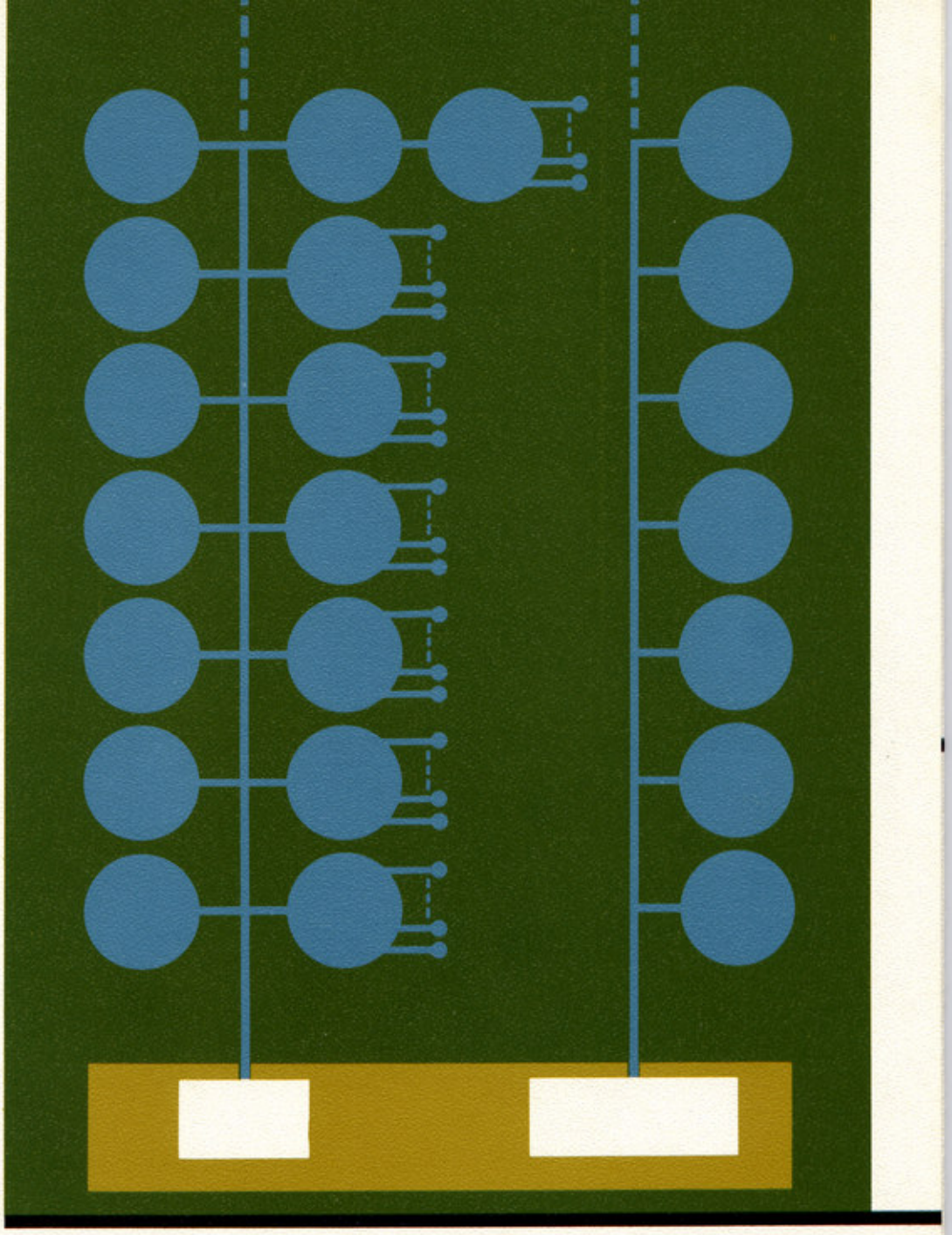


r2 4000 ©
COMPUTER

THE RC 4000 AND REGNECENTRALEN

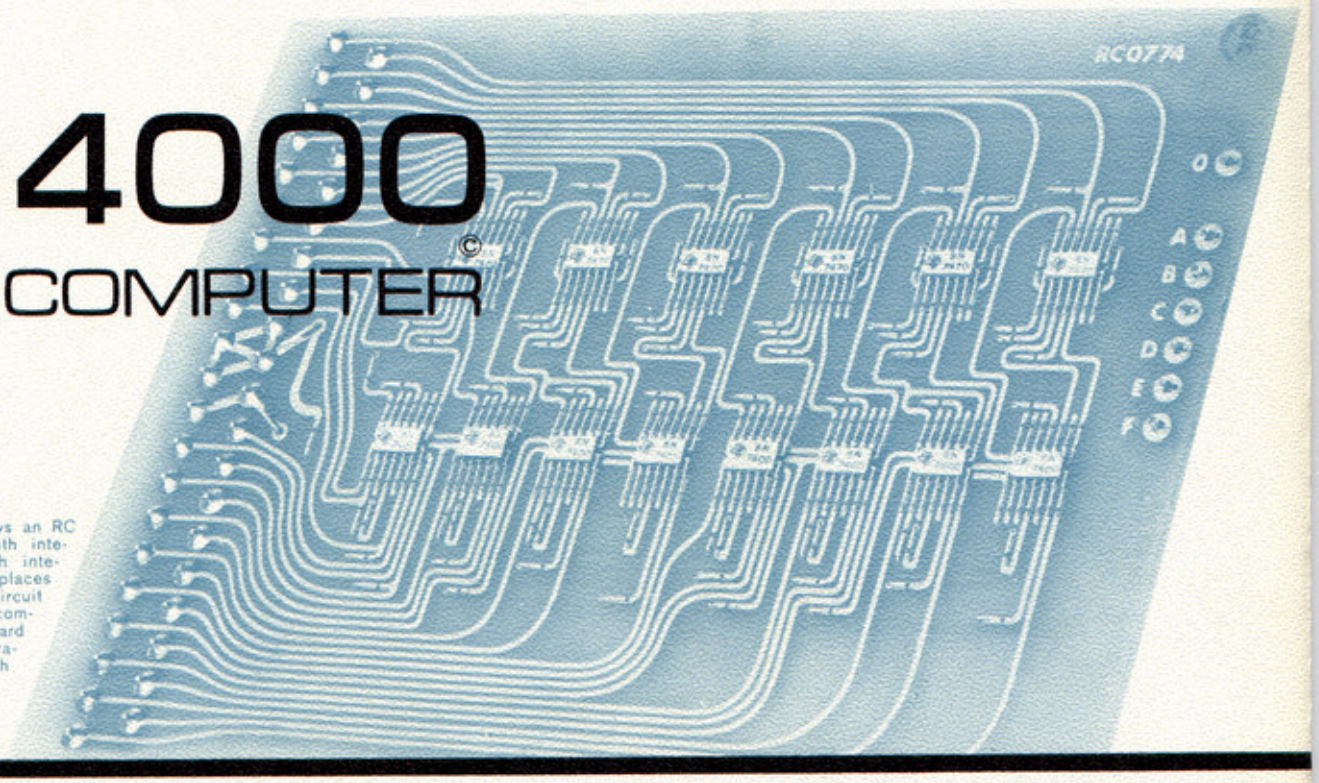
The RC 4000 is a general-purpose digital computer, designed and manufactured by A/S Regnecentralen. The basic model is a medium-size computer oriented toward real-time computation in industrial control applications. An extended model includes floating-point arithmetic for scientific computation and high-speed input/output devices for administrative data processing.

The RC 4000 is Regnecentralen's third computer. In 1957 Regnecentralen built the DASK on the basis of existing electronic tube technology; it was Denmark's first computer. In 1962 Regnecentralen began the manufacture of a completely transistorized computer called the GIER. With a full array of peripherals, an extensive software library, and one of the most effective ALGOL compilers available, GIER Computer Systems are now in operation throughout Europe.

Instituted in 1955 "to acquire or construct and operate computing machinery," Regnecentralen has gained experience and made contributions in many data processing areas, while developing such products as the RC 1000 Data Logger, the RC 2000 Paper Tape Reader, and the RC 3000 Converter. Concurrent with the manufacture and sale of these and the GIER, Regnecentralen today carries on large-scale public education and training programs, runs an international chain of service centers, and developes hardware and software for internal needs as well as on contract.

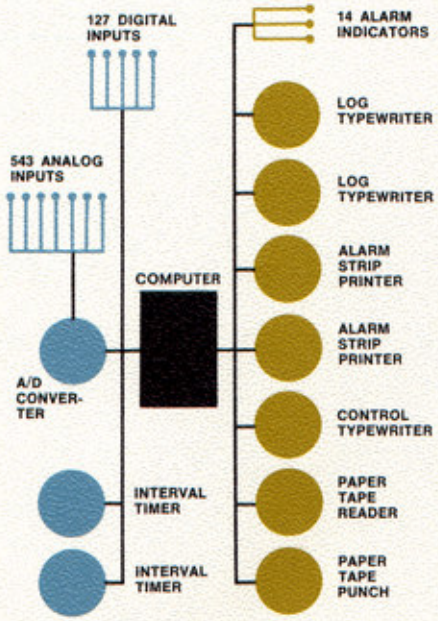
With the backing of this considerable experience in diverse computer fields, Regnecentralen now introduces the RC 4000 Computer. Like its predecessors, the RC 4000 incorporates the latest advances in electronic technology, bringing as it does the advantages of integrated circuits to industrial, scientific, and commercial computer users.

RC 4000 COMPUTER©



The photograph shows an RC 4000 circuit card with integrated circuits. Each integrated circuit replaces an entire transistor circuit of about twenty-five components; the circuit card itself replaces six traditional cards with transistor circuits.

THE RC 4000 PROCESS CONTROL SYSTEM AT PULAWY



Regnecentralen is responsible for the hardware configuration and multiprogramming system at a new chemical plant, built by the Danish engineering company Haldor Topsøe at Pulawy in Poland. The plant, which is operated manually under continuous computer supervision, illustrates the application of the RC 4000 to industrial process control.

Process Control Tasks Every five minutes, the RC 4000 performs alarm monitoring by scanning and checking some 250 process variables against prescribed alarm limits. Every hour, the RC 4000 produces two log reports on all process variables in the plant (about 600); at any time, the operator can call for trend logging of a single variable. Every eight hours, the RC 4000 makes a process evaluation report on 135 material balances as well as production and consumption figures for the period. In idle intervals, the RC 4000 performs self-checking of basic hardware functions to detect and report possible malfunctions.

Multiprogramming System A flexible multiprogramming system permits independent task programs for alarm monitoring, data logging, and production of reports to be executed regularly on a time-sharing basis. One of the task programs keeps the control typewriter operative continuously so that the operator can type a command to the system at any time. Major operator options are: selection of start time and frequency of each process control task; exclusion of analog and digital inputs from one or more production lines; change of scale factors and alarm limits of analog inputs; and selection of alternative output devices for printing of log and balance reports.

RC 4000 IN BRIEF

Single-address, binary computer with typical instruction execution times of from 2.5 to 5.5 microseconds.

24-bit word (plus 1 parity bit and 1 protection bit).

Basic core store of 4096 words, expandable in modules, with a cycle time of 2 microseconds.

Core store non-volatile on power shut-down and start-up.

Monolithic integrated circuits used extensively.

Direct addressing of up to 8 388 608 words.

Optional backing stores: magnetic drum of 128 or 256 k words; disk file.

Four accumulators, three of which also function as index registers.

Direct inter-register operations.

Standard integer arithmetic with 12-bit and 24-bit operands.

Optional integer and floating-point arithmetic with 48-bit operands.

Address modification includes indexed, indirect, and relative addressing; the latter permits dynamic program relocation.

Repertoire of 54 instructions includes manipulation of 12-bit bytes, word comparison, and setting and testing of single bits.

Standard data channel for transfer of single words between low-speed devices and working registers.

Optional high-speed data channel for block transfers directly to and from internal store.

Program execution concurrent with input/output operations.

Input/output exceptions under complete program control.

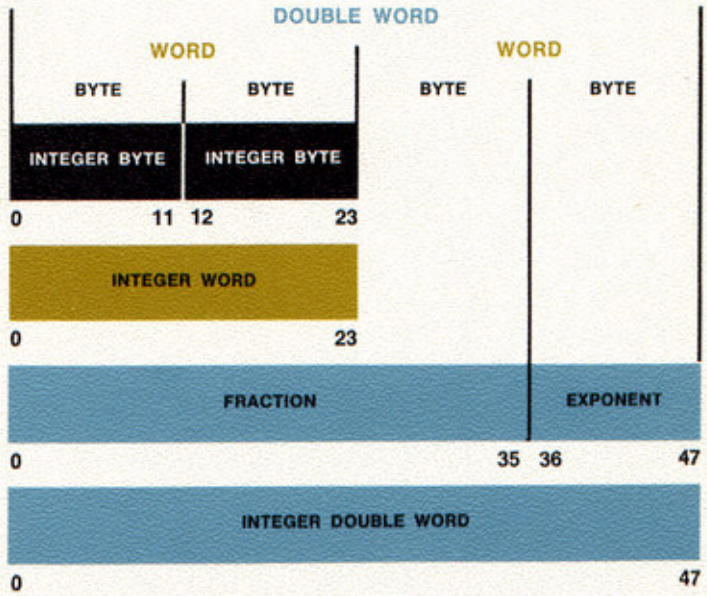
Privileged instructions and storage protection associated with a monitor program facilitate multiprogramming.

Program interruption system with up to 24 maskable priority levels.

Wide ambient temperature range permits computer operation without air conditioning.

Maintenance console enables manual operation and includes execution of instructions step by step as well as alteration and display of registers.

Operating console with keys for reset, start, and autoload; the latter initiates a boot-strapping routine for program loading.



RC 4000 PERIPHERAL EQUIPMENT

In addition to the following on-line peripherals that can be used with the RC 4000, Regnecentralen has developed a multidirectional off-line converter, the RC 3000. This device converts a wide variety of input/output media off-line to and from magnetic tape, which can then be used exclusively for high-speed data transfers to and from the computer.

STANDARD PERIPHERAL EQUIPMENT

Console Typewriter	14 characters/second
Paper Tape Punch	150 characters/second
Paper Tape Reader	2,000 characters/second

OPTIONAL PERIPHERAL EQUIPMENT

Strip Printer	50 or 1,200 lines/minute
Line Printer	667 lines/minute
Punched Card Reader	1,200 cards/minute
Magnetic Tape Station	25,000 characters/second
Digital Increment Plotter	300 or 900 steps/second
Analog Input Multiplexer	20 or 10,000 channels/second
Analog Digital Converter	20 or 10,000 conversions/second
Digital Analog Converter	100,000 conversions/second
Digital Clock	
Digital Count Inputs	
Digital Sense Inputs	
Digital Outputs	
Set Point Station Controller	

RC 4000 ©

DATA FORMATS

ARITHMETIC OPERANDS The basic arithmetic operand is a 24-bit word. This word length is sufficient for most integer arithmetic in process applications. The extended model of the RC 4000 includes double-length operands of 48 bits to satisfy the requirements of scientific computation and administrative data processing.

BYTE HANDLING As a control computer, the RC 4000 must handle large quantities of analog input data of from 10 to 12 bits. Direct addressing of 12-bit bytes ensures efficient storage of these small integers. Byte handling is also a powerful tool in manipulating character strings encountered in file maintenance activities and program translation.

REGISTER STRUCTURE

The RC 4000 has four accumulators, three of which also function as index registers. By removing the distinction between index registers and accumulators and by extending the number of the latter to four, the full instruction set is made available for immediate address modification, while emply transfers of registers to the store are considerably lessened. The registers are addressable as the first four words of the internal store, which makes inter-register operations possible.

MULTIPROGRAMMING FEATURES

The RC 4000 is designed for multiprogramming operation under the control of a monitor program. Features that facilitate multiprogramming are storage protection, privileged instructions, and program interruption.

PROGRAM PROTECTION SYSTEM To prevent an erroneous task program from destroying process data or parts of the monitor program, each storage word in the RC 4000 contains a protection bit, which the monitor program sets and clears. An unprotected program can neither alter nor jump to the protected program.

All input/output operations as well as the interruption system and storage protection are handled by privileged instructions, which can only be executed within the monitor. Attempts to violate the protection system cause program interruption.

PROGRAM INTERRUPTION SYSTEM A computer used in process control must respond quickly to exceptional internal and external events. This is accomplished in the RC 4000 by means of a program interruption system, which is capable of registering up to 24 signals simultaneously. Any of these signals interrupts the current task program at once and starts the monitor program.

SOFTWARE

SYMBOLIC ASSEMBLER Apart from conditional assembly to facilitate the handling of programs existing in several versions, the symbolic assembly language SLANG permits symbolic addresses to be evaluated as general arithmetic expressions.

ALGOL COMPILER An ALGOL 60 compiler will be made available for the RC 4000. Like the present ALGOL compiler developed by Regnecentralen for the GIER computer, the RC 4000 compiler will conform to existing standards of efficiency and adherence to ALGOL 60.

MULTIPROGRAMMING SYSTEMS Regnecentralen developes multiprogramming systems for process control applications such as the Pulawy system, described in detail on the first page of this brochure.

RC 4000 INSTRUCTION FORMAT

OPCODE	W	M	X	DISPLACEMENT
6	2	2	2	12

The RC 4000 instruction format is divided into an operation byte of 12 bits and an address byte of 12 bits.

The operation byte specifies: one of 64 basic operations; a result register, W; an addressing mode, M; and an index register, X. (An index designator equal to zero indicates no indexing).

The address byte specifies a displacement, D, of from – 2048 to 2047 bytes within the program. This is adequate for most addresses.

For direct addressing of the entire store, an effective address of 24 bits, A, is generated as follows (where M indicates addressing mode, X index register, D displacement, and IC instruction counter):

M = 00	A = X + D	direct addressing
M = 01	A = word [X + D]	indirect addressing
M = 10	A = X + IC + D	relative addressing
M = 11	A = word [X + IC + D]	relative-indirect addressing

RC 4000 INSTRUCTION LIST

INSTRUCTION	EXECUTION TIME
ADDRESS HANDLING	
Modify Next Address	2.5 µsec
Load Address	2.5
Load Address Complemented	3.0
REGISTER TRANSFER	
Load Half Register	4.0
Store Half Register	5.5
Load Register	4.0
Store Register	5.5
Exchange Register and Store	6.0
INTEGER BYTE ARITHMETIC	
Load Byte with Zeros	4.0
Load Integer Byte	4.0
Add Integer Byte	4.5
Subtract Integer Byte	4.5
INTEGER WORD ARITHMETIC	
Add Integer Word	4.0
Subtract Integer Word	4.0
Multiply Integer Word	17.0
Divide Integer Word	30.0

The execution times listed apply to direct addressing. For address modification, add the following:

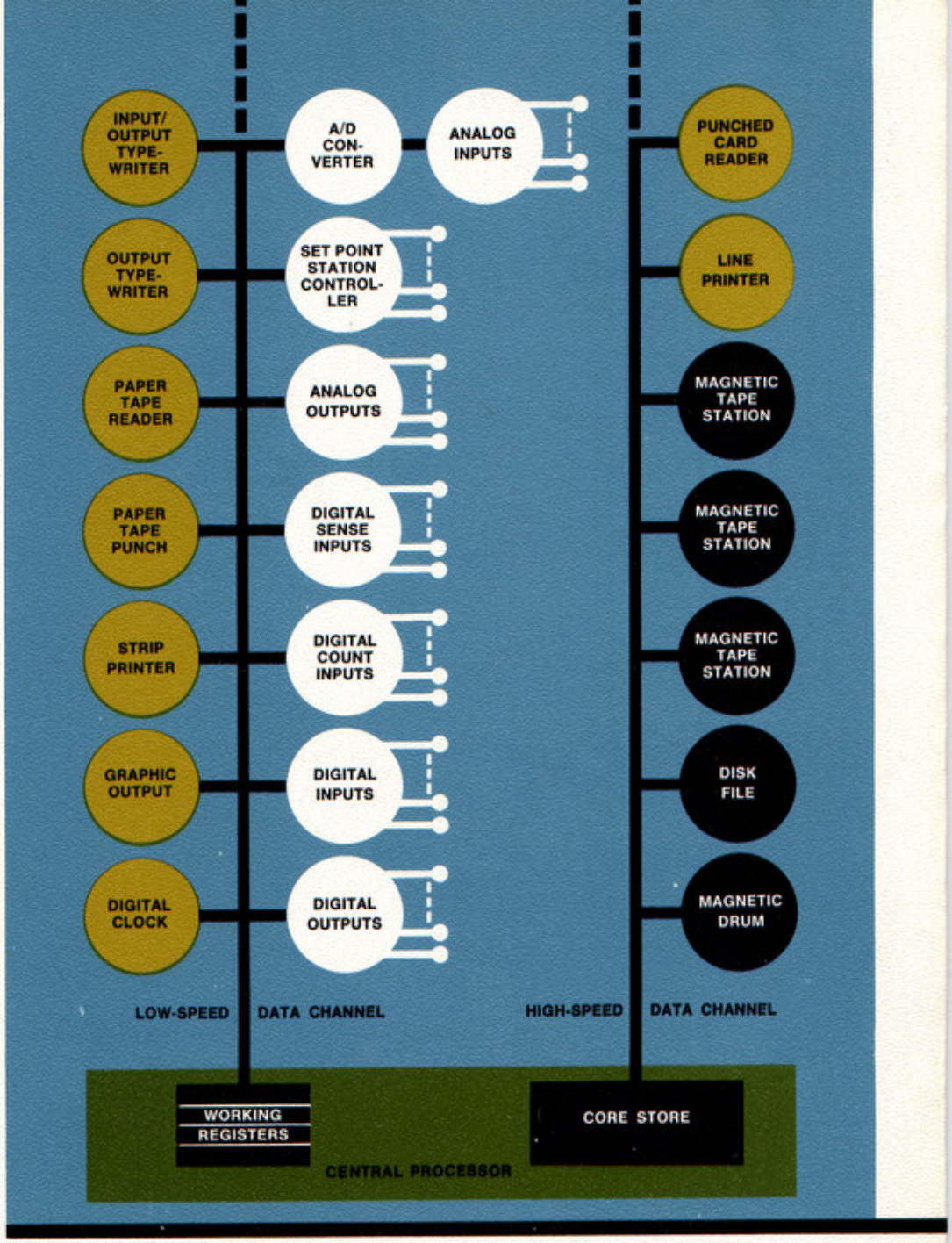
relative addressing	0.5 µsec
indexed addressing	1.0
indirect addressing	2.0

* privileged instruction

INSTRUCTION	EXECUTION TIME
LOGICAL OPERATIONS	
Logical And	4.0 µsec
Logical Or	4.0
Logical Exclusive Or	5.0
SHIFT OPERATIONS	
Shift Single Arithmetically	4.5 + 0.5 × shifts
Shift Double Arithmetically	5.0 + 0.5 × shifts
Shift Single Logically	4.0 + 0.5 × shifts
Shift Double Logically	4.5 + 0.5 × shifts
Normalize Single	6.5 + 0.5 × shifts
Normalize Double	7.5 + 0.5 × shifts
SEQUENCING	
Jump with Register Link	2.5 or 3.5 (with link)
Skip if Register High	3.5 or 4.0 (with skip)
Skip if Register Low	3.5 or 4.0 (with skip)
Skip if Register Equal	3.5 or 4.0 (with skip)
Skip if Register Not Equal	3.5 or 4.0 (with skip)
Skip if Register Bits One	4.0 or 4.5 (with skip)
Skip if Register Bits Zero	3.5 or 4.0 (with skip)
Skip if No Exceptions	3.5 or 4.0 (with skip)
Skip if No Protection	4.0 or 4.5 (with skip)

** Extended Instruction Set
(execution times to be made available)

INSTRUCTION	EXECUTION TIME
MONITOR CONTROL	
* Jump with Interrupt Enabled	3.0 µsec (with or without link)
* Jump with Interrupt Disabled	2.5 or 3.5 (with link)
* Clear Interrupt Bits	3.5
Store Interrupt Register	5.5
* Load Mask Register	4.5
Store Mask Register	5.5
Load Exception Register	4.0
Store Exception Register	5.5
* Clear Protection Bit	5.5
* Set Protection Bit	5.5
* Input/Output	10.0 (average)
* Autoload Word	(depends on device)
REGISTER TRANSFER	
** Load Double Register	
** Store Double Register	
ARITHMETIC CONVERSION	
** Convert Integer to Floating	
** Convert Floating to Iinteger	
FLOATING-POINT ARITHMETIC	
** Add Floating	
** Subtract Floating	
** Multiply Floating	
** Divide Floating	



The block diagram illustrates a large-scale RC 4000 system configuration for process control, technical and scientific computation, and administrative data processing.

RC 4000 SYSTEM CONFIGURATION

Low-Speed Data Channel Slow, character-oriented devices such as typewriters, paper tape readers, and paper tape punches are connected to a single low-speed data channel, which communicates directly with the internal working registers. Each device has a separate buffer register of 24 bits, which transmits or receives one character at a time to or from the external data medium.

The data channel consists of a control unit and an input/output bus, with 24 bits for transfer of data to or from device buffers and 8 bits for channel control information.

Transfers of data between working registers and device buffers take place one at a time under program control. Transfers between buffer registers and external data media, however, are controlled independently by the devices; several such transfers can therefore occur simultaneously.

High-Speed Data Channel Input/output devices like magnetic drums, disk files, magnetic tape stations, punched card readers, and line printers, which transmit large volumes of data at high speeds, are connected to a single high-speed data channel.

This channel provides buffered input/output directly to or from the internal store on a cycle-stealing basis. Program execution and input/output operations occur simultaneously.

Block transfers can take place on several devices at once. A multiplexer switches rapidly among the devices, connecting them whenever they are ready to transfer a complete data word to or from the store.

All input/output operations are handled by a single instruction, and high-speed devices are simply addressed in continuation of low-speed devices.

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