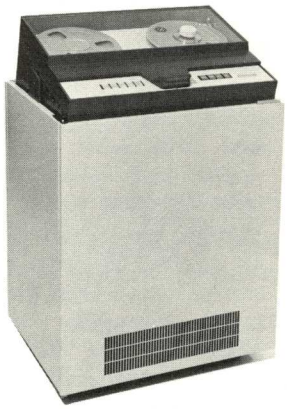
With Honeywell 20 Systems, several peripheral devices are available to facilitate convenient input-output of system programs and data. A Teletype Model 33 ASR input-output typewriter with integral tape punch and reader is included as a standard feature with each system. This device allows off-line preparation of paper tapes and on-line communication with the program via reader, punch, page printer and keyboard at 10 characters per second. This unit can also be used as an auxiliary logging or alarm typewriter. For continuous or heavy duty service, the Teletype Model 35 ASR is optionally available.

Additional optional peripheral devices include higher speed perforated tape punches and readers, wide-carriage logging typewriters, Teletype Model 35 page printers, magnetic tape units, and communications adapters for both private and common-carrier transmission lines.

LOGGING TYPEWRITER

10 characters per second; up to 30″ carriage widths.

MAGNETIC TAPE UNIT



Writes at 7.2 KC at 200 BPI, or 20 KC at 556 BPI.

Wouldn't *you* like to know more about the Honeywell 20 Digital Control System? Your local Honeywell office has the complete story. They'll be pleased to hear from you.*

*Pictured is a console-mounted version of the H21 Central Processor, ideal for location remote from system racks or for use in EDP or off-line environments. The input-output writer (Teletype Model ASR 33) is a standard system feature.

Honeywell can provide all support services required for the complete implementation and maintenance of computer-directed control systems. Contact your local Honeywell office for further information.

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