

Magnetic tape labelling is done. Storage for magnetic tapes is provided in the computer room and each tape is in a dust proof clear plastic container. The containers are stored in metal cabinets. In addition, Master Personnel tapes (The 2 most recent "as of" dates) are maintained in a separate vault (approximately 300' and 2 firewalls away from computer, but in same building). Because of presence of operating personnel and technicians on 24 hours basis, no special warning devices or controls to indicate humidity, temperatures, electrical or other damage. We have not shipped magnetic tapes but are studying means of protection for use at later date when we will be shipping tapes to other installations.

Fidelity-Philadelphia Trust Company

Outstanding features include building block principle, transistorized, and low unit cost.

Unique system advantages include a completely variable word length.

Adopted procedures for magnetic tape labelling, storage, shipping, and protection from humidity, temperature and physical, electrical, fire, or other damage include duplicate tapes stored in vaults, tapes labelled internally as well as externally, and a 40-Ton air conditioner serves as back up.

General Tire and Rubber Company

Outstanding features include variability of field size.

Adopted procedures for magnetic tape labelling, storage, shipping, and protection from humidity, temperature and physical, electrical, fire, or other damage, include normal computer room procedures and restrictions.

State Farm Life Insurance Company

Unique system advantages include daily cycle policy record updating.

Adopted procedures for magnetic tape labelling, storage, shipping, and protection from humidity, temperature and physical, electrical, fire, or other damage, all of these procedures considered as "normal" for e.d.p.

Electronic Data Processing Division, RCA

Outstanding features include reading magnetic tape in both directions, complete flexibility of the console, and easy matching color decor.

RCA Electronic Systems Center

Other outstanding features include complete transistorization throughout system. Expandability in core memory-tape stations and configuration of peripheral equipment.

Unique system advantages include complete service routine package-memory serial (re-programming not necessary with additional memory).

Adopted procedures for magnetic tape labelling, storage, shipping, and protection from humidity, temperature and physical, electrical, fire, or other damage include blank label for customer preference, metal cabinet in air conditioned room for storage, and no special fireproofing or protection.

RCA Service Company - E D P Sales Dept.

Outstanding features include completely transistorized; high processing speeds at low costs; operates with completely variable length data items; automatically controls up to 62 magnetic tape trunks; automatically controls random access drum storage (expandable in steps of 1 1/2 million characters); simultaneous on line print/read, write or compute; simultaneous magnetic tape read-compute, write-compute, read-write; reads magnetic tape in forward or backward motion; permits programming methods which can save 30% to 50% program storage space; and transfers 1 or 4 alpha-numeric characters in 15

microseconds.

The RCA 501 Electronic Data Processing System is a general-purpose system using transistor logic. The design employs the "building-block" principle which results in an expandable, highly flexible, integrated data processing system. Because of this "building-block" principle, the System can be tailored to present needs and can be expanded to meet future requirements.

Adopted procedures for magnetic tape labelling, storage, shipping, and protection from humidity, temperature and physical, electrical, fire, or other damage are separately zoned air conditioning for computer room with temperature of 72° - 80° with variance of only ± 2° over 6 hour period. Humidity control maintained at 20% - 65% with variation of only ± 5% over 6 hours. Dew point maintained at 54°F. Complete automatic fire alarm and extinguishing system for all areas with central control panel indicators.

RCA Astro Electronics Division

Truly variable processing. Equipment is ideally suited for intelligence type data processing. The Random Access File is well suited for scientific problems. The Random Access File is EXTREMELY useful due to its independent searching capabilities in language translation, general non numeric information retrieval system, and engineering table look up work.

Procedures have been adopted for magnetic tape labelling, storage, shipping, and protection from humidity, temperature and physical, electrical, fire, or other damage.

Initial experience in using this equipment for scientific research has been eminently successful.

Ordnance Weapons Command

Adopted procedures for magnetic tape labelling, storage, shipping, and protection from humidity, temperature and physical, electrical, fire, or other damage includes putting visible labels on reels and tape labels at beginning of tape. An alarm bell set for 4 degree rise in temperature. An alternate storage site is used for one previous generation of reference, transaction and program library tapes.

Tape station substitution between Off & On-Line is a few minutes, which minimizes down time due to tape station malfunction.

Air-conditioning is for the area with no direct ductwork to the equipment.

Alarm permits sufficient time to dump memory prior to shutting down equipment. An eight degree rise in temperature over a brief period will cause the computer to malfunction.

Atlantic City Electric Company

Outstanding features include fast memory access time, solid state construction, variable format, punched paper tape output, high speed paper tape input, dual recording in magnetic tape and self checking circuits.

Unique system advantages include complete elimination of punched cards, printing of address side of utility bill simultaneously with billing information side, after which bill is folded and heat-sealed into postcard weight form. Automative reentry of cash through optical scanning of heat-sealed stubs with results punched into paper tape.

Adopted procedures for magnetic tape labelling and storage include tapes stored vertically in racks in partitioned area with full humidity and temperature control. Self-adhesive color-coded labels for identification.

Raytheon Company - Missile Systems Division

Outstanding features include true variable item length, which decreases tape passing time, low start-stop time (3.5 mil sec) which decreases tape passing time, dual recording which eliminates r/w errors, an octal numbering system, which conserves memory, and forward/backward read on tape.

Unique system advantages include a fully transistorized system, built-in modifiers (7), building block concept allowing future expansion of system, read/write and read or write/compute simultaneously feature, built-in controls (parity checks, arithmetic checks, etc), and forward/backward read.

Adopted procedures for magnetic tape labelling, storage, shipping, and protection from humidity, temperature and physical, electrical, fire, or other damage include a CO₂ foam automatic fire detection and extinguishing system, a humidity control with air conditioner, and all magnetic tape storage in a separate "tape room".

FUTURE PLANS

U.S. Naval Propellant Plant

It is proposed that when the cost of overtime operations exceeds the rental fee of an on-line high-speed printer, a printer will be rented. Additional tape stations may be added to accommodate additional applications.

Scott Air Force Base

At the present time, we plan to put the reporting and accounting system for Commercial Service Authorizations on this system by 15 June 1960.

Mitchel Air Force Base

Short Range Plans.

Acquisition of tape switching unit Model 547-6. This is a manually controlled switching device. It is capable of switching from one to six predetermined tape station trunks to from one to six predetermined machine trunks by means of relay switching.

Re-engineering of systems design and programs for greater machine efficiency.

New applications.

Using the data in the Master Personnel Tape, qualitative selection of personnel for specific assignments is being studied. As a corollary to a computer selection would also be determination as to type of military order required and production of the order via computer.

Possible acquisition of a small computer which would replace present off line printer as well as provide for faster data input to 501 System via magnetic tape.

Elimination of card transcriber and reliance upon paper tape input for all transactions against the Master Personnel File.

Long Range Plans.

Possible acquisition of character recognition equipment. This equipment would "read" documents and the data would be placed on magnetic tape ready for processing by the computer.

Increased use of the computer to act as a personnel clerk making determination as to personnel actions (orders, reassignments, discharges, etc.) to a larger extent than is presently being done.

Use of the computer as an aid in performing operations research programs for management decisions. We envision the computer to be used in the areas of work measurement and the establishment of work standards, the analysis of present and projected personnel actions, particularly in the area of manpower re-

quirements and assignments, etc.

Inclusion of our data processing system into the USAF combat logistics network (COMLOGNET).

Fidelity-Philadelphia Trust Company

On 1 February 1961, we will add 2 Burroughs MICR Sorters plus a converter from the sorters to the computer. After the Regular Checking Accounts are fully converted, plans will be made to convert Trust Department Accounting, Savings Accounts, Payroll, Commercial and Collateral Loans and Mortgages from Punched Card Systems to the Computer.

State Farm Life Insurance Company

Programming of all printing being arranged for ease in moving to off-line printer.

"System" designed for "bi-product" production of input paper tape in remote regional offices--but will be pioneered with all input tapes produced in Home Office.

Ultimately plan to move all present punched card work to RCA 501 eliminating all punched card equipment.

RCA Service Company - E D P Sales Dept.

Present plans call for installation within one year of a 2nd basic RCA 501 or advanced system together with additional off-line equipment.

There will also be available complete system design and programming services available on a contract basis, with and without computer operation.

RCA Astro Electronics Division

Additional tape stations and verification equipment, and additional modules of memory equipment for expanded applications will be required.

Ordnance Weapons Command

Investigating possibility of substituting an RCA-301 for off-line equipment. Complement to include a card reader, card punch, printer and two (2) tape stations. This should result in a rental savings of approximately \$4,000 per month. This would serve to reduce main computer time since sorting could be done on the 301. It would also provide random access for special interrogations, precluding interruption of main frame production operations to satisfy the interrogations. No conclusive decisions have yet been reached, however.

Additional tape stations (7) will be added when production requires. (Approximately 1 year)

A modification of the paper tape reader will permit reading of eight (8) channel paper tape in addition to the present seven (7) channel.

Future applications to be programmed using RCA's Common Business Oriented Language. This will materially reduce both programming and debugging time.

Atlantic City Electric Company

It is anticipated that the RCA 501 equipment will be adequate for present applications and expected growth for at least the next ten years. Future applications may be continuing Property Records, Meter and Pole History Records, Personnel History Records and Engineering Studies.

Raytheon Company - Missile Systems Division

Planned applications include:

Inventory control for raw material, finished parts, max-min items and peculiar parts, covering initial inventory, cycle counts, required orders, and P. O. receipts, S. O. receipts, issues, adjustments, and transfers in order to provide transaction costs, in-process cost, stock status, and order analysis.

Shop order system covering process sheet preparation, material and labor explosion, and shop order initiation in order to provide S. O. progress reports and labor and material status reports.

Financial control of labor, material, and overhead in order to provide payroll and labor distribution, contract status reports, indirect labor expense, cost of work in process, and miscellaneous accounting reports.

When capacity is reached, the on-line printer will be changed for off-line equipment.

New equipment for future growth might include a 301 system for off-line card and tab effort.

INSTALLATIONS

U. S. Naval Propellant Plant
Indian Head, Maryland

AACS DCS/Compt/Stat Services Division
Scott Air Force Base, Illinois

Air Reserve Records Center
3800 York Street
Denver 5, Colorado

Ordnance Weapons Command
Rock Island, Illinois

Ordnance Ammunition Command
Joliet, Illinois

Atlantic City Electric Company
1600 Pacific Avenue
Atlantic City, New Jersey

EDPD - New York Electronics System Center
45 Wall Street
New York, N. Y.

Fidelity-Philadelphia Trust Company
135 S. Broad Street
Philadelphia, Pennsylvania

General Tire and Rubber Company
1708 Englewood Avenue
Akron 9, Ohio

Raytheon Company
Missile Systems Division
Haverhill Street
Andover, Massachusetts

RCA Astro Electronics Division
P. O. Box 800
Princeton, New Jersey

RCA Electronic Data Processing Division
Camden, New Jersey

RCA Electronic Systems Center
Cherry Hill Plant
Rte 38 & Haddonfield Road
Merchantville, New Jersey

RCA Service Company
EDP Administration, Cherry Hill
Camden 8, New Jersey

RCA Service Company
Electronic Data Processing Sales Department
Cherry Hill, Camden 8, New Jersey

State Farm Life Insurance Company
112 East Washington Street
Bloomington, Illinois

Bureau of Naval Weapons
18th & Constitution Avenue, N. W.
Washington 25, D. C.

Chase Manhattan Bank
57 William Street, Room 200
New York, N. Y.

Educational Testing Service
20 Nassau Street
Princeton, New Jersey
(Installation Rosedale)

RCA 601

Radio Corporation of America 601

MANUFACTURER

Radio Corporation of America
Electronic Data Processing Division

APPLICATIONS

The computer is a general-purpose, stored program, digital device utilizing transistor and diode circuitry. It provides high-speed storage, processing, and on-line input-output device control capabilities.

The 601 System is able to handle simultaneous routines. The number of such routines is not fixed but is a function of the speed-weight of any peripheral devices involved and the complexity of the individual routines.

In general, minimum storage capacity and complexity is required in external buffers due to maximum use of the internal memory under control of programmed routines. This permits flexible and economical input-output buffering to be achieved.

Computers may also be coupled together. This permits various multi-computer configurations to be obtained. Each computer may be oriented to some particular function, such as input-output processing, or may be completely general purpose in nature.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary, Binary Coded Decimal Alphanumeric
Binary digits/word	6, 8, 12, 16 or Variable
Binary digits/instruction	Variable 24 to 144
Instructions per word	Variable size instructions from 1/2 word to 3 words each
Instructions decoded	Variable over 120
Arithmetic system	Flo point, dec and bin (optional) Fix point, dec and bin (optional) Variable word length Operands limited by memory size
Instruction type	Number of address is variable. One, two, three address at programmer's option.
Number range	Depends on memory size
Instruction word format	Binary digit count

1	3	6	3	3	9	3	1	3	4	1	16	3
P	T	Op	D In-	ACD As-	Count	Cl	P	T	Ad-	I	Half	Char
A	A	Code	errupt	sumed	Sym		A	A	dress	N	Word	Add
R	G		Set-	Address	Regis-		R	G	Mod.	D	Add.	
			Sense		ter No							
			Tags									

Automatic built-in subroutines are available. For example, automatic servicing of queue table for input-output instructions. Calculation of weight-load of input-output devices. Sortable preparation of criteria address list as data is read in. Several operation codes have the effect of a subroutine, i.e., code convert provides conversion from one bit structure to another.

Automatic coding includes Automatic Assembler, RCA Narrator (COBOL), and RCA ALGOL.

Registers and B-boxes include 8 address modifiers.

1/2 word	1/2 word
Address Modifier	This modifies the Address Modifier

Additional op codes can be added by the programmer since the elemental operations of the op code are available to him.

ARITHMETIC UNIT

	Incl Stor Access	Exclud Stor Access
Operation	Microsec	Microsec
Add	9.75	6 (fixed word 11+11 char)
Mult	13.75	10 (fixed word 11x11 char)
Div	28.75	25 (fixed word 11:11 char)

Arithmetic speed is variable depending on arithmetic unit and instruction control units ordered.

Construction Quantities of transistors, diodes, and magnetic cores used in the arithmetic unit depend on particular unit used. No vacuum tubes are used.

Arithmetic mode Serial for variable length arithmetic
Parallel for fixed length arithmetic

Timing Asynchronous
Operation Concurrent

STORAGE

	No. of	No. of	Access
Media	Words	Digits	Microsec
Magnetic Core	32,768	523,288-3 bit digit	0.9-1.5
	Variable	393,216-4 bit digit	
		262,144-6 bit digit	
		196,608-8 bit digit	
		Number of bits per digit is optional with programmer (3, 4, 6 or 8)	

Memory is in modules of 8,192 words. Use of more than one module permits overlap reducing access time to 0.9 microsec.

Word length is also completely variable if desired.

All magnetic tape units (22K, 33K, 66K) available with the 501 System are also available with the 601 in addition to that described here.

Eight bit code is Field at a 3.

Magnetic Tape	
No. of units that can be connected	64 Units
No. of characters/linear inch	800 Chars/inch
Channels or tracks on the tape	10 Tracks/tape
Blank tape separating each record	0.9 Inches
Tape speed	150 Inches/sec
Transfer rate	120,000/180,000 Chars/sec
Start time	6 Millisec
Stop time	6 Millisec
Average time for experienced operator to change reel of tape	45 Seconds

Physical properties of tape
 Width 3/4 Inches
 Length of reel 2,400 Feet
 Composition Mylar
 Hamming code check bits provide data reconstruction on each character on magnetic tape.

INPUT

Media	Speed
Paper Tape	1000 char/sec
Cards	600 cards/min
Magnetic Tape	120,000/180,000 22,222; 33,333; 66,666 char/sec

Teletype line Up to 50 lines/min
 Optional time scanning unit available.

Same magnetic tapes available on the RCA 501 are also available on the RCA 601. 22K and 33K tapes are interchangeable between RCA 601, 501, 301. 66K tapes are interchangeable between RCA 601 and 501.

OUTPUT

Media	Speed
Paper Tape	100 or 300 char/sec
Cards	100 cards/min
Magnetic Tape	120,000/180,000 22,222; 33,333; 66,666 char/sec

Printer 600 lines/min

Up to 6 magnetic tapes may be read simultaneously and up to 8 magnetic tapes may be written out simultaneously.

Up to 8 card readers may be operated simultaneously.

Up to 8 card punches may be operated simultaneously.

Up to 6 printers may be operated simultaneously.
 On-line card readers, card punches and printers may be operated independently of program being run.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	
Transistors	
3696	2N1495
3696A	2N1289
3697	2N581
3697A	
Diodes	
8945076-B1	8512070-A5
8989190-B2	

Quantity depends on system.

The system consists of modules which are assembled in accordance with the requirements of the operation. For example the instruction control unit for floating point calculations and the high speed arithmetic unit are not normally included in a data processing configuration but could be if the customer required the additional speed.

PERSONNEL REQUIREMENTS

Personnel requirements vary in accordance with the complexity of the problem and the configuration of equipment.

Training courses made available by the manufacturer include systems analysis courses, programming courses, special purpose courses, and operators training.

CHECKING FEATURES

Accuracy control is accomplished in the RCA 601 system by the following methods:

General

Provision is made for utilization of error correcting code at points of higher error probability.

Extensive checking and indicating equipment is utilized at key points in the system to detect and facilitate rapid diagnosis of system error.

Error indication is made available to the program to permit self diagnosis and attempted correction of alarm conditions.

A large variety of programmed checking procedures are facilitated with features such as data tagging and real-time clock interruption.

Use of Error Correcting Code

It is generally recognized that electro-mechanical equipment is inherently more prone to error than completely electronic equipment. For this reason RCA 601 high-performance magnetic tapes are provided with the option of an error correcting code. An alpha-numeric character is then represented on tape by ten parallel bits. Six of these define a character. The remaining four bits are utilized to provide automatic correction of an error detected while reading a character from tape.

In the computer it is possible to utilize the two tag digits associated with each word as a six-bit word correction digit.

This feature is particularly effective when applied to micro-instruction routines stored in the high-speed memory.

Error Correction

An automatic half-word parity check is made at key points in the RCA 601 Computer during each data transfer. Some of the points checked are the input and output paths of the high-speed memory, arithmetic operand registers, output buffers, etc. The check points are selected to facilitate error diagnosis either manually or by program.

In addition to the above, a number of special error detecting circuits have been incorporated. These circuits may be divided into three classes.

Circuits which detect alarm conditions caused by the program.

Those which detect an error condition which may have been caused by either program or component malfunction.

Circuits that detect an error which could only be due to a component failure.

Alarm Indication

An alarm condition may be detected by the above checking circuits or by the program itself. In either case, an appropriate indicator is set upon detection of the alarm condition. Three alternatives are available when an indicator is set:

An immediate shut-down can occur

The indicator can be ignored

Automatic transfer of control to an auxiliary routine can be initiated.

In the latter case, the auxiliary routine can be used to analyze the alarm condition and:

Attempt correction by re-running the portion of the program in error, or

Bypass the alarm condition by means of an alternative program path, if available, or

Initiate a shut down if the alarm condition can neither be alleviated nor by-passed.

On-Line Considerations

Operating equipment on-line results in several advantages regarding system accuracy control:

More powerful, automatic, diagnostic techniques may be utilized by the computer than by most test equipment.

Time sharing the computer electronics results in less special-purpose hardware in which a failure can occur.

Alternate program paths can often be provided to permit equipment which is malfunctioning to be automatically by-passed.

Full advantage can be taken of the above on-line system characteristics in the RCA 601 System. If, for example, an operable alarm occurs upon connection to an on-line device, control can be automatically transferred to an auxiliary program.

Sufficient information is supplied to this routine so that an existent alternative path may be determined.

Accuracy control on specific components include:

Computer - Model No. 603 and No. 604

Special error detecting circuits provide machine malfunction alarms. In addition, a real-time clock, memory lock-out facilities, and other checking features permit the detection of a wide range of programming errors.

Magnetic Tape Transfer Channel - Model No. 610

Parity is checked or generated on all data which is received by or transmitted from the buffers. The 22K and 33K tape stations have dual track reading and recording. The 66K tape station has dual track reading and recording plus read after write. The 120/180K tape station has data reconstruction with 6 data bits and 4 check bits for each "character" position.

Magnetic Tape Transfer Channel - Model No. 611

Six bit characters in the write buffer are converted to 10 bit self-correcting code for recording on tape. When reading from tape, the 10 bit characters are converted back into six bit code for accumulation in the buffer storage. Special circuits provide automatic error correction for characters read from tape. A read-after write check is automatically executed when writing data into tape.

Parity is checked or generated on all data which is received or transmitted by the sub units.

Card Transfer Channel - Model No. 613

Read -- Each column of the card is read by two sensing stations, and the outputs of these stations are transmitted to the Card Transfer Channel where they are compared.

Punch -- Read after punch returns are checked against the information previously transmitted to the Card Punch.

Inquire Transfer Channel - Model No. 617

Parity is checked or generated on all half words received from or transmitted to the computer. Parity is checked on all characters received from the Inquiry Console.

Inquiry Console - Model No. 607

Indicators on the control panel indicate when criteria may be introduced into the system, when the computer is searching for the data, and when all the data has been typed.

Card Reader - Model No. 623

Each column on a card is read twice thereby facilitating a check of the reading operation by the computer. The Card Reader stops upon sensing a card jam, empty input hopper, full output hopper, or full reject hopper.

Card Punch - Model No. 634

Each card is read after it is punched, thereby facilitating a check by the computer on the punching operation. The Card Punch automatically halts when either the card supply is exhausted or the output hopper capacity is exceeded.

Magnetic Tape Station - Model No. 681

Remote lockout
Local lockout
Inoperable indication to user equipment

Tape station in local status
Power off
Servo off
Capstan motor off
Any transport mechanism interlock open
Improper amount of tape in bins

Automatic stopping of tape at end of reel
Write lockout
Read after write parity check.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	Approx. 45 Kw	Approx. 58 KVA
Power, air conditioner	Depends on air conditioner used Approx. 1.5 Tons	
Volume, computer	275 cu ft	
Area, computer	60 sq ft	
Room size	1,000 sq ft, computer	
	400 sq ft, service area	
	1,400 sq ft, Total	
Floor loading	100 lbs/sq ft	
Capacity, air conditioner, computer	1.5 Tons	
Weight, computer	Approx 1,900 lbs	

System input must be supplied from a Y connected grounded neutral 3-phase source of 208 volts $\pm 10\%$ at 60 cycles $\pm 1/2$ cycle/sec.

False flooring is desirable for cable connections only.

All power, cooling and space requirements are subject to change and will vary from system to system due to the highly modular concept of the equipment.

PRODUCTION RECORD

A prototype is under construction.
Time required for delivery 18 Months
First deliveries will be in July 1961

ADDITIONAL FEATURES AND REMARKS

Flexibility of configuration and application by options in speed, size and op code.

Data and program security are enhanced when multiple programs are run.

Multiple computer systems can share memory.

COST, PRICE AND RENTAL RATES

Components of basic system

Model	Quantity	Data Processing System	Cost	Monthly Rental
603	1	Computer with 8,192 words of memory (65,536 alpha or 98,304 numeric Char), console and power supply	\$ 839,700	\$ 19,500
610	1	Tape Transfer Channel	26,100	580
640	2	Tape Switch	31,800	700
582	10	Tape station (66,666 char/sec)	432,600	8,750
632	1	On-Line Printer	32,200	700
612	1	Print Transfer Channel	23,600	515
623	1	Card Reader	15,850	350
613	1	Card Transfer Channel	<u>11,300</u>	<u>250</u>
TOTAL			\$ 1,443,150	\$ 31,345

Scientific System

604	1	Computer with 8,192 words (98,304 numeric or 65,536 alpha chars) high speed arithmetic, console and power supply	\$ 998,600	\$ 22,300
661	1	Additional high speed storage (8192 words)	314,200	6,980
610	1	Tape Transfer Channel	26,100	580
640	1	Tape Switch	15,900	350
580	6	Tape stations (22,222 char/sec)	151,140	2,790
632	1	One-Line Printer (600 lines/min)	32,200	700
612	1	Print Transfer Channel	23,600	515
621	1	Paper Tape Reader	<u>11,900</u>	<u>260</u>
TOTAL			\$ 1,573,640	\$ 34,475

Additional components

681		Tape Station 120,000/180,000 char/sec	\$ 56,300	\$ 1,080
580		Tape Station 22,222 char/sec	25,190	465
581		Tape Station 33,333 char/sec	29,700	550
611		Tape Transfer Channel for 681 (max. of 48 tape stations per channel)	76,800	1,670
641		Electronic Tape Switch (max. of 6 Tape stations per switch) for 681	36,100	785
614		DaSpan Coupler	13,200	290
615		Extensor scanner	25,500	565
616		Extensor	1,580	35
607		Inquiry Console	12,600	280
617		Inquiry Transfer Channel	11,700	260
634		Card Punch (100 cards/min)	8,900	200

READIX

Readix General Purpose Computer

MANUFACTURER

Idaho Maryland Mines Corporation
Magnetics Division

Photo by Magnetics Division, Idaho Maryland Mines Corporation

APPLICATIONS

Manufacturer

System is designed and used for scientific computation, commercial data processing, record keeping, and data reduction.

USAF Aerospace Technical Intelligence Center
Located in Building 828, Area A, at W-PAFB, Ohio, the system is used for performance calculations for aircraft and guided missiles.

U.S. Air Force Flight Test Center

Located at 125 South Grand Avenue, Pasadena, California, the system is used for the calibration of bombing range instrumentation including Askania Cine-theodolites, Mitchel and Bowen-Knapp Cameras, Fairchild Ballistic Cameras, and impact geophones and sound microphones; for the space positioning of military aircraft for performance studies and evasive tactics studies; and for the space positioning of bombs, and air-to-ground and air-to-air missiles; and for ballistic studies.

Science Research Associates, Inc.

Located at 104 Pearl Street, McHenry, Illinois, the system is used for score conversions and statistical correlations.

Universal Research and Testing Laboratories
Located at 1733 Flower Street, Glendale, California, the READIX II is used for engineering applications, including control and timing of test set-up's (with the use of an Analog-Digital Converter), for scientific and engineering problems, and for numerical analysis. The business applications include anticipated usage for accounting problems, production control, and for a Service Bureau.

Applications include digital techniques in statistical analysis of experiments, feedback control system design considerations, and selection of method of synthesis for feedback controls. Feedback system compensation applications include design criteria and techniques, compensating components: D-C Systems, compensating networks: A-C Systems, and open-closed loop control. Studies of measurement of noise, system response to noise, system design in the presence of noise, and random variable concepts have also been made. Applications also include general nonlinear system problems, control and timing of test set-ups, analysis of general sys-

Photo by Universal Research and Testing Laboratories

tems, designing for reliability, component characteristics, and transistor circuits.

Other applications include

- Facility Requirements
- Physical Installation
- Personal Requirements

Accounting Applications

Design of Business Systems

Inventory and Scheduling Application

- Inventory Control
- Aircraft Production Scheduling

Scientific and Engineering Applications

- Simultaneous Linear Algebraic Equations
- Characteristic Roots and Vectors
- Linear Programming
- Differential Equations
- Statistical Analysis

Techniques for Reliability

- Summary of Operating and Design Techniques
- System Design
- Circuit Design
- Maintenance

Logical Design

- Algebraic Techniques of Logical Design
- Preliminary Design Considerations
- Detailed Logical Design

Arithmetic and Control Elements

- System Considerations
- Binary Operations
- Decimal Operations
- Control Elements

Random Variables and Distribution

Operations Research

- Operations Research and Mathematical Models
- Data for Testing
- Controlling the Solution

Numerical Analysis

- Interpolation, Curve Fitting, Differentiation, and Integration
- Inversion and Simultaneous Linear Equations
- Digital Techniques in Statistical Analysis of Experiments
- Ordinary Differential Equations
- Partial Differential Equations

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary Coded Decimal
Decimal digits/word	Ten plus sign
Decimal digits/instruction	5
Arithmetic system	Floating point
	Add, subtract, multiply and divide
	Fixed point
	Add, subtract, multiply, divide, and square root

Photo by U.S. Air Force Flight Test Center, Edwards AFB

STORAGE

Manufacturer				USAF ATIC			
Media	No. of Words	No. of Digits	Access Microsec	Medium Drum	No. of Words	No. of Digits	Access Microsec
Magnetic Drum	4,000	40,000	8,000 avg	Drum	4,000	40,000	17,000
Magnetic Drum	160	1,600	4,000 avg	Access time to working storage (160 words) is 1,700 microsec.			
Register	5	50	220 avg	USAF AFFTC			
Magnetic Tape	No. of units that can be connected 10 Units			Magnetic Drum	4,000	10 decimal	4,250
	No. of chars/linear inch of tape 500 Chars/inch			Quick Access			
	Channels or tracks on the tape 5 Tracks/tape			Magnetic Drum	160	10 decimal	1,063
	Blank tape separating each record 1 Inch			Science Research Associates, Inc.			
	Tape speed 60 Inches/sec			Magnetic Drum	4,000	40,000	440
	Transfer rate 1,000 Chars/sec			There are 40 words/channel and 100 channels.			
	Start time 7 Millisec			Universal Research and Testing Laboratories			
	Stop time 7 Millisec			Magnetic Drum	4,160	41,600	4,000
	Average time for experienced operator to change reel of tape 30 Seconds			Magnetic Tape			
	Physical properties of tape			There are 150,000 words/reel or 1,500,000 digits/reel.			
	Width 0.5 Inches			The magnetic tape is used as intermediate storage of digitized information from the analog to digital converter to the READIX computer.			
	Length of reel 2,400 Feet						
	Composition Red oxide						

INPUT

Manufacturer	Media	Speed
	Flexowriter	10 char/sec
	Paper Tape	60 char/sec
	Cards (IBM)	100 cards/min
	Magnetic Tape	1,000 char/sec
USAF ATIC		
	IBM Card Reader	100 cards/min
	Flexowriter	10 digits/sec
USAF AFFTC		
	Keyboard (Flexowriter)	Manual
	Paper Tape (Flexowriter)	10 char/sec
	Paper Tape (Teletype)	60 char/sec
	Science Research Associates, Inc.	
	Cards	100 or 33.3 cards/min
	Paper Tape (Flexowriter)	75 10-digit words/min
	Universal Research and Testing Laboratories	
	Keyboard (Flexowriter)	Manual
	Paper Tape (Flexowriter)	12 char/sec
	Cards (IBM)	100 cards/min

OUTPUT

Manufacturer	Media	Speed
	Flexowriter Keyboard	10 char/sec
	Paper Tape	60 char/sec
	Cards (IBM)	100 cards/min
	Magnetic Tape	1,000 char/sec
USAF ATIC		
	IBM Card Punch	100 cards/min
	Flexowriter	10 digits/sec
USAF AFFTC		
	Printed Page (Flexowriter)	10 char/sec
	Paper Tape (Flexowriter)	10 char/sec
	Paper Tape (Teletype)	60 chars/sec
	Science Research Associates, Inc.	
	Cards	100 or 33.3 cards/min
	Paper Tape (Flexowriter)	75 10-digit words/min
	Universal Research and Testing Laboratories	
	Paper Tape (Flexowriter)	12 char/sec
	Cards (IBM)	100 cards/min

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Tubes	
5687	200
5963	38
6U8	14
6350	11
Diodes (Germanium)	
1N116	3,050
S49	1,010
1N100	15

CHECKING FEATURES

Manufacturer

Checking features include overflow, non-existent number (all decimal), non-existent instruction, non-existent address, and double decision.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Manufacturer	Power, computer	Volume, computer	Area, computer	Room size	Weight, computer
	8 Kw	68 cu ft	14 sq ft	14 ft x 14 ft	1,750 lbs
	Site requirements include a 100V, AC, 100 AMP Line. Ambient temperature should be no higher than 80° F.				
USAF ATIC					
	Power, computer	5 Kw			
	Power, air conditioner	3 Kw			
	Volume, computer	180 cu ft			
	Volume, air conditioner	65 cu ft			
	Area, computer	40 sq ft			
	Area, air conditioner	8 sq ft			
	Room size	650 sq ft			
	Capacity, air conditioner	5 Tons			
	Weight, computer	1,750 lbs			
	Weight, air conditioner	400 lbs			
	System is mounted on a false floor. A central power box is installed. No special ducting for air conditioner is required.				

USAF AFFTC	Power, computer	Volume, computer	Area, computer	Room size	Floor loading	Weight, computer	Weight, air conditioner
	3.2 Kw	1,373 cu ft	78 sq ft	14 ft x 22 ft	18 lbs/sq ft	1,400 lbs	250 lbs
	3.8 Kw	12 cu ft	78 sq ft	14 ft x 22 ft	18 lbs/sq ft	1,400 lbs	250 lbs
	2 - 1 1/2 ton window type						
	Power, computer	3.0 KVA	0.88 pf				
	Power, air conditioner	3.8 Kw					
	The ceiling has been sound proofed with acoustical tile and a 7 1/2 KVA 3 phase and single phase power line was installed. No structural modifications were made.						
	Universal Research and Testing Laboratories						
	Power, computer	7.5 Kw					
	Volume, computer	156 cu ft					
	Area, computer	22 sq ft					
	Room size	14 ft x 14 ft					
	Floor loading	100 lbs/sq ft					
		300 lbs concen max					
	Weight, computer	2,200 lbs					
	100 Amps at 115 Volts, AC, single phase line required. No other modifications were required.						

PRODUCTION RECORD

Manufacturer	Number produced to date	Number in current operation	Number in current production	Number on order	Anticipated production rates	Time required for delivery
	6	6	1	1	One/month	3 Months

COST, PRICE AND RENTAL RATES

Manufacturer	Cost	Monthly Rental
READIX Computer (all decimal w/both fixed and floating point); 4,000 word drum; 107 instructions; desk console; Flexowriter, power supply; ventilation system; component tester.	\$70,000	\$2,400
IBM Converter	20,000	600
Magnetic Tape	25,000	800
Service Costs		
Engineer at Installation	\$12,000 per year	
On Call Service	\$100 per call plus traveling expenses	

USAF ATTC

Basic machine (power, logic, console) cost \$55,000.
A Punch Card Converter cost \$17,500.
\$12,500 per annum for a full time maintenance man.

USAF AFFTC

Computer main frame, console including input-output units, and power supply, total cost is \$80,000.

In shop maintenance and service contract back-up, total approximate cost is \$7,900 per annum.

Universal Research and Testing Laboratories

Basic system \$70,000

Punched card converter at \$20,000

Rental contracting and rates for basic system \$50 per hour, including engineering assistance.

Rental rates for additional equipment

\$30 per hour, including engineering assistance.

Maintenance is by on call service from manufacturer.

PERSONNEL REQUIREMENTS

Manufacturer

Training made available by manufacturer to user includes programming and maintenance.

USAF ATTC

	One 8-Hour Shift
Supervisors	1
Analysts	1
Programmers	2
Coders	0
Clerks	0
Librarians	0
Operators	1
Engineers	1
Technicians	0
In-Out Oper	0
Tape Handlers	0

Operation tends toward open shop.

Methods of training includes on-the-job training.

READIX is used in support of a BURROUGHS 205.

USAF AFFTC

	One 8-Hour Shift	
	Used	Recommended
Supervisors	1	1
Analysts		1
Programmers	1	1
Coders		1
Clerks	1	1
Technicians	1	2

One supervisor and one technician is assigned exclusively to the computer. Other personnel used are drawn from other areas as necessary.

Operation tends toward open shop.

Methods of training used includes classroom lectures and individual training in programming and

operation.

Science Research Associates, Inc.

	Two 8-Hour Shifts	
Supervisors		2
Programmers		2
Operators		2
Technicians		1

Operation tends toward open shop.

Universal Research and Testing Laboratories

One 8-Hour Shift

	Used	Recommended
Analysts	1	1
Programmers	1	1
Operators	1	

Methods of training used included a normal two week course from manufacturer.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Manufacturer

All perishable components are mounted on plug-in boards (ease of replacement). As standard equipment the READIX contains two internal test panels which check the only six types of plug-in boards used in the logic and arithmetic sections.

Average uptime in the field is over 90%.

Two READIX computers have been in the field for over five years and are still computing successfully.

USAF ATTC

Good time	30 Hours/Week (Average)
Attempted to run time	35 Hours/Week (Average)
Operating ratio (Good/Attempted to run time)	0.85
Above figures based on period	Jul 59 to Mar 60
Passed Customer Acceptance Test	Feb 56
Time is not available for rent to outside organizations.	

USAF AFFTC

Average error-free running period	6.0 Hours
Good time	35.0 Hours/Week (Average)
Attempted to run time	41.9 Hours/Week (Average)
Operating ratio (Good/Attempted to run time)	0.835
Above figures based on period	1 May 59 to 27 Apr 60
Passed Customer Acceptance Test	15 Feb 57
Time is not available for rent to outside organizations.	

Science Research Associates, Inc.

Operating ratio (Good/Attempted to run time) 0.95
Time is available for rent to qualified outside organizations.

Universal Research and Testing Laboratories

Good time 32 Hours/Week (Average)

ADDITIONAL FEATURES AND REMARKS

Manufacturer

The READIX medium general purpose computer, with 107 commands, is easy to learn and to program.

Unique system advantages include ease of maintenance. The READIX is most suited for scientific problems.

USAF ATTC

System is considered to be an excellent machine for small problems.

USAF AFFTC

Outstanding features include built-in floating point arithmetic, 9 external switches, program checked, and static and dynamic test equipment built into the computer. Manual procedures only for temperature, humidity and fire control have been adopted for the safeguarding of magnetic tapes.

Maintenance and spare parts provided locally.

Science Research Associates, Inc.

Outstanding features include large capacity memory.

Universal Research and Testing Laboratories

Outstanding features include floating point and fixed point, all decimal, large memory and large command list. Unique system advantages include ease of programming, operating, and maintaining.

FUTURE PLANS

Manufacturer

Transistorizing flip flops and memory plug-ins would make the READIX a solid state machine. Changing the working storage (160 words) to core would speed the READIX 2 to 5 times. 600 cards/minute input. Condense the size of READIX to the size of a desk.

USAF ATTIC

By December 1960 ATTIC will be operating a large 7090 system for both engineering and information storage problems and the READIX system will be phased out.

USAF AFFTC

Additional components planned are a punched card converter and associated card handling equipment.

INSTALLATIONS

United States Air Force

Air Technical Intelligence Center

Wright-Patterson Air Force Base, Ohio

Data Reduction Section

Air Force Flight Test Center

125 South Grand Avenue

Pasadena, California

General Electric Company

13430 No. Black Canyon Highway

Phoenix, Arizona

Science Research Associates, Inc.

104 Pearl Street

McHenry, Illinois

Universal Research and Testing Laboratories

4310 San Fernando Road

Glendale 4, California

RECOMP I CP 266

Recomp Model I
(Formerly designated CP 266)

MANUFACTURER

Autonetics Division
North American Aviation, Incorporated

Photo by Autonetics Division, North American Aviation, Inc.

APPLICATIONS

Scientific computing and data processing for laboratory, field or mobile use.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits per word	40
Binary digits per instruction	20
Instructions per word	2
Instructions decoded	34
Arithmetic system	Fixed point
Instruction type	One address
Number range	- ($2^{39} - 1$) to + ($2^{39} - 1$)

Three commands are provided in order to simplify "floating point" operation.

ARITHMETIC UNIT

	Incl Stor Access Microsec	Exclud Stor Access Microsec
Add	2,000	1,000
Mult	21,000	20,000
Div	21,500	20,500
Construction		Transistors
Rapid access word registers		4
Arithmetic mode		Serial
Timing		Synchronous
Operation		Sequential

Computer clock pulses are recorded on magnetic memory disc.

Access time above is based on minimum access time. Transistors are used throughout. No vacuum tubes or magnetic amplifiers are employed.

Photo by Autonetics Division, North American Aviation, Inc.

STORAGE

Media	No. of Words	No. of Digits	Access Microsec
Magnetic Disk	2,048	40	1,000-32,500
Magnetic Disk	16	40	1,000- 2,500

The 2,500 microsecond maximum access time for the high speed loop occurs on a read operation. The computer memory is of the rotating magnetic disk. A special air bearing maintains an extremely close spacing between the rotating disc and the optically precise headplate. The air gap sensed by the magnetic circuit is about 100 microinches wide. This highly efficient recording system has permitted pulse densities of 300 pulses per inch with write currents of 15 milliamperes.

INPUT

Media	Speed
Paper Tape Reader	37 char/sec
Decimal Keyboard	Manual
Electric Typewriter	Manual

Conversion of decimal mixed numbers to binary is wired in. Input process is automatically checked when the "verify" feature of computer is used.

OUTPUT

Media	Speed
Paper Tape Punch	10 char/sec
Decimal Readout Panel	66 millisec/dig
Electric Typewriter	Manual

All output errors are automatically detected using "echo" checking feature of computer.

Up to 15 decimal digits plus sign may be displayed on the Decimal Read-Out Panel.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Crystal diodes	7,000
Transistors	1,600

Standardized etched (printed) circuit cards.

CHECKING FEATURES

Fixed System contains self-checking features designed to eliminate input-output errors. System has an "input-verify" feature and an "output-echo" checking feature.

Photo by Autonetics Division, North American Aviation, Inc.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	0.3 Kw	0.3 KVA
Power, air conditioner	0.3 Kw	0.3 KVA
Volume, computer	5.7 cu ft, including air conditioner	
Size, computer	19.5 in x 23.5 in x 21.5 in, excluding typewriter and paper tape units	
Weight, computer	200 lbs	

Power requirement figures exclude typewriter and paper tape units. Air conditioner is built into computer package. Voltage regulated power supply is included.

PRODUCTION RECORD

Number produced to date	1
Number in current operation	1

PERSONNEL REQUIREMENTS

One operator per shift is required. Computer is designed for simple operation. Inherent reliability and test equipment make computer easy to checkout and maintain.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

All circuits and components used are designed to meet environmental conditions of the field, including continuous operation in 120° F ambient, vibration, humidity, etc.

ADDITIONAL FEATURES AND REMARKS

A checkout console is plugged into the computer, which makes it possible to rapidly check the complete computer system and its plug-in components. Outstanding features include small size, weight and power requirements for efficient use in office, laboratory or field. It is compact and rugged. System was developed by Reconnaissance Charting Branch, Intelligence Laboratory, Rome Air Development Center, under contract with Autonetics Division of North American Aviation, Incorporated.

Photos by Autonetics Division, North American Aviation, Inc.

RECOMP II

Autonetics Recomp Computer

MANUFACTURER

North American Aviation, Incorporated
Autonetics Division

APPLICATIONS

Manufacturer

RECOMP II is an all-transistorized general-purpose digital computer. This desk size computer does computations in mathematics, data reduction and analyses, optical engineering, photogrammetric calculations, operations research, and other civil engineering and scientific applications.

U.S.A. Combat Development Experimentation Center
Located in Building 2871, Fort Ord, California, the system is used for the analysis of field data from Combat Development Experimentation Center experiments and for the calculation of fire effects.

USASS ADPS OD

Located in Building 621, Fort Monmouth, New Jersey, the system is used by the Officers Department, ADPS Committee, U.S. Army Signal School, for the preparation of demonstration programs to illustrate the military applications of computer systems. These demonstrations include logistics and personnel accounting, radioactive decay calculations and fire control calculations. It is also used for the train-

Photo by Autometric Corporation, Operations Division

ing of programmers.

USASS CONARC Briefing Team

On tour, the system is used by the USCONARC ADPS Briefing Team, U.S. Army Signal School, to demonstrate military applications of a digital computer to military audiences throughout the United States.

USASS Special Training Department

Located at Myer Hall, Dept. of Special Training, U.S. Army Signal School, Fort Monmouth, New Jersey, the RECOMP II in many respects is similar to the BASICPAC, a member of Army's FIELDATA family. For this reason, it can be and is being used for simulation for programmer training. It also demonstrates capabilities, limitations and applications during FIELDATA programmer, operator and maintenance training.

Offutt AFB

Located at the Offutt AFB, 544th Reconnaissance Technical Group, Analysis Center, the system is used for Geodesy (datum conversions; coordinate transformations; range and azimuths; geodetic position computations) and Photogrammetry (analytical triangulation; photo orientation and rectification).

Photo by North American Aviation, Inc., Autonetics Division

Turner AFB

System is used in Geodetic Positioning, and Hiran distance computations. It is presently used to inverse, and position points and adjust these points to a most probable position. It is being programmed to do Hiran distance reduction computations.

W - P AFB

Located at the Institute of Technology (Air University), Wright-Patterson Air Force Base, Ohio, the system is used for training USAF officers in use of computers. It is used also for student and faculty research on problems of interest to the U.S. Air Force.

Autometric Corporation

System is used primarily to solve geodetic equations in aerial mapping and other branches of photogrammetry.

Melpar, Inc.

Located at 11 Galen Street, Watertown, Massachusetts, the system is used for radar calculations, information theory problems, character recognition, and

considerable matrix work (eigenvalues, etc).

PROGRAMMING AND NUMERICAL SYSTEM

Manufacturer	
Internal number system	Binary
For output	Binary Coded Decimal
Binary digits/word	39 + sign
Binary digits/instruction	20
Instructions per word	2
Instructions decoded	Will hold over 8,000 at one time (49 different plus 5 input-output variants)
Arithmetic system	Floating point Fixed point
Instruction type	One address (Single)
Number range	Fixed ($2^{39} - 1$); Floating ($1 - 2^{39}$). $2 (2^{37} - 1)$ or 10^{\dagger} Forty billion

Photo by North American Aviation Inc., Autonetics Division

Instruction word format

Sign	OP	Address	Sign	OP	Address	
1	6	13	1	6	13	Bits

Automatic built-in subroutines include trapping on negative instructions, floating point operations, and fixed and floating square root. Assemblies and compilers are available.

There are four registers, designated A, R, C and B.

ARITHMETIC UNIT

Manufacturer

Exclud Stor Access
Microsec

	Fixed point	Fixed point
Add	540	1,350
Mult	10,800	12,400
Div	11,300	12,700

Arithmetic unit is constructed of transistors.

Arithmetic mode	Serial
Timing	Synchronous
Operation	Sequential

STORAGE

Manufacturer

Medium	No. of Words	No. of Decimal Digits
Magnetic Disk	4,096	49,000

Average access time is 9,000 microseconds for main memory and 900 microseconds for high speed memory. There are two high speed loops of 8 words each.

Melpar, Inc.

High-speed storage can hold 32 commands or 4 floating point numbers and 16 commands, etc. An additional 16 or 32 words of high-speed storage would be helpful in allowing more data to be contained in the high-speed loops at one time.

INPUT

Manufacturer

Media	Speed
Paper Tape (Photoelectric)	400 char/sec
Control Console Keyboard	
Electric Typewriter	

Other methods are under development.

Melpar, Inc.

An off-line paper tape preparation unit should be used to avoid wasting computer time during keying operations. An off-line Flexowriter, with compatible code for this purpose, has been ordered.

Photo by North American Aviation, Inc., Autonetics Division

OUTPUT

Manufacturer	Media	Speed
	Paper Tape Punch	20 char/sec
	Electric Typewriter	10 char/sec
	Console Visual Readout (Nixie)	

Other methods are under development.
Machine operates in binary, but accepts decimal or alphanumeric input.
Melpar, Inc.
High-speed punch to be added in order to speed up output operations.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Manufacturer	Approximate Quantity
Diodes		10,000
Transistors		2,000

CHECKING FEATURES

Manufacturer
All output is checked by echo signal to ensure accuracy.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Manufacturer	
	Power, computer 0.5 Kw
	Volume, computer 4.7 cu ft
	Area, computer 45 sq ft
	Floor loading 80 lbs/sq ft
	Weight, computer 197 lbs
	115V, AC, outlet is required.
	USA CDEC
	Voltage regulation installed on 110V line.
	USASS ADPS OD
	Power, computer 0.4 Kw
	Excluding typewriter and paper tape unit
	Room size 3 ft x 5 ft
	Weight, computer, including Input-Output 400 lbs
	No special site preparation is required. Power source may need a constant voltage regulator installed

Photo by U.S. Army Combat Development and Experimental Center, Fort Ord

to minimize line transients effect on computer.

USASS Special Training Dept.

Room size 25 ft x 29 ft

Capacity, air conditioner Approx 5 Tons

No special site preparation required.

Offutt AFB

Room size 10 ft x 10 ft including
filing & maint equip

AC Voltage Regulator is the only necessary preparation.

Turner AFB

Power, computer 0.5 Kw Approx 0.5 KVA > 0.95 pf

Room size 10 ft x 10 ft

Floor loading 45 lbs/sq ft

45 lbs concen max

Weight, computer Approx 400 lbs

No site preparation is required. Machine operates on standard 115V outlet. Installation time is approx. 2 hours. Air conditioner is not required.

W - P AFB

Air conditioner is not necessary.

Desk size computer-loading etc., is negligible.

No site preparation is required.

Autometric Corporation

Room size 45 sq ft

No special site preparation or air conditioner is required. Power outlet is 115V, 60 cycle, single

phase.

Melpar, Inc.

Room size 7 ft x 10 ft

Normal building air conditioner is used.

PRODUCTION RECORD

Manufacturer

Time required for delivery 3 months

COST, PRICE AND RENTAL RATES

Manufacturer

	Price	Monthly Rental
Computer and memory, photo-electric tape reader, typewriter, tape punch, and console	\$95,000	\$3,000
Maintenance service included in rental. Purchaser service contract at \$5,000 per year.		

USA CDEC

Total cost of computing system \$85,000.
2 Off-line Flexowriters cost \$2,400 each. Total additional is \$4,800.
Maintenance/service contract is \$6,000 per year.

USASS ADPS OD
 Rental is \$3,000 per month, including maintenance service.
 USASS Special Training Dept.
 Annual maintenance contract with manufacturer is approximately \$5,000.
 Offutt AFB
 Computer and input-output devices - \$92,000.
 Two magnetic tape unit price is undetermined.
 Maintenance service contract is approximately \$20,000 per year plus parts.
 Turner AFB
 System cost is \$92,000.
 Autometric Corporation
 Maintenance contract is at rate of \$5,000 per year for one shift operation. Additional shifts are 50% of first shift.
 Melpar, Inc.
 Off-line Flexowriter and high speed punch cost \$2,200.
 Computer, typewriter, console, paper-tape reader and punch rent at \$3,000/month including maintenance service.

Photo by U.S. Army Signal School, Fort Monmouth

PERSONNEL REQUIREMENTS

Manufacturer

One supervisor and one programmer per 8 hour shift. System can be used by persons desiring a solution to a problem even if they have little or no computer experience.

Complete operation training consisting of any or all of a 1 week familiarization course, a 2 week programming course, and/or a 1 week assembly and compiler course is made available by the manufacturer to the user. Maintenance course also available.

USA CDEC

	One 8-Hour Shift
Supervisors	1
Programmers	3
Clerks	1

Operation tends toward closed shop.

Methods of training used includes individual instruction.

USASS ADPS OD

A machine supervisor is recommended.

No formal operating procedures are necessary. Personnel familiar with the computer and programming may use the computer whenever they have the need on a first come basis.

Operation tends toward open shop.

Methods of training used includes manufacturer conducted on site courses lasting for periods of 1

Photo by U.S. Air Force 544th Reconnaissance Group, Offutt AFB

week to 1 month.

USASS CONARC Briefing Team

	One 8-Hour Shift	
	Used	Recommended
Supervisors	1	1
Technicians	1	1

Operation tends toward open shop.

Manufacturer conducted on site courses lasting for periods of 1 week to 1 month.

No formal operating procedures are necessary.

Personnel familiar with the computer and programming may use the computer whenever they have the need on a first come basis.

USASS Special Training Dept.

Programming and operating are performed by instructor personnel to meet their specific training requirements.

Methods of training used includes training provided by manufacturer and on-the-job training.

Turner AFB

	One 8-Hour Shift	
	Used	Recommended
Supervisors	1	1
Programmers		2
Operators	2	1

W - P AFB

Operation tends toward open shop.

A 40-hour course, spread over ten weeks, is given. Each student has, in addition, 20 or more hours of machine time, and he carries a problem of appreciable magnitude through all its stages.

Autometric Corporation

One programmer, who usually does own operating, is used and recommended.

Operation tends toward open shop.

Manufacturer of system offers a three week programming/operating course free with purchase of system. A programmer so trained may in turn instruct others at the home installation in the use of the equipment.

Offutt AFB

	One 8-Hour Shift	
	Used	Recommended
Supervisors	1	1
Programmers	3	3
Technicians	1	1

Operation tends toward open shop.

Methods of training used include Computer Programmers School (2 weeks), frequent classes conducted by the Field Engineer, and on-the-job training.

Melpar, Inc.

	One 8-Hour Shift	
	Used	Recommended
Supervisors	1	1
Analysts	0	2
Programmers	3	4
Coders	0.5	2
Operators	0.5	1
In-Output Oper	0.5	1

Operation tends toward open shop.

Engineers were trained to use algebraic translator. (Some were trained to use machine code.) Programmers (all familiar with at least one other computer) taught themselves from the manual.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

USA CDEC

Good time 33 Hours/Week (Average)
Attempted to run time 40 Hours/Week (Average)
Operating ratio (Good/Attempted to run time) 0.82
Above figures based on period 1 Jan 60 to 1 Jul 60
Passed Customer Acceptance Test 1 Oct 59
Time is not available for rent to outside organizations.

USASS ADPS OD

Good time 38 Hours/Week (Average)
Attempted to run time 40 Hours/Week (Average)
Operating ratio (Good/Attempted to run time) 0.95
Above figures based on period 1 Jul 59 to 1 Jul 60
Time is not available for rent to outside organizations.

2 hours/week required for preventive maintenance.

USASS CONARC Briefing Team

Good time 38 Hours/Week (Average)
Attempted to run time 40 Hours/Week (Average)
Operating ratio (Good/Attempted to run time) 0.95
Above figures based on period 1 Jul 59 to 1 Jul 60
Time is not available for rent to outside organizations.

2 hours/week required for preventive maintenance.

USASS Special Training Dept.

Average error-free running period 129.3 Hours
Good time 38 Hours/Week (Average)
Attempted to run time 40 Hours/Week (Average)
Operating ratio (Good/Attempted to run time) 0.95
Above figures based on period 28 Jun 60 to 10 Aug 60
Passed Customer Acceptance Test 28 Jun 60
Time is not available for rent to outside organizations.

Turner AFB

Good time 30 Hours/Week (Average)
Attempted to run time 30 Hours/Week (Average)
Operating ratio (Good/Attempted to run time) 1.0
Above figures based on period 26 Jun 60 to 10 Aug 60
Passed Customer Acceptance Test 20 Jun 60
Time is not available for rent to outside organizations.

Autometric Corporation

Good time 29 Hours/Week (Average)
Attempted to run time 30 Hours/Week (Average)
Operating ratio (Good/Attempted to run time) 0.97
Above figures based on period May 59 to Aug 60
Passed Customer Acceptance Test May 59
Time is not available for rent to outside organizations.

Melpar, Inc.

Average error-free running time 60-90 Hours
Good time 60 Hours/Week (Average)
Operating ratio (Good/Attempted to run time) 44 out of 45 starts
Above figures based on period 8 Mar 60 to 8 May 60

Time is available for rent to outside organizations.

There has been only one computer failure to date: two burned out diodes in the power supply. There was difficulty with the typewriter and punch during the first month but they are both highly reliable now. The RECOMP II system replaced a larger system, and is far more reliable, with only 2 hours maintenance per week instead of 10-15.

ADDITIONAL FEATURES AND REMARKS

Manufacturer

Outstanding features - Rugged solid-state construction; simplified programming; built-in floating point arithmetic and square root; fingertip control console with digital readout; high-speed photoelectric tape reader (400 characters/sec); 49 commands; magnetic disk memory with 4,096 words, each of 40-bit length, including 16 words in high-speed loops.

USA CDEC

Outstanding features includes built in floating point commands, and Baudot (teletype) input. Tape is stored in a fire proof safe file cabinet. System is input-output limited.

USASS ADPS OD

Outstanding features include compact large family of instructions, easy to use and understand, and console. It is more rugged than most commercial computers and may be moved easily with only normal household goods type care.

USASS CONARC Briefing Team

Shipment between presentations done by commercial movers or in a specially constructed shelter which has modified shock mountings and built in recesses and tie-down straps for fast packing.

USASS Special Training Dept.

Unique system advantage is that the RECOMP paper tape code and FIELDATA 5 chan code are the same.

Transistorized, serial, binary, single address, internally stored program, general purpose, digital computer, with 49 instructions including 15 arithmetic instructions; 25 logical and transfer instructions; 9 input/output instructions. Among these are 9 built-in floating point instructions.

Offutt AFB

Outstanding features include two high speed rapid access loops, floating point arithmetic, completely transistorized, small computer compactness, and economy of power.

Turner AFB

Outstanding features include small physical size, no site preparation, reliability, and ease of programming.

W - P AFB

Outstanding features include ease of communication with the system and simplicity of coding.

Autometric Corporation

Outstanding features include Arabic numeric display under manual or program control and trapping mode (negative command actuated). Following built-in advantages include preset stop mode, checking features, verification mode for input, decimal to binary conversion on input, floating point, and three sense switches.

Unique system advantages include no special site preparation, no air conditioning, the system is portable, and ease of programming and debugging.

Melpar, Inc.

Outstanding features include reliability, automatic floating point, square root commands, and full word floating point exponent.

FUTURE PLANS

Manufacturer

Magnetic tape will be available in the near future, as soon as testing is completed.

USASS Special Training Dept.

As other equipment and components for this system become available and as they increase the effectiveness of the training offered, they will be added.

Offutt AFB

Two magnetic tape input-output units are to be installed in the near future. The computer will be sent back to Autonetics for modification. Anticipated time necessary for modification is between 30 and 90 days.

Turner AFB

Plan to add magnetic tape input-output system.

Melpar, Inc.

Modifications include off-line Flexowriter for input preparation and printing of results, a high-speed punch, a Melpar-built plotter using paper tape input, and a large-scale open shop training program. New applications expected are interference studies, satellite tracking, operations research and missile trajectories.

INSTALLATIONS

U.S. Army Combat Development Experimentation Center
Fort Ord, California

U.S. Army Signal School
ADPS, Officers' Department
Fort Monmouth, New Jersey

U.S. Army Signal School
CONARC Briefing Team
Fort Monmouth, New Jersey

U.S. Army Signal School
Special Training Department
Fort Monmouth, New Jersey

544th Reconnaissance Technical Group
Analysis Center
Offutt Air Force Base, Nebraska

1370th P. M. W.
Turner Air Force Base, Georgia

Institute of Technology (Air University)
Wright-Patterson Air Force Base, Ohio

Autometric Corporation
351 W. 44th Street
New York 36, N. Y.

Melpar, Inc.
11 Galen Street
Watertown, Massachusetts

REPAC

REFAC

MANUFACTURER

North American Aviation, Inc.
Autonetics Division

APPLICATIONS

System is designed for general purpose computing.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	40 including sign bit
Binary digits/instruction	20 including sign bit
Instructions/word	2
Arithmetic system	Fixed and floating point
Instruction type	One address
Number range	$+1 \times 2^{39} Y_0 -1 \times 2^{39}$

Floating Point Exponent Range (+ or - 1×2^{39})
Instruction word format

Instruction	Sign Bit	Octal Digits Operation Code	Octal Digits Address	Half-Word Indicator Bit
First	(1/0)	(XX)	(XXXX)	(1/0)
Second	Same as first instruction			

Automatic built-in subroutines include automatic conversion from decimal to binary during input.

Registers include:

- A - Accumulator register
- R - Remainder register
- B - Operand register
- X - Exponent register
- L - 8-word rapid access storage
- V - 8-word rapid access storage

ARITHMETIC UNIT

	Incl Stor Access Microsec	Exclud Stor Access Microsec
Add	1,980	540
Mult	22,240	10,800
Div	22,740	10,800

Construction (Arithmetic unit only)

Transistors	1,500
Condenser-diodes	13,000

Timing Synchronous
Operation Sequential

STORAGE

Media	No. of Words	No. of Dec Digits/Word	Access Microsec
Disk Memory (Main)	4,080	12	8,000
Disk Memory (Rapid)	16	12	540

Magnetic Tape

No. of units that can be connected	32 Units
Channels or tracks on the tape	5 Tracks/tape
Transfer rate	30,000 Char/sec

Tape units have not yet been connected to the REPAC Computer at this time.

INPUT

Media	Speed
Paper Tape (Photoelectric)	400 char/sec 5 or 6 channel
Typewriter	Manual
Keyboard on Console	Manual

Input can be either command format, alphanumeric information, or decimal numbers from paper tape and typewriter and command or decimal from keyboard on console.

OUTPUT

Media	Speed
Paper Tape	20 char/sec 5 or 6 channel
Typewriter	10 char/sec
Nixie Tubes on Console	0.54 millisecc/Nixie

Output can be either command format, alphanumeric information, or decimal numbers to paper tape and typewriter and command or decimal to Nixie tubes on console.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Diodes	
HD2289	10,000
Other	2,000
Transistors	
All types	1,500

CHECKING FEATURES

Echo checking on punch and typewriter.
Verify mode on tape input.

POWER. SPACE. WEIGHT. AND SITE PREPARATION

Power, computer	0.6 Kw	5.4 KVA
Volume, computer		6 cu ft
Area, computer		4 sq ft
Room size, computer		One-man office
Floor loading		50 lbs/sq ft
Weight, computer		205 lbs

PRODUCTION RECORD

Number produced to date	1
Number in current operation	1
Not in production	

PERSONNEL REQUIREMENTS

	One 8-Hour Shift	Two 8-Hour Shifts	Three 8-Hour Shifts
Programmers	1	1	2
Coders	1	2	3

Training made available by the manufacturer includes Service Engineer Training School and Programmer Training School.

ADDITIONAL FEATURES AND REMARKS

Outstanding features include comprehensive control console with digital display, built in floating point, high-speed reader, and magnetic-disk memory.

This computer has been further developed into RECOMP II, which is produced in quantity.

INSTALLATIONS

North American Aviation, Inc.
Autonetics Division
9150 East Imperial Highway
Downey, California

RICE UNIVERSITY

Rice University Computer

MANUFACTURER

Rice University

8,192 Word Electrostatic Memory

Photo by Bel Air - Rice University

APPLICATIONS

General purpose computing, primarily scientific applications.

Arithmetic system Fixed and floating point

Instruction type One address

Two short addresses, initial fetch and final store or index arithmetic unit are possible.

Number range

Fixed point 0 to $1 - 2^{-47}$

Floating point $n = \pm c (2^8)^{\pm e}$

$0 \leq c \leq 1 - 2^{-47}$ $0 \leq e \leq 31$

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Number of binary digits per word	54
Number of instructions per word	1
Total number of instructions decoded	2^{13} Approx.

Instruction word format

6	15	6	12	15
Initial Fetch w/Inflections	Operation Code	Final Store	Index Modification, Inflections	Address

Automatic coding system being written, general compiling system being designed. Assembly system, algebraic coding system, algebraic coding system being designed.

Registers and B-Boxes Arithmetic registers (54 bits): U,R,S, four temporary stores. Control registers (15 bits): Eight index registers, including control counter and pathfinder; Eight special purpose registers.

ARITHMETIC UNIT

Operation	Incl. Stor.	Excl. Stor.
Microseconds	Access	Access
Add	50	40
Mult	85	75
Div	85	75

Operation times are for floating point.
Construction (Arithmetic Unit Only)
1000 Vacuum tubes
60 Transistors
5000 Diodes

Arithmetic mode	Parallel
Timing	Asynchronous
Operation	Sequential

STORAGE

Media	Words	Digits	Access Microsec.
Electrostatic tubes	8,192	8,192x54	10
Fast Flip-flop Registers	4	4x54	1

Magnetic Tape

Maximum number of units that can be connected to the system	4 Units
Maximum number of characters per linear inch of tape	*430 Char/in.
Channels or tracks on the tape	10 Track/tape
Tape speed	75 In/sec
Transfer rate	*32,000 Char/sec.
Start time	6 Millisec.
Stop time	6 Millisec.
Average time for experienced operator to change reel of tape	*60 Seconds

Physical properties of tape

Width	3/4 Inches
Length of reel	2,400 Feet

INPUT

Media	Speed
Paper Tape	300 char/sec
Magnetic Tape	4,000 words/sec

OUTPUT

Media	Speed
Paper Tape	60 char/sec
Printer	600 lines/min
Magnetic Tape	108 char/line
	4,000 words/sec

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity	Type	Quantity
Tubes			
5965	3,000	1858	256
6147	300		
Diodes			
T3G	13,000		
Transistors			
2N585	500	2N393	1,000
2N598	400		

The above figures are for the final machine 32K-word memory. The 1858 tubes are used in the RADECHON fast storage unit.

CHECKING FEATURES

An error correcting code for 1 error/word operates with fast memory and magnetic tape.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	20 K.W.
Space, computer	400 sq. ft.
Space, air conditioner	5 ft. x 10 ft., blower
Capacity, air conditioner	13 tons

All equipment installed in an ordinary 50 ft. x 50 ft. room.

PRODUCTION RECORD

Number produced to date	1
Number in current operation	1

COST, PRICE AND RENTAL RATES

The computer is being built with financial support by the Atomic Energy Commission at a cost of approximately \$400,000.

PERSONNEL REQUIREMENTS

For One 8-hour shift during the construction phase:

Programmers	4
Engineers	3
Technicians	2
Secretary	1

INSTALLATIONS

Rice University
Houston 1, Texas

FUTURE PLANS

Memory capacity will be expanded to 32,768 words.

RPC 4000

Royal Precision Computer Model 4000

MANUFACTURER

Royal McBee Corporation
Librascope, Incorporated

APPLICATIONS

Systems are located at Fort Chester, New York and Burbank, California. Typical examples of applications include engineering, e.g. flight simulation, thermal distribution, motor fuel blending, heat exchanger design, highway design, water network calculations, electrical power loadflow calculations, optical ray trace, and reduction of wind tunnel test data; and business data processing, e.g. production control, payroll, accounts receivable, order analysis, financial statements, job costing, sales analysis, quality control, and operations research.

Photo by Royal McBee Corporation

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system Binary
Binary digits/word 32
Binary digits/instruction 32
Instructions per word 1
Instructions decoded 42
Arithmetic system Fixed point
 Floating point can be simulated
Instruction type Two address (one over one)
Number range 9 decimal digits
Instruction word format

Sign	Command	Operand Address	Next Instruction Address	Index Tag
S	1 4	5 17	18 30	31

Automatic coding includes, compilers, assemblers, and interpretive systems.

Registers include upper accumulator, lower accumulator, instruction, index, and 8008 memory registers.

ARITHMETIC UNIT

	Incl Stor Access Microsec	Exclud Stor Access Microsec
Add	500	250
Mult	17,000	17,000
Div	17,000	17,000

Construction (Arithmetic unit only)
Transistors and diodes are employed as the circuitry of the 4000.
Arithmetic mode Serial
Timing Synchronous
Operation Next instruction designated

STORAGE

Medium	No. of Words	No. of Binary Digits	Average Access Microsec
Magnetic Drum	8,008	32	8,500

INPUT

Media	Speed
Paper Tape (Photo Electric Reader)	500 char/sec
Paper Tape (Tape Typewriter Reader)	60 char/sec
Punched Card Reader	
Magnetic Tape	

OUTPUT

Media	Speed
Paper Tape (High Speed Punch)	300 char/sec
Paper Tape (Tape Typewriter Punch)	30 char/sec
Tape Typewriter Print	12 char/sec

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Transistors and diodes are used in the circuitry of the RPC-4000.

CHECKING FEATURES

Parity checks are included.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	0.725 Kw
Volume, computer	25.4 cu ft
Area, computer	8.8 sq ft
Room size	Depends upon equipment configuration
Floor loading	78.2 lbs/sq ft 600 lbs concen max
Length, computer	46 3/4 in
Width, computer	27 in
Depth, computer	34 3/4 in
Weight, computer	600 lbs

Normal office power required.

COST, PRICE AND RENTAL RATES

Cost of basic system	
Computer (including one Tape Typewriter)	\$87,500
Additional equipment	
Photo Electric Reader	15,000
High Speed Punch	20,000
Tape Typewriter (off line)	5,000
Rental for basic system	
Computer (including one Tape Typewriter)	\$1,750
Rental additional equipment	
Photo Electric Reader	300
High Speed Punch	400
Tape Typewriter (off line)	150
Maintenance included in rental; service contract available for purchasers.	

PERSONNEL REQUIREMENTS

Personnel requirements will vary according to the applications under consideration and the size of the system.

The basic system, i.e., computer and tape typewriter, tends towards an open shop type operation; however, since the system is modular and up to 17 input-output units (up to 60 with minor modifications) may be employed on-line at any time, the system as a data processing system would tend towards a closed shop type operation.

Training provided by the manufacturer includes programming schools for users at no extra cost, local assistance by applications analysts at no cost, and maintenance schools for users at a nominal additional cost.

ADDITIONAL FEATURES AND REMARKS

System is fully transistorized, large memory-8008 words, programming flexibility, high operating speeds, Index Register for automatic high speed address modification, repeat execution feature, complete memory search of 8,000 words in 2 1/2 to 4 seconds, high speed input and output, up to 17 input-output devices (or up to 60 with minor modifications), parity checking on input, dual access and high speed tracks, utilizes 110-120 volt "house current".

INSTALLATIONS

Royal McBee Corporation
Port Chester, New York

Royal McBee Corporation
Burbank, California

PRODUCTION RECORD

Number produced to date	10
Number in current operation	2
Number in current production	10
Number on order	75
Anticipated production rate	10 per month
Time required for delivery	4-6 months

RPC 9000

Royal Precision Computer Model 9000

MANUFACTURER

Royal McBee Corporation
Librascope, Incorporated

APPLICATIONS

Located in Port Chester, New York and Burbank, California, system is designed for all typical business-type data processing and engineering type activities.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary coded decimal
Decimal digits/word	12
Decimal digits/instruction	2
Instructions per word	6
Instructions decoded	43
Arithmetic system	Fixed point
Floating point can be simulated.	
Instruction type	One address
Number range	12 decimal digits
Instruction word format	

Single Character Command, Single Character Address:
e.g. the command may be F, the address may be P.

Automatic coding includes compilers, and assemblers.
Registers and B-boxes include 3 - Arithmetic Registers, 1 - Command Register, and 1 - Address Register.

ARITHMETIC UNIT

	Incl Stor Access Average Microsec	Exclud Stor Access Microsec
Add	110	230
Mult	2,860	1,980
Div	3,520	3,520

Access times are not optimized.
Construction (Arithmetic unit only)
Transistors and diodes are employed in the circuitry of the RPC-9000.
Arithmetic mode Serial
Timing Synchronous
Operation Sequential

Photo by Royal McBee Corporation

STORAGE

Media	No. of Words	No. of Digits	Access Microsec
Magnetostrictive Delay Lines	77	864	0.880
Magnetic Tape (per unit)	80,000	960,000	1,785,000

Magnetic tape access is average for a reel.

INPUT

Media	Speed
Paper Tape	500 char/sec
Cards	400 cards/min
Paper Tape (Punch and Reader)	60 char/sec

Tape Typewriter System

OUTPUT

Media	Speed
High Speed Paper Tape Punch	300 char/sec
Punched Card Punch	100 cards/min
High Speed On-line Printer	667 or 1,000 lines/min
Paper Tape Punch and Reader	30 char/sec

In addition, there is a slower speed line printer at 150 lines per minute and the typewriter at 12 characters per second available as output.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Transistors and diodes are used in the circuitry of the RPC-9000.

CHECKING FEATURES

Parity checks are included.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	0.2 Kw
Volume, computer	43.4 cu ft
Area, computer	12.4 sq ft
Floor loading	24.2 lbs/sq ft
	300 lbs concen max
Weight, computer	300 lbs

Normal office power required.

PRODUCTION RECORD

Number produced to date	10
Number in current operation	4
Number in current production	25-30
Number on order	50
Anticipated production rates	6 per month
Time required for delivery	9 months

COST, PRICE AND RENTAL RATES

Cost of basic system	
Computer	\$60,000
Tape Typewriter System	5,000
Magnetic Tape Storage Unit	50,000
32 word-expandable Memory Units	5,000
Cost of additional equipment	
Photo Electric Reader	\$15,000
High Speed Punch	20,000
Punch and Reader	2,500
Punched Card Reader	20,000
Punched Card Punch	25,000
Line Printer (150 lpm)	50,000
Line Printer (1,000 lpm)	175,000
Auxiliary Magnetic Tape Storage Unit	20,000
Rental for basic system	
Computer	\$1,200
Tape Typewriter System	150
Magnetic Tape Storage Unit	1,000
32 word expandable Memory Unit	100
Rental additional equipment	
Photo Electric Reader	300
High Speed Punch	400
Punch and Reader	75
Punched Card Reader	400
Punched Card Punch	450
Line Printer (150 lpm)	1,000
Line Printer (1,000 lpm)	3,500
Auxiliary Magnetic Tape Unit	400

Maintenance included in rental; service contract available for purchasers.

PERSONNEL REQUIREMENTS

Personnel requirements will vary according to the applications under consideration and the size of the system.

Methods of training made available by the manufacturer are programming schools for users at no cost, maintenance schools for users at a nominal additional cost, and local assistance by applications analysts at no cost to user.

ADDITIONAL FEATURES AND REMARKS

Fully transistorized, random in-line processing, extremely high speed processing, compatible with any alphabetic or numeric "account number" system, complete file search - every record inspected on every cycle, data parity checked, all data in decimal form, internally stored program, tape cartridges easily interchanged, up to 30 input-output devices operating simultaneously, overlapped functions, modular construction throughout, efficient program storage-2 characters per instruction, fully automatic operation.

INSTALLATIONS

Royal McBee Corporation
Port Chester, New York

Royal McBee Corporation
Burbank, California

RW 300

Thompson Ramo Wooldridge Computers Company
Model RW 300

MANUFACTURER

Thompson Ramo Wooldridge Computers Company

APPLICATIONS

Manufacturer

Automatic, on-line, real-time uses include industrial process control, process data logging, pilot plant operation, quality control testing, electronic or electromechanical systems checkout, test stand data acquisition and data reduction. Off-line uses include general purpose computing.

System has built-in analog-digital conversion logic. Programming is not required to store analog data in memory. System has built-in digital-analog conversion logic. Program is required only to change the output values.

National Aviation Facilities Experimental Station located at the NAFEC, Federal Aviation Agency, Atlantic City, New Jersey, the system is used for air traffic control simulation, and terminal area sequencing control for the Idlewild area. Twenty sim-

ulators via analog tieup are connected to the 300 for input and digital displays are connected for output. With these, a simulation of aircraft in the terminal area and the IFR Room are produced for testing machine automation of air traffic control.

PROGRAMMING AND NUMERICAL SYSTEM

Manufacturer

Internal number system	Binary
Binary digits/word	17 bits plus 1 sign bit
Binary digits/instruction	36 (2 words)
Instructions per word	one-half
Instructions decoded	21
Arithmetic system	Fixed point
Instruction type	Two address (one plus one)

National Aviation Facilities Experimental Station
(FAA)

Number range $\pm (2^{18} - 1)$

Instruction word format

WORD ONE				WORD TWO			
18	14	13	1	18	14	13	1
Execution Code		Operand Address		Operation		Next Instruction Address	

Automatic built-in subroutines include a program loader.

Automatic coding features include "OPUS", a routine for compiling optimum-coded computer program from sequential, symbolic listing, and "SAFARI", an assembly and interpretive program for scientific problems.

Registers include an A register (accumulator), a B register (lower accumulator), 3 one-word control registers, and an output-buffer register (18 bits).

Photo by Thompson Ramo Wooldridge Computers Company

ARITHMETIC UNIT

Manufacturer	Incl Stor Access	Exclud Stor Access
	Microsec	Microsec
Add	780	780
Mult	2,990	2,990
Div	3,120	3,120
Construction (Arithmetic unit only)		
Transistors	approx. 580	
Diodes	approx. 4,000	
Arithmetic mode	Serial	
Timing	Synchronous	
Operation	Sequential	
	Zero access for optimum coding	
	8,330 microsec avg. access for sequential coding	

STORAGE

Manufacturer	No. of Words	No. of Binary Digits	Access Microsec
Media			
Magnetic Drum	7,936 or 15,520	18 x 7,936 or 18 x 15,520	8,330 avg.

Magnetic drum contains 32 words of fast-access memory; 2,080 microsec avg.

The 8,330 microsec average access is for general storage only.

Manufacturer	No. of units that can be connected	8 Units
	No. of chars/linear inch of tape	240 Char/inch
	Channels or tracks on the tape	8 Tracks/tape
	Blank tape separating each record	0.5 Inches
	Tape speed	75 Inches/sec
	Transfer rate	2,560 Words/sec
	Start time	less than 5 Millisec
	Stop time	less than 5 Millisec

Physical properties of tape
 Width 0.5 Inches
 Length of reel 2,400 Feet
 The magnetic tape system is available in 150 and 240 lines per inch models; the figures above are for the 240 lines/in model.

The tape system can be purchased compatible with both RW 300 and IBM 709 equipment.

Manufacturer	No. of Words	Access Microsec
Media		
Drum	7,936	830
Core Buffer	128	215/128 words

INPUT

Manufacturer	Speed
Media	
Paper Tape	10 char/sec
	60 char/sec optional
Digital On-off Signals	Up to 540 bits available
Analog	Continuous Up to 1,920 samples/sec and 1,024 channels of input

Manufacturer	Speed
Keyboard (Flexowriter)	9 char/sec
Paper Tape (Ferranti)	60 char/sec
Magnetic Tape	1,920 words/sec
Analog	128 10 bit words
Digital	700 microsec

Paper tape is 8 level. Analog output is updated every 2.1 seconds. The digital output is up to 18 bits at a time.

OUTPUT

Manufacturer	Speed
Media	
Automatic Typewriter	10 char/sec
	Several typewriters can be operated simultaneously.
Paper Tape Punch	10 char/sec
	60 char/sec punch optional
Analog	Continuous up to 128
Digital On-off Signals	Up to 540 bits available

The RW 300 is unique in that the input-output, buffering, selection, and analog-digital conversion equipment are an integral part of the computer and operate completely independently of the program. The RW 300 can therefore be connected directly to meas-

uring instruments and control devices.

Manufacturer	Speed
National Aviation Facilities Experimental Station	
Media	
Typed Page (Flexowriter)	9 char/sec
Paper Tape (Flexowriter)	9 char/sec
Paper Tape (Teletype)	60 char/sec
Magnetic Tape	1,920 words/sec
Digital	700 microsec
	Paper tape is 8 level. Digital output is up to 18 bits at a time.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Manufacturer	Quantity
Type	
Tubes	13
Diodes	4,000
Transistors	580
Magnetic Cores	2,304
	The tubes are used only in the power supply. The magnetic cores are used in the tape-to-computer buffer storage. The diode and transistor quantities are approximate.

CHECKING FEATURES

Manufacturer	Quantity
There is an optional parity bit on the Flexowriter input/output.	

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Manufacturer	Quantity
Power, computer	0.5 Kw
Volume, computer	120 Volts
Area, computer	60 cps
Room size	33.5 cu ft
Weight, computer	11.2 sq ft
	Small
	600 lbs
	Volume figure does not include input-output equipment.
National Aviation Facilities Experimental Station	
Power, computer	1 Kw
Volume, computer	72 cu ft
Area, computer	18 sq ft
Room size	8 ft x 10 ft
Floor loading	40 lbs/sq ft
	90 lbs concen max
Weight, computer	700 lbs
	Room is kept below 86°F by building air conditioning.
	False floors for cable runs is installed.
	Humidity and temperature is controlled at 72°F and 50% relative humidity.

PRODUCTION RECORD

Manufacturer	Quantity
Number in current operation	18
Anticipated production rates	4 per month
Time required for delivery	6 months

COST, PRICE AND RENTAL RATES

Manufacturer

Price of basic computer (includes automatic typewriter and paper tape punch) is \$98,000.

Price of input-output system (Analog), optional equipment, control console, and magnetic tape units, is available on request.

On-call maintenance contract and full-time maintenance contract are available.

National Aviation Facilities Experimental Station

The price of the basic computer, a Ferranti High Speed Punch, an input-output distribution panel, a real time clock, one analog to digital-digital to analog converter and 4 magnetic tape units cost \$212,920.

Two data flow systems, 64 analog input channels, 36 analog output channels, 504 digital outputs, and 288 digital inputs cost an additional \$90,673.

Rentals for these are \$5,962 and \$2,589 per month, respectively.

Maintenance/service contract is \$3,000/month.

PERSONNEL REQUIREMENTS

Manufacturer

After installation, the system is designed to operate 24 hrs/day, 365 days/year, with no direct supervision. For 3 - 8 hour shifts, 3 operators and 1 technician are needed.

Training made available by the manufacturer to the user includes Programming course (2 weeks to 4 weeks), a Theory of Operation course (3 weeks), and a Maintenance course (4 weeks). Operators are trained on site. All but maintenance course are free of charge at Beverly Hills facility.

National Aviation Facilities Experimental Station

One 8-Hour Shift

Programmers	6
Coders	2
Clerks	1
Librarians	1

Operation tends toward open shop.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Manufacturer

The system is designed and built for continuous (24 hrs/day, 365 days/yr) operation under normal environmental conditions in process plant control rooms. It is completely transistorized except for the power supply. Less than 1% unscheduled down time experience in the majority of installations. These remarks are based on approximately 48 operating months in actual control installations.

National Aviation Facilities Experimental Station

Average error-free running period	40 Hours
Good time	40.0 Hours/Week (Average)
Attempted to run time	40.5 Hours/Week (Average)
Operating ratio (Good/Attempted to run time)	0.98

Above figures based on period Nov 59 to Apr 60

Passed Customer Acceptance Test Nov 59

Time is not available for rent to outside organizations.

ADDITIONAL FEATURES AND REMARKS

Manufacturer

Outstanding features include integration of analog/digital conversion equipment in one package, high reliability, and compact size.

Unique system advantages are that one system can measure process conditions, compute proper settings for optimum process operation, and automatically control process variables.

A typical RW 300 reactor monitoring system includes an RW 300 Digital Control Computer as the central unit; the required analog and digital input-output equipment; standard measuring and sensing instruments such as compensated and uncompensated ion chambers and scintillometers, and pressure, temperature, and flow sensors; indicating devices; and, where desirable, control devices actuated by the computer.

In operation, the RW 300 continuously scans the instruments connected to it, converts analog and other readings to binary digital form, calculates corrections for measured values where necessary, compares these values against predetermined limits, actuates alarm and warning devices when limits are exceeded, and prints out measured and calculated data.

To insure that the protection of continuous monitoring is available without interruption, two RW 300 computers can operate in parallel (as is the case in two nuclear power station installations in France), with both machines receiving all input data and making all calculations. Only one of the computers operates the automatic typewriters, the alarm devices, and the other output devices. If that computer stops or makes a mistake, the other computer automatically takes over the output device communications.

Alternatively, the first computer might have the single function of alarm scanning, with the second computer and the tape unit used for computations, statistical correlations and trend analyses, data logging, processing of historical data read into the computer from the tape, and control of reactor and power plant variables, as well as backing up the alarm scanning computer.

National Aviation Facilities Experimental Station

The RW 300 is unique in that the input-output, buffering, selection, and analog to digital conversion equipment has been made an integral part of the computer.

Magnetic tapes are stored in metal cabinets in the computer room with temperature and humidity controls.

INSTALLATIONS

National Aviation Facilities Experimental Station
Federal Aviation Agency
Atlantic City, New Jersey

RW 400

Polymorphic Data Processing Systems Model RW 400

MANUFACTURER

Ramo Wooldridge Division
Thompson Ramo Wooldridge Division

Photo by Ramo Wooldridge Division, Thompson Ramo Wooldridge, Inc.

APPLICATIONS

General or special purpose data processing and real-time, on-line, instrumentation, data processing.

Registers include an exchange register, an instruction register, a program counter, accumulator (A), accumulator extension (B), and a sense register.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system Binary
 Binary digits/word 26 + 2 parity
 Binary digits/instruction 26
 Instructions per word 1
 Instructions decoded 38
 Arithmetic system Fixed point
 Instruction type Two address
 System has some 3-address capability, due to special instructions.
 Instruction word format

26	21	20	11	10	1
Op Code	First Operand Address	Second Operand & Result Address			

ARITHMETIC UNIT

Incl Stor Access
 Microsec
 Add 36 (555555+555555)
 Mult 80 (555555x5555)
 Div 128 (3086108025/5555)
 Arithmetic unit is constructed of transistors.
 Arithmetic mode Parallel
 Timing Synchronous
 Operation Concurrent

STORAGE

Media	No. of Words	Access Microsec
Magnetic Core	Variable; 7 char/word	10
Magnetic Drum	8,192 each; 7 char/word	8,500

Modules
A variable number of drums and core units may be added. The characters are numeric.

Magnetic Tape Modules

No. of units that can be connected	64 Units
No. of alpha chars/linear inch	400 Chars/inch
No. of numeric chars/linear inch	700 Chars/inch
Channels or tracks on the tape	16 Tracks/tape
Blank tape separating each record	1.25 Inches
Tape speed	150 Inches/sec
Transfer rate	105,000 Chars/sec
Start time	1.5 Millisec
Stop time	1.5 Millisec
Average time for experienced operator to change reel	30 Seconds

Physical properties of tape

Width	1 Inch
Length of reel	2,400 Feet
Composition	Mylar

INPUT

Media	Speed
Peripheral Buffer (Drum)	8,192 words 3,600 rpm - 8.5 ms av. access
Up to 32 input/output devices may be connected to a peripheral buffer incl. flexowriters, consoles, card readers, etc.	
Central Exchange	35 microsec connect speed
For direct connect of input devices to system, card read, tape read, flexo, etc.	
Cards	2,000 cards/min
Variable read format is utilized.	

OUTPUT

Media	Speed
Typed Page (Flexowriter)	10 char/sec
Paper Tape (Flexowriter)	10 char/sec
Printer (Analex)	900 lines/min
Plotter	lines \approx 25 increments/min symbols \approx 50/min

Card Punch --etc.

The Flexowriter is modified for edge-punched cards and 7 level paper tape, read and punch. 32 may be connected to one peripheral buffer.

Additional input/output devices include a display and analysis console and a data communication console.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Size, weight and power requirements for some typical RW 400 modules. A false floor for cabling is recommended.

Item	Dimensions (feet)			Weight (lbs)	Power (KW) Requirements	Mechanical Blower Capacity cu Ft/min	Heat Dissipation BTU/min
	L.	W.	H.				
Computer Module	8	2	7	1,800	2.665	1,866	152
Buffer Module	6	2	7	1,450	2.545	1,474	145
Tape Module	2	2	7	1,000	1.460	392	83
Tape Adapter	2	2	7	1,000	1.200	392	68
Central Exchange (large)	8	2	7	2,000	4.445	1,866	255
Central Exchange (small)	6	2	7	1,450	2.755	1,474	160
Drum Module	2	2	7	1,000	0.460	392	26
Printer, Elec. (large)	8	2	7	1,900	9.635	1,866	550
Printer, Mich.	2.5	3.5	2	300			
Peripheral Buffer	8	2	7	1,800	3.925	1,866	225
Display Buffer	4	2	7	1,100	0.540	784	31
Flexowriter	Small			100	0.250	--	15
Plotter	6	4	3	1,500	1.000	--	57

PRODUCTION RECORD

Number produced to date	4
Number in current operation	3
Number in current production	2
Number on order	4
Time required for delivery	9 months

COST, PRICE AND RENTAL RATES

Price on a per module basis is available on request.
Maintenance/service contracting is available.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

The RW 400 was designed as the AN/FSQ 27 and meets the required Military Specifications in construction and reliability.

ADDITIONAL FEATURES AND REMARKS

Outstanding features include a multiple input-output capability, full parallel processing capability, limited only by size of the particular installation and a distributed memory and control.

Unique system advantages include expandability and flexibility. System can be a small tailored installation and then be expanded by addition of related modules to meet new or more stringent requirements. Expansion does not necessitate re-programming.

Programming Convenience. The natural format of the two-address instruction logic, augmented by three arithmetic modes (replace, hold and store), makes powerful concise programming easy. The 38 basic instructions are readily learned, and easily applied. They are sufficiently generalized and varied to permit expansion in accordance with the programming situations. A programmer is thus able to employ the full power of the computer to every problem rather than that defined by his own subset of an overly long and randomly evolved instruction list. The direct access of computer instructions, via the indirect addressing and address incrementing feature, to data in a connected buffer's storage minimizes data transferral housekeeping. The buffer's self-instruction ability maximizes computer utility by providing parallel data acquisition while computing is taking place. Programmed control over the computer's response to externally initiated "alert" signals permits nondisruptive handling of system interrupt requests. The generalized input-output instructions make man-machine communication devices operable as integral parts of the RW 400 system.

For this type of programming the computation system provides a mnemonic compiler system, necessary input-output routines, basic scientific subroutines, and diagnostic routines such as selective output, trace, and dump.

Types of service routines include:

"Dump" routines enable the programmer to obtain printed listings of the contents of computer and buffer core storage.

Drum and magnetic tape dumps.

Magnetic tape editing routine.

Program analyzer routine.

Tracing routine.

Types of scientific subroutines include:

Fixed point elementary functions - trigonometric, logarithmic, and exponential.

Fixed point numerical integration.

Binary to binary coded decimal conversion.

Interpretive multiprecision floating point abstraction.

Many other routines are being written to provide a complete service package.

The RW 400 is a unique data processing system which permits many new programming techniques. For example, many computations divide naturally into independent but related parts. These independent parts may be programmed for separate computers within the RW 400 system. The separate computations may proceed simultaneously with resultant low execution time. New programming techniques are developing methods of employing more than one computer for economical high-speed solution of problems which do not separate naturally into independent parts.

RW 400 Module Descriptions

Central Exchange CX-400 and Interim Exchange IX-400

The IX-400 or CX 400 provides all of the communication paths between modules of the system. Its size is dependent upon the number of required paths. The interim exchange, a transistor-diode device, is adequate for small systems; for large systems the central exchange, a transfluxor device, is available. Features of the exchanges are as follows:

The exchange function at electronic speeds.

The exchange is controlled by both computer and buffer modules.

All transmission formats are standard.

Unidirectional transmission is employed.

Each exchange itself can be increased in capacity by adding more channels.

The RW 400 central or interim exchange performs a function similar to a telephone exchange. On request, it will set up a communication path between modules of the system. Several communication paths between different pairs of modules can exist at any given time; however, a request for connection to a module in use will result in a "busy" signal. It is convenient to think of the central exchange as a rectangular array of crosspoints, having computers and buffers positioned along one axis, and devices to which they can connect along the other axis. Only CM 400's and BM 400's can request connections; hence these are the executive elements. RW 400 modules communicate in a standard format, and can be connected into the central exchange in an arbitrary position; however, since buffers and computers must communicate, each buffer has a position on both axes of the crosspoint array.

In its implementation the central exchange bears little resemblance to the telephone exchange. A conversation path actually consists of 37 lines in parallel, and the information rate through the exchange can be as high as 400,000 bits per second per line. Connections are made at electronic speeds.

Computer Module, CM 400

The CM 400 is a high-speed, general-purpose digital computer which is housed in a four-bay cabinet approximately 7 feet high, 8 feet wide, and 2 feet deep. The characteristics and capabilities of the CM 400 are described in the following paragraphs:

High-Speed Operations: There are 38 internal instructions for arithmetic and logical operations. The CM 400 is a parallel binary computer. The computer instruction word is 26 bits long and has two 10-bit addresses and a 6-bit operation code. A typical instruction line, including both memory accesses, is 40 microseconds, an add operation is performed in 35 microseconds, and a multiply operation is performed in 80 microseconds. Five general external (input-output) instructions are provided.

The computer instructions have two addresses. The set of arithmetic instructions has been chosen in a manner to effectively provide three-address efficiency in many cases. Each of the arithmetic operations-addition, subtraction, multiplication, division, square root of a sum, occur in three modes: replace, hold and store. In the replace mode, a division operation, for example, calls out two operands - the divisor and dividend - from the addresses specified by the instruction. After completion of the operation, the quotient is stored in one of the operand locations. In the hold mode, the same process occurs except the quotient is held in the accumulator and is not stored in memory. In the store mode of division, the divisor is obtained from any address in memory but the dividend is taken as the number retained in the accumulator at the end of the preceding instruction. The quotient is then stored in the location specified by the second address of the instruction. These three modes provide practically all of the one and two address combinations desired for arithmetic operations. Special interpretation is made of addresses containing all zeros or all ones - the latter providing access to operands or result locations in the memory of a connected buffer module.

Memory. The CM 400 has a 1,024-word random access magnetic core memory. The read-write cycle time is 10 microseconds. Stored words are 28 bits long - 26 bits of information and 2 parity bits.

Interrupt Capability. Automatic interrupt of a CM 400 is controlled by the masking action of an internal sense register which is under program control. Interrupts may be due to "master" computer intervention, alerting signals from external system modules, and internal conditions such as overflow. An interrupted CM 400 may be programmed to process the condition that caused the interrupt. It then returns to its normal sequence of operations at the point of interruption.

In more detail, each computer has a 20-bit sense register which permits program-controlled interruptions. Each flip-flop of this register senses an alert signal. If an alert signal becomes true and the sensing flip-flop is also true, then a program interrupt occurs. Interruption causes the computer program to next take the instruction stored in address zero. This instruction causes the program to jump to an "interrupt" subroutine. Conventional instructions are used to save the contents of the arithmetic registers and the address at which to reenter the interrupted program. Thirteen of the twenty alert conditions can be arbitrarily assigned from external sources. The remaining conditions arise from internal sources such as overflow, "ready" or other status signals received during standard communication.

Switching Capability. A CM 400 may connect itself through the central exchange to any available buffer module, tape module, tape adapter, drum module, printer module, peripheral buffer, or display buffer. Connections are made within the central exchange. All modules communicate over identical standard cables.

The system network of alert signals of the RW 400 is required in multiple computer systems to permit one computer to control the operation of other computers. It allows the system to efficiently accept infrequently occurring asynchronous input signals, and can be used to implement the timing of certain kinds of computer operation. Alert signals are extremely useful for indication of operator requests, causing prompt response to queries or modifications of console displays. If two or more occur simultaneously, the resulting interrupts are processed in a specifiable order or priority.

FUTURE PLANS

Plans include a new 32,000 word memory, word length up to 48 bits, optional, and automatic floating point.

SCRIBE

Scoring and Data Transcription Computer

MANUFACTURER

United Aircraft Corporation
Norden Division

APPLICATIONS

Manufacturer

System is used for special purpose data processing and off-line scoring and transcription, with general applications to topologically equivalent systems.

Educational Testing Service

Located at Princeton, New Jersey, the SCRIBE consists of a paper handler and mark-sensing unit, a processing unit and a card punch. It is designed primarily for the processing of test answer sheets. As a data processor and transcriber, it processes up to 2,240 pencil marks on one side of one 8 1/2" x 11" sheet of paper onto one punched card at the rate of 100 sheets per minute.

PROGRAMMING AND NUMERICAL SYSTEM

Manufacturer

Internal number system	Binary Coded Decimal
Decimal digits/word	Variable
Binary digits/instruction	5
Instructions per word	Variable 1 to 3
Instructions decoded	15
A single bit adder is used.	
Instruction type	One address
Number range	0 - 999
Instruction word format is variable.	

A wired program interpreting core memory is used. The equipment is a special purpose data processor used mainly for the scoring and transcription of answer sheets. It can be used for other topologically

Photo by Educational Testing Service

equivalent documents. It is programmed by scanning an array sheet which is marked in accordance with the identification instructions and their addresses. A drum memory with 24 answer keys is used for automatically scoring as many as 6 different keys indicated on an answer sheet.

ARITHMETIC UNIT

Manufacturer

Construction (Arithmetic unit only)

Transistors and diodes are used in a single bit adder.

Arithmetic mode	Serial
Timing	Synchronous
Operation	Sequential

STORAGE

Manufacturer

Media	No. of Words	No. of Bits	Access Microsec
Core	600	17	14
Drum	784	40	17,000

The drum memory also contains two 480-bit recirculating registers for output buffering to card punch.

INPUT

Manufacturer
Medium Speed
8 1/2 x 11 inch Sheet 100 sheets/min
(2240 marking positions)
The sheet is arranged into 40 positions per row and a maximum of 56 rows. The row arrangement is 8 groups of positions.

OUTPUT

Manufacturer
Medium Speed
Punched Card (80 column) 100 cards/min
Parallel card punch speed synchronous with input.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Diodes	
1N770	Approximately 5,000
et al	
Transistors	
2N317	
2N388	
2N404	
2N426	
and others	
Total	Approximately 3,500
Magnetic Cores	10,800

There are a few vacuum tubes (110) in the system for voltage reference plus the photomultiplier tubes used for sensing.

CHECKING FEATURES

Manufacturer
Checking features include many built in routines plus parity check on magnetic core memory.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Manufacturer	
KVA, System	3 KVA
Volume, System	250 cu ft
Area, System	50 sq ft
Floor loading	86 lbs/sq ft
Weight, System	4,300 lbs

Air conditioned at 60° - 95°F
Relative humidity at 20% - 60%.
208 V, 3 phase, 60 cps

PERSONNEL REQUIREMENTS

Manufacturer	One 8-Hour Shift	Two 8-Hour Shifts
Operators	1	2
Engineers	1	1
Technicians	1	2
In-Output Oper	1	2

Training made available by the manufacturer to the user includes training to suit users requirements.

ADDITIONAL FEATURES AND REMARKS

Manufacturer
Provides mark sensing capabilities of most intense mark in a group plus ability to provide for variations in background level. Includes printing facility for identifying sheets in alternate stack. System has a capability of scoring mixed answer sheets of different tests.

Educational Testing Service
Outstanding features include sensing of marks by reflected light, extensive automatic checking, and stored-program processing.
Unique system advantages include the ability to use any of 24 distinct scoring keys during one scoring run, the ability to process positionally coded information, and the ability to shunt certain sheets aside for separate processing.

INSTALLATIONS

Educational Testing Service
20 Nassau Street
Princeton, New Jersey

SEAC

Standards Electronic Automatic Computer
General Purpose Scientific Calculator

MANUFACTURER

National Bureau of Standards
U. S. Department of Commerce

APPLICATIONS

General data processing, scientific calculation and engineering development. Man-machine systems studies in conjunction with analog computer.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits per word	44 plus sign
Binary digits per instruction	45
Instructions per word	1
Instructions decoded	16
Instructions used	16 + 2 optional (switch)
Arithmetic system	Fixed point
Instruction type	Three or four address (switch)
Number range	$-(4 \cdot 2^{-42})$ to $+(4 \cdot 2^{-42})$

Picture by National Bureau of Standards

Instruction word format

4 Ad- dress	10 bits α	10 bits β	10 bits γ	10 bits δ	4 bits opera- tion	1 bit sign
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3 Ad- dress	12 bits α	12 bits β	12 bits γ	4 bits counters	4 bits opera- tion	1 bit sign
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In 3 address operation instruction sequencing is done by 2 counters which are independently sequenced by bits in the instruction. Relative programming can thus be accomplished.

ARITHMETIC UNIT

	Incl. Stor. Access Microsec.	Exclud. Stor. Access Microsec.
Add time	192 - 1,540	48
Mult time	2,300 - 3,650	2,112
Div time	2,300 - 3,650	2,112

Construction 1200 Germanium diodes, 80 delay lines, 60 pulse transformers, 61 vacuum tubes.

Rapid access word registers	3
Basic pulse repetition rate	1 Megacycle/sec
Arithmetic mode	Serial
Timing	Synchronous
Operation	Sequential

Operation time varies with memory being used.
Acoustic and electrostatic memory may be used together in computer.

STORAGE

Media	Words	Digits	Microsec Access
Acoustic (Mercury)	1,024	46,080	216 (avg)
Electrostatic (CRT)	1,024	46,080	12
Magnetic Tape	24,000	52 x 24 x 10 ³	bits/unit
No. of units that can be connected		5 Units	
No. of chars per linear inch		260 Chars/inch	
Channels or tracks on the tape		7 Tracks/tape	
Blank tape separating each record		0.75 Inches	
Tape speed		37.5 Inches/sec	
Transfer rate		104 Chars/sec	
Start time		0.5 Millisec	
Stop time		0.5 Millisec	

Picture by National Bureau of Standards

Physical properties of tape

Width	.5 Inches
Length of reel	3600 Feet
Composition	Mylar - 1 Mil

Multi-channel tape system is under construction.

INPUT

Media	Speed
Keyboard (Flexowriter)	Manual (Max 10 char/sec)
Paper Tape (Flexowriter)	10 char/sec
Paper Tape (Potter)	150/600 char/sec (Photoelectric)
Magnetic Wire (Pierce)	65 words/sec (New unit)
Magnetic Tape	135 words/sec (Single Channel)
Magnetic Tape	4,500 words/sec (Multichannel)
Punched Card	330 char/sec

OUTPUT

Media	Speed
Printer (Flexowriter)	10 char/sec
Paper Tape (Flexowriter)	10 char/sec
Paper Tape (Teletype)	58 char/sec
Paper Tape (Soroban)	240 char/sec
Magnetic Wire (Pierce)	65 words/sec
Magnetic Tape	135 words/sec
Magnetic Tape	4,500 words/sec

Input-output word lengths are single word, 8 words, or variable block up to capacity of memory with single instruction.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Tubes	
6AN5	1,625
6AK5	256
Misc	400 (approx)

Approximately 45 tube types, including power supplies, etc.

Diodes	
Germanium	24,000 (approx)
Several types	
Delay lines	850 (approx)

CHECKING FEATURES

Fixed
Parity check for acoustic storage.
Parity check for electrostatic storage.

Optional
"AUTOMONITOR" - Order by order and breakpoint monitoring of program progress available to operator by console switch setting. Address in memory, instruction being performed and its result may be printed on Flexowriter, punched paper tape, magnetic wire or tape automatically.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	25 KVA
Power, air conditioner	5.76 Kw 7.2 KVA 0.80 pf
Volume, computer	680 cu ft
Area, computer	85 sq ft
Volume, air conditioner	77 cu ft
Area, air conditioner	17 sq ft
Weight, computer	3,000 lbs (Central Machine)
Weight, air conditioner	1,500 lbs.

Dimensions of computer are 5 x 17 ft. Air conditioner measures 77 x 31 x 56 inches. Floor space for computer control console, memories and auxiliaries is 1,386 sq. ft. Floor space for air conditioner and power supplies is 225 sq. ft.

PRODUCTION RECORD

Number produced to date	1
Number in current operation	1

PERSONNEL REQUIREMENTS

Since SEAC is being used as a research tool rather than for computation, it is not used on a regularly scheduled basis. Training of programmers is done internally within the user groups. Available only to Government agencies.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Average error-free running period	3 hours
Good time	4,877 hours
Attempted to run time	5,786 hours
Operating ratio (Good/Attempted to run)	0.83
Figures based on period	26 Aug. 55 to 14 Sep. 56
Acceptance test	May 1950

The above figures are for system reliability and include the SEAC and all its auxiliary equipments.

Basic building block is well-designed pulse repeater stage of excellent reliability. Plug in pulse transformers, gating diodes and electrical delay lines simplify maintenance problems. Heat producing elements are mounted on same side of vertical chassis in cooled airstream. All signals are ready accessible for oscilloscope monitoring.

When computer was in operation 20 hrs/day, 7 days a week, with 4 hrs. for preventive maintenance, high speed circuitry was approximately 95% reliable. Overall system 85% - 95%. Computer is now 10 years old and with reduced demands and maintenance staff this figure must be de-rated somewhat.

ADDITIONAL FEATURES AND REMARKS

Outstanding features include a variety of auxiliary devices, automonitoring of program, ease of "talking" with the machine, and two counter registers which may be used for program sequencing and address base numbers. See DYSEAC also.

FUTURE PLANS

Possibility exists for adding 1,024 words of acoustic delay line memory to be used as parallel access memory for activating display devices. In combination with the existing machine features this will greatly aid continuing work in character recognition studies.

INSTALLATIONS

National Bureau of Standards
U. S. Department of Commerce, Washington 25, D. C.

SPEC

SPEC Mark III Computing System

MANUFACTURER

Computer Control Company, Incorporated

Front

Photo by Computer Control Company, Inc.

APPLICATIONS

System is designed and used for teaching machine operation and basic programming techniques, teaching logical design, general purpose computation, the solution of differential equations, and for the rapid implementation of special logical systems.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	13
Binary digits/instruction	13
Instructions per word	One
Instructions decoded	8
Arithmetic system	Fixed point
Instruction type	One address
Number range	- 4095 to + 4095

Photo by Computer Control Company, Inc.

Instruction word format

13	12 11	10	4	3	1
Sign	Unused	Address		Operation Code	

The above information applies to SPEC as a general purpose computer. As a digital differential analyser, SPEC has 20 integrators, a 21 bit word length, and is a binary, stored program machine.

ARITHMETIC UNIT

	Incl Stor Access Microsec	Exclud Stor Access Microsec
Add	221	13
Arithmetic mode	Serial	
Timing	Synchronous	
Operation	Sequential	

STORAGE

Media	No. of Words	No. of Bin Digits	Access Microsec
Magnetostrictive Delay Line	128 (GPC)	13	208 (Avg)
Magnetostrictive Delay Line	20 (DDA)	21	

GPC - General Purpose Computer

DDA - Digital Differential Analyzer

Four 416-bit delay lines are available, in which words of almost any length may be stored merely by making appropriate changes in the logical wiring.

INPUT

Octal Keyboard. Speed depends on operator's skill. System input is adaptable to punched paper tape input.

Rear

Photo by Computer Control Company, Inc.

OUTPUT

Media	Speed
Register Indicator Lights For both GFC and DDA	
Analog Output (for plotter) DDA only	
Digital Output (incremental for plotter) DDA only	Up to 200 points/sec

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Diodes	1,617
Transistors	279

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	0.06 Kw
Volume, computer	19 cu ft
Area, computer	4.52 sq ft
Floor loading	68.5 lbs/sq ft
Weight, computer	77.5 lbs concen max 310 lbs

PRODUCTION RECORD

Number produced to date	1
Number in current operation	0
Number in current production	4
Number on order	4
Time required for delivery	3 months
Four are on order to Redstone Arsenal	

SPEC

COST, PRICE AND RENTAL RATES

Mark I Model	\$17,695.00
Mark II Model	19,195.00
Mark III Model	24,895.00

INSTALLATIONS

Computer Control Company, Inc.
Western Division
2251 Barry Avenue
Los Angeles 64, California

Redstone Arsenal
Huntsville, Alabama

ADDITIONAL FEATURES AND REMARKS

The entire logical wiring is on removable patchboard, which facilitates quick change from general purpose computer to digital differential analyzer or utilization for logical implementation. The system allows the student or user complete freedom in logical design study without any possibility of equipment damage due to incorrect wiring.

The SPEC (stored program educational computer) is available in three models:

- Mark I - General purpose computer only
- Mark II - Digital differential analyzer only
- Mark III - General purpose computer, digital differential analyzer, universal logic implementer.

Only Mark III has logical wiring on patchboard and may be converted from GPC to DDA merely by interchanging two prewired patchboards. Other arrangements of components may be accomplished by appropriate wiring of other patchboards. Components of SPEC are Computer Control Company's standard plug-in digital modules.

STORED PROGRAM DDA MANUFACTURER

Stored Program Digital Differential Analyzer

International Business Machines Corporation
Federal Systems Division

APPLICATIONS

Computing system is used for missile guidance and the simulation of complex weapons systems by a real-time tie-in to an IBM 704 E. D. P. M.

Photo by International Business Machines Corporation,
Federal Systems Division

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	nominally 22 bits
Binary digits/instruction	4
Instructions per word	5
Instructions decoded	365 (16 basic)
Arithmetic system	Fixed point
Instruction type	Transfer direction - "To" and "From"

Instruction word format

"From" Word	1	2	3	4	19	20	21	22
"To" Word										
	Instruction Word Lengths								Two Bit Word Control	

The organization of the computer will allow various trade-off possibilities between number of integrators, accuracy and solution rates. For example, a solution rate of approximately 33,000 iterations per second can be achieved in generating a sine¹⁵ cosine function with an accuracy of 1 part in 2¹⁵. On the other hand, a problem requiring 300 integrations with the same accuracy can be solved at a rate of 220 iterations per second. Program is defined as for an IBM 704 System.

ARITHMETIC UNIT

Integration	22 Microseconds
Arithmetic mode	Serial
Timing	Synchronous
Operation	Sequential
Nominal standard mode	
Iteration Rate	623 Solutions/sec
Capacity	73 Integrators (w/22 bit words)
Bit Rate	1 megacycle

Arithmetic mode can be selected to operate in a standard mode. Rate mode (623/21 x 2^N iterations/sec) or Number Mode (21 x 2^N), where 0 ≤ N ≤ 5.

STORAGE

Medium	No. of Words	No. of Digits	Access Microsec
Magnetostrictive	219	3,358	22
Delay Line			

INPUT

Media	Speed
Toggle Switches	
Cards (IBM 402)	240 words/sec
I/O Register	625 words/sec

The I/O Register is used with Tie-in to the IBM 704 EDPM. Automatic programming by the IBM 704 EDPM can be coded into cards which can be loaded into the DDA via the card feed unit.

OUTPUT

Media	Speed
Pulse Motor	40 pulses/sec (bidirectional)
Neon Lights	(For online checks)
I/O Register	625 words/sec (DC Analog Computer)
Pulse Motor	240 pulses/sec (Omni-directional)

The I/O Register is used with Tie-in to an D-C Analog Computer to provide an analog display on an X-Y coordinate Variplotter, and/or in a solution to a simulation problem requiring both analog and digital computations. Neon lights are used for digital display. Pulse motors are used as direct outputs from the DDA computer, which, in turn, can be used to control potentiometer settings for control of an analog plant.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
DDA System	
Diodes	886 (T-16G Germanium)
Transistors	309 (Microalloy Drift Germanium)
Control Unit for 704 Tie-in	
Transistors	400 (MADT)
Diodes	30 (GE 396)
Diodes	1,133 (T16G)
Total Components (with 704 Tie-in)	
DDA Computer	3,114
704 Tie-in Control Unit	4,675
Control Unit for ASM application	
Transistors	220 (MADT)
Diodes	504 (T16G)

Circuits have been packaged for ground base military operation or airborne applications using either germanium or silicon transistors.

CHECKING FEATURES

Manual operation in observing results of simulated problem is possible for performing checking operations. Checks are visual - sine-cosine generation, problem reversal, and pre-computed accuracy at a given time from a reference.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	0.029 Kw
Volume, computer	0.73 cu ft
Area, computer	0.75 sq ft
Weight, computer	30.5 lbs

PRODUCTION RECORD

Number produced to date	1
Number in current operation	1
Time required for delivery	4 months

PERSONNEL REQUIREMENTS

	One 8-Hour Shift
Programmers	1/4 - 1
Technicians	1/2

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Circuit designs include, 100,000 hour reliability, noise rejection (33% to 40% of signal), environmental tests Mil-E-S272-A and radiation tests (integrated flux ≈ 3 x 10¹³ neutrons/cm²). Packaging techniques include welded encapsulated modules, cube pack, and printed circuit cards. The estimated Mean-Time between Failures (EMT) is 2,855 hours.

ADDITIONAL FEATURES AND REMARKS

Outstanding features include a variable solution rate mode. Unique system advantages include automatic 704 programming and computer flexibility for binary or ternary increment transfer. Tie-in to IBM 704 EDPM and D-C Analog computer will provide problem solutions requiring both full value and incremental techniques, and permit investigation of computer communications.

FUTURE PLANS

Plans include an increase in speed and a reduction of circuit costs by a factor of 3.

SWAC

NBS Western Automatic Computer

MANUFACTURER

National Bureau of Standards

APPLICATIONS

General purpose scientific computation, research in numerical analysis computing methods.

The National Bureau of Standards Western Automatic Computer (Originally the "Zephyr", known as SWAC).

A medium-sized, high-speed computer with 256 word electrostatic (Williams type) memory, and an 8,192 word drum storage. The machine is described in the IRE, Proceedings, Computer Issue, 1953.

Some applications of SWAC includes the study of discrete variable problems. The use of diffuse surface optical model of the nucleus in the analysis of elastic scattering of charged particles by complex nuclei. The analysis of the crystalline structure of vitamin B12. Determination of many of the larger prime numbers. Valuable work on semi-groups, traffic simulation, the growth of cloud drops, counter gradient methods, queueing theory, and on correlation and factor analysis in psychology.

The SWAC is used as a training tool and as a prototype for computer study in courses of the UCIA curriculum. Its increased use as a data translator is contemplated if the University acquires another high

Photo by National Bureau of Standards

speed computer. Some data conversion is now done on SWAC in connection with problems to be solved on the WDPC 709 computer, operated on campus under the direction of the Department of Business Administration.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	37 incl. sign
Binary digits/instruction	36
Instructions/word	1
Instructions decoded	13
Instructions used	13
Arithmetic system	Fixed point
Instruction type	Four address
Number range	$-(1 - 2^{-36})$ to $+(1 - 2^{-36})$

Binary point lies between sign and most significant digit. Arithmetic is done with absolute value and sign. The fourth address controls an optional jump and selects the auxiliary devices.

ARITHMETIC UNIT

	Incl Stor Access Microsec	Exclud Stor Access Microsec
Add	64	5.3
Mult	368	296
Div	Not a logical operation	
Construction	9 tubes/register	
Rapid access word registers	3	
Basic pulse repetition rate	125 Kc/sec	
Arithmetic mode	Parallel	
Timing	Synchronous	
Operation	Sequential	

Auxiliary equipment asynchronous, computer halts and waits for signal. The storage access time includes the 4th address reference. There are 37 parallel registers in the arithmetic unit (three input adders). System uses simultaneous carry and static storage of the addend and the augend. Germanium diodes (semi-conductors) for logical "and" and "or" circuitry.

STORAGE

Media	No. of Words	No. of Digits	Access Microsec
Electrostatic (CRT)	256	9,984	8
Magnetic Drum	8,192	311,296	17,000

The regeneration time on the electrostatic storage unit is 8 microseconds. The drum access time is given for a 64-word block transfer. The drum transfers in blocks of 64, 32, 16 or 8 words. Average time of transfer for less than a 64 word block is 13,000 microseconds. A magnetic core memory of 512 words has been built to replace the present 256-word electrostatic store, and it is currently planned to attach two magnetic tape units of 150 inch/second read-record speed.

INPUT

Media	Speed
Punched Cards (IBM)	240 cards/min
Keyboard	Manual

Eleven words may be punched on each card. The keyboard is adapted for code checking. Peripheral equipment includes IBM punched card reader, card punch, and EAM printer, for on-line use, and a typewriter. The usual card preparation equipment forms part of the installation.

OUTPUT

Media	Speed
Punched Cards	100 cards/min
Tabulator (IBM 402)	80 lines/min
Typewriter	30 words/min

Twenty-four words per card may be punched on output. The tabulator is a decimal output device, printing 72 characters per line.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Tubes	2,500
Crystal diodes	4,000

CHECKING FEATURES

Fixed
No interlocks or transfer checks are used.

Optional

Parity check on drum transfers is controlled by a toggle switch. Breakpoints may be stored on non-commands to halt machine when loss of control occurs.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	30 - 35 Kw
Power, air conditioner	20 HP
Capacity, air conditioner	Two 10-Ton units and a 5,000 cu ft/min fan

PRODUCTION RECORD

Number produced	1
Number operating	1

COST, PRICE AND RENTAL RATES

Approximate cost of basic system	\$400,000
Rental rates for additional equipment	
IBM equipment	\$750/month

The rental charge for use of the computer and auxiliary equipment is \$40/hour. The rental rate does not apply to use of peripheral equipment when not connected to the computer. Such additional use is free.

PERSONNEL REQUIREMENTS

The personnel requirements for maintenance consist of one full time supervisor, one full time principal electronics technician, and two half-time technicians recruited from the students.

The programming is done mostly by the users of the machine, in "open-shop" style, but there are a programming supervisor, one full time, and one half-time systems programmers.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Average error-free running period	25 Minutes
Good time	796 Hours
Attempted to run time	938 Hours
Operating ratio (Good/Attempted to run time)	0.85
Figures based on period	1 Apr 56 to 30 Jun 56
Passed Customer Acceptance Test	Mar 51

ADDITIONAL FEATURES AND REMARKS

The SWAC was moved during the period from September 1959 to June 1960, from quarters in a temporary building to a permanent site in one of the Engineering buildings on campus. While the move was underway modernization of the power equipment was undertaken, primarily to replace obsolescent equipment with new. The console was modernized with the addition of a portable keyboard permitting remote operation of the computer for instructional purposes. The drum, which had been in operation since January 1956, was rebuilt with new bearings, and the surface turned down. A new air-conditioning plant was installed. The computer was debugged by September 1, 1960, and has been operating regularly since that date. Its reliability is better than before the move, but by how much will have to be determined by the performance records of the next few months.

INSTALLATIONS

Department of Mathematics, Numerical Analysis Research
University of California
Los Angeles 24, California
(Sponsored by: Office of Naval Research and Office of Ordnance Research)

SYLVANIA S 9400

Sylvania Model S9400 ADFS

MANUFACTURER

Sylvania Electric Products, Incorporated

APPLICATIONS

The Sylvania 9400 Data Processing System has been designed as a general purpose computing system with built-in real time applications ability. The computer is capable of handling the largest of the commercial type data processing problems and is equally at home when working on the most sophisticated scientific problems.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	37
Binary digits/instruction	37
Instructions per word	1
Instructions decoded	64
Arithmetic system	Fixed and floating point
Instruction type	Modified single address
Number range	- $2^{242} + 2^{255}$ - 1×2^{-256} + 1×2^{-256} + ($2^{242} - 2^{255}$)

Instruction word format

OP	1	M	A
1 6	7 9	10 21	22 36

Automatic built-in subroutines include clear memory.

Automatic coding includes COBAL, ALGOL, 94AP.

Registers and B-boxes

Arithmetic Registers

Accumulator

B Auxiliary Register of the Arithmetic Unit

Q Used during multiplication and division

P/C Program Counter to count steps of Program

P/C facilities return from sub-routines

Index Registers

Instruction Register

Address Register

X Register

G Register

Error Alarm Register

Real Time In

Real Time Out

Control Register

Decoder Register

ARITHMETIC UNIT

	Incl Stor Access Microsec	Exclud Stor Access Microsec
Add	8	4
Mult	43	39
Div	44	40

Construction (Arithmetic unit only)

Vacuum-tubes	None
Transistors	13,507
Condenser-diodes	5,565

STORAGE

Media	No. of Words	No. of Bin/Dig	Access Microsec
Magnetic Cores	32,768	38	4
Random Access Disc	6,000,000		200,000

Magnetic Tape

No. of units that can be connected	64	Units
No. of char/linear inch of tape	600	A/N Char/inch
Channels or tracks on the tape	16	Tracks/tape
Blank tape separating each record	1	Inch
Tape speed	150	Inches/sec
Transfer rate	90KC	A/N Char/sec
Start time	3	Millisec
Stop time	1.5	Millisec
Average time for experienced operator to change reel of tape	45	Seconds

Physical properties of tape

Width	1	Inch
Length of reel	3,600	Feet
Composition		Mylar

INPUT

Media	Speed
Magnetic Tape	90,000 char/sec
Card Reader	2,000 char/min
Paper Tape	270 char/sec
Real time	120,000 char/sec

OUTPUT

Media	Speed
Typewriter	10 char/sec
Magnetic Tape	90,000 char/sec
Paper Tape Punch	100 char/sec
Card Punch	250 char/min
Printer	900 lines/min
	120 char/line
	64 printing characters

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	None	
Tubes	None	
Diodes	2,000	Varies depending on system configuration
Transistors	36,000	Varies depending on system configuration
Magnetic cores	1,319,920	This includes buffers for I/O devices.

CHECKING FEATURES

Internal parity
Marginal checking capabilities

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer 20 KVA 0.9 pf
 Volume, computer 2,220 cu ft
 Volume, air condi 150 cu ft
 Area, computer 360 sq ft
 Area, air conditioner 15 sq ft
 Room size, computer 1,200 sq ft
 Room size, air condi 30 sq ft
 Floor loading 175 lbs/sq ft
 1,000 lbs concen max
 Capacity, air conditi 10 Tons
 Weight, computer 21,825 lbs

Minimum preparation is required for the system. It is desirable to install a raised floor to allow the cables to be buried out of the way. The S-9400 operates on 208 volt, three phase, 4 wire, 60 cycle power supply. Line voltages must be maintained plus or minus 10%.

PRODUCTION RECORD

Number produced to date 1
 Number in current operation 1
 Number in current production 4
 Number on order 2
 Time required for delivery 12 months

Training of programming analysts and operators provided, either at manufacturer's training center or at customer's installation.

This system has entered system tests.

COST, PRICE AND RENTAL RATES

Description	Model No.	Monthly Rental	Purchase Price	Monthly Maintenance
ON-LINE SYSTEM UNITS				
Central Processor Includes	9401	\$16,500	\$825,000	\$1,110
Arithmetic and Control Unit				
Console and Output Typewriter				
Floating Point				
Power Supply				
32,768 Word Memory	9432	12,500	625,000	633
16,384 Word Memory	9416	9,400	470,000	475
Input-Output Processor	9410	2,750	137,500	140
Magnetic Tape Unit	9490	950	47,500	185
High-Speed On-Line Printer and Buffer	9440	3,200	160,000	610
Disc Storage Unit & Buffer:				
20 Million Char. One Address Register	9452	5,640	282,000	1,340
80 Million Char. One Address Register	9453	6,800	340,000	1,750
20 Million Char. Three Address Registers	9450	6,720	336,000	1,340
80 Million Char. Three Address Registers	9451	8,840	442,000	1,750
Card Reader Punch & Buffer 100-100 cpm	9481	850	42,500	90
Card Reader Punch & Buffer 800-250 cpm	9482	2,250	112,500	380
High-Speed Card Reader & Buffer 2000 cpm	9486	2,400	120,000	550
Paper Tape Reader & Punch System	9460	1,200	60,000	276
Real Time System	9415	760	38,000	50
OFF-LINE SYSTEMS				
High-Speed Paper Tape to Magnetic Tape System Includes:	9465	4,140	207,000	925
Magnetic Tape Unit				
Buffer & Control Unit				
2 Paper Tape Readers (1000 cps)				
High-Speed Off-Line Printer System Includes:	9445	5,750	287,500	1,195
Magnetic Tape Unit				
Buffer & Control Unit				
High-Speed Printer				
High-Speed Card to Magnetic Tape System Includes:	9485	5,200	260,000	1,135
High-Speed Card Reader (2000 cpm)				
Buffer & Control Unit				
Magnetic Tape Unit				

ADDITIONAL FEATURES AND REMARKS

Outstanding features are functional modularity, moderate size, low power and air conditioning requirements, high speed, flexibility, real time, the ability to work with a large number and a wide variety of I/O devices, scatter read/write, and read tape reverse.

Large computer systems such as this one are seldom

duplicated from one installation to another. Individual problems and applications require unique configurations and special features that establish either purchase or lease price. Upon completion of a feasibility study, when the requirements are known along with a calculated growth, costs could be determined.

SYLVANIA UDOFTT

Sylvania Universal Digital Operational Flight
Trainer Tool

MANUFACTURER

Sylvania Electric Products, Incorporated

APPLICATIONS

Manufacturer

UDOFITT (Universal Digital Operational Flight Trainer, Tool) represents the first application of a high-speed, general purpose digital computer to real-time control of operational flight trainers. Developed by Sylvania under contract with the U. S. Naval Training Device Center, UDOFITT is presently being used as a research tool upon which extensive mathematical investigations relative to real-time simulation will be conducted.

As a joint Navy and Air Force project, the first UDOFITT system has the capability of simulating Navy Sub-Sonic and Air Force Super-Sonic jet aircrafts. To accomplish simulation of actual aircraft flight, UDOFITT consists primarily of three units:

- Stored program digital computer

- Aircraft cockpit mockups

- Instructors' consoles

Through the use of a stored program digital computer, simulation of different aircraft can be accomplished by merely changing the computer program. The exploitation of this flexibility is the key to the realization of the full advantages of digital over analog systems as operational control elements.

Basically, a high speed, general purpose digital

Photo by U. S. Naval Training Device Center

computer, UDOFITT represents an advancement in the design of real-time control computers. Using dual 4096-word random access core memories, the basic order time for UDOFITT is five microseconds with the result that a complete addition, including memory access time, can be accomplished in the five microsecond interval.

Containing actual aircraft controls, the cockpit is connected to the computer portion of UDOFITT so that actuation of the controls and instruments will give the appearance of actual flight.

Consisting primarily of a duplication of the instruments contained in the aircraft cockpit, the instructor's console is used to monitor aircraft performance. It can also be used for the insertion of emergency situations such as engine failure, fires, rough air, and many others.

Developed as a research tool for evaluation and testing of digital computers for flight simulation, UDOFITT is equally adaptable to such simulation functions as space vehicles, submarines and testing of flight dynamics.

A study has been conducted for the U. S. Naval Training Device Center on a transistorized successor to UDOFITT. As a result, future digital computers for real-time control systems may be reduced to 40

cubic feet and may be adapted to either fixed site or vehicular mounted applications.

U. S. Naval Training Device Center
The system, located at the U. S. Naval Training Center, Simulation Computer Lab., 605 Stewart Avenue, Garden City, N. Y., is used for the investigation of the application of high speed digital electronic data processing machines to real time training and simulation problems of the military services. The initial phase concerns the application to the operational flight trainer (flight simulator) problem utilizing the F9F-2 and F100A cockpits and programs. Problems to be considered are the optimum mathematical formula for numerical integration, standardization of programming procedures, trainer maintenance and logistic requirements and human engineering aspects of the equipment and utilization of the equipment. Additional uses involve the application of the system to the real time solution of simulation problems of submarines, surface and space vehicles for analysis and training.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	20 plus sign plus parity check bit
Binary digits/instruction	19 plus parity check
Instructions/word	1
Instructions decoded	28
Arithmetic system	Fixed point
Instruction type	One address
Number range	(1 - 2 ⁻²⁰) to - (1 - 2 ⁻²⁰)

ARITHMETIC UNIT

	Exclud Stor Access
	Microsec
Add time	5
Mult time	10
Div time	105
Construction	
Vacuum tubes and crystal diodes	
Arithmetic mode	Sequential - parallel
Timing	Synchronous
Operation	Sequential

The system utilizes sequential-parallel operation using serial synchronous circuits. Construction of the arithmetic unit is similar to the SEAC System. Employs W.E. type 404A tube. Some transistors are used. A 5 phase clock source is used. Clock rate is 1.2 microseconds.

STORAGE

USN TDC			
Media	No. of Words	No. of Binary Bits	Access Microsec
Instruction Memory	4,095	20	5
Magnetic Core			
Number Memory Magnetic Core	4,094	22	5

The storage system consists of two separate units: 4,094 number words and 4,095 instruction words. Both units require an access time of 5 microseconds while the arithmetic unit is operating on the previous instruction.

INPUT

USN TDC		Speed
Media		
Punched Cards		500 words/min
Analog Input: Gray code shaft converters		10 microsec
Switches (console)		Manual
Discrete Input Switches		5 microsec

Punched cards are used only at start of simulation to load the memories. 64 discrete input switches are available as inputs from the cockpit and instructor's console. Analag and discrete switches are initiated by pilots controls and flight instructor inputs.

OUTPUT

USA TDC		Speed
Media		
Facility for binary printer		
Electric Typewriter		10 lines/min
Analog Output		100 microsec
Discrete Output		5 microsec

Analog and discrete outputs provide voltages to actuate pilots instruments and indicators.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Tubes	1,800
Tube types	3
Crystal diodes	20,000
Magnetic cores	180,224
Transistors	500

Above figures are approximate. A tube type utilized is the 404A.

Separate cabinets 6 (not including A-D conversion equipment)

CHECKING FEATURES

Parity, marginal, overflow, unused order type Slow computation switch and one cycle operation for program check and calibration.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

USN TDC			
Power, computer	24 Kw	30 KVA	0.8 pf
Power, air conditioner		40 KVA	
Volume, computer		1,350 cu ft	
Volume, air conditioner		350 cu ft	
Area, computer		160 sq ft	
Area, air conditioner		50 sq ft	
Room size, computer		30 ft x 40 ft	
Room size, air conditioner		12 ft x 22 ft	
Floor loading		135 lbs/sq ft	
		175 lbs concen max	
Capacity, air conditioner		40 Tons	
Weight, computer	22,000 lbs		
Weight, air conditioner	5,000 lbs		

Conditioned air distribution to computer area. 100 KVA electrical service. Data does not include cockpits and utility power.

PERSONNEL REQUIREMENTS

USN TDC

	One 8-Hour Shift	
	Used	Recommended
Supervisors	1	1
Programmers	.2	2
Engineers	2	2
Technicians		2

Operation tends toward closed shop.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

USN TDC

Average error-free running period 5 - 6 Hours
Good time 32 Hours/Week (Average)
Attempted to run time 33 Hours/Week (Average)
Operating ratio (Good/Attempted to run time) 0.97
Above figures based on period 1 Jan 60 to 1 Apr 60
Passed Customer Acceptance Test 1 Apr 60
Time is available for rent to qualified outside organizations.

Time may be made available to federal or government organizations for the solution of real-time simulation and training problems.

ADDITIONAL FEATURES AND REMARKS

Manufacturer

Ultra high speed is achieved through a novel logical structure. System includes an interval timer of great flexibility for real-time simulation.

USN TDC

The system solves in real time complete aerodynamic, engine and systems equations, in flight and on ground, for either the F9F or the F100A aircraft. A complete solution of the equation in less than 50 milliseconds permits a 20 cycle/second solution.

FUTURE PLANS

USN TDC

Future models to be transistorized and possibly mobilized. Has possibility of simulating more than one cockpit simultaneously.

INSTALLATIONS

U. S. Naval Training Device Center
Port Washington, New York

TARGET INTERCEPT

Target Intercept Computer (TIC)

MANUFACTURER

Remington Rand Univac Division
Sperry Rand Corporation

APPLICATIONS

System is used for missile guidance in real time (on-line), system simulation, data processing, and automatic coding (Autocode).

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system Binary
Binary digits/word 24
Binary digits/instruction 24
Instructions/word 1
Instructions decoded 35
Arithmetic system Fixed point
Instruction type One address
Number range $-1 \leq X < 1$ and, in R Memory
 $0 \leq X < 2^{14}$ (integer addresses)

Instruction word format

Op Code	j	Factor	Operand	Parity	
0	5	6	9	10 23	24

Photo by Remington Rand Univac

Shift Instruction							
Operation Code	J Factor	Not Used	Shift Control	Not Used	Shift Count	Parity	
0	5	6	9	10 11	12 17	18 19 23	24

Automatic built-in subroutines include error checking, system diagnosis, and program sequence control.

Automatic coding includes special Autocode programs.

Registers includes fifteen 15-bit registers, referenced by j factor.

ARITHMETIC UNIT

	Incl Stor Access Microsec	Exclud Stor Access Microsec
Add	10	5
Mult	25	20
Div	45	40

Construction (Arithmetic unit only)
Transistors 6,200 (approx) includes Arithmetic Sequence Control

Arithmetic mode Parallel
 Timing Synchronous
 Operation Concurrent

An overlapping instruction repertoire, plus the ability to simultaneously execute arithmetic and non-arithmetic sequences, causes certain operations in the computer to be concurrent.

STORAGE

Media	No. of Words	No. of Digits	Access Microsec
Permanent (Z) Memory	10,240	25	2.8
Variable (O) Memory	2,048	25	2.2
Reference (R) Memory	15	14	0.9
Real-Time (Z) Memory	48	25	2.8

Magnetic Tape
 No. of units that can be connected 5 Units
 No. of chars/linear inch of tape 200 Chars/inch
 Channels or tracks on the tape 7 Tracks/tape
 Blank tape separating each record 3/4 Inches
 Tape speed 150 Inches/sec
 Transfer rate 30,000 Chars/sec
 Start time 3.9 Millisec
 Stop time 0.7 Millisec
 Average time for experienced operator to change reel of tape 15-30 Seconds
 Physical properties of tape
 Width 0.5 Inches
 Length of reel 2,400 Feet
 Composition 1.5 mil mylar, polyester backing
 Start time Write 4.3 millisec
 Stop time Write 0.7 millisec + 3-8 millisec total start-stop time.
 Start time Read 3.5 millisec
 Stop time Read 0.68 millisec + 7.2 millisec total start-stop time.

In both write and read operations, this 3 millisec-ond interfunction relay must be added to obtain total start stop time.

INPUT

Media	Speed
Flexowriter, Model F1 Automatic Typewriter	8 chars/sec
Ampex FR 307 Magnetic Tape Units	30 KC

Six alphanumeric is equivalent to 1 character.
 Flexowriter and Ampex units are specially adapted.

OUTPUT

Media	Speed
Flexowriter, Model F1 Automatic Typewriter	8 chars/sec
Ampex FR 307 Magnetic Tape Units	30 KC

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Diodes	1,344
1N98	
1N2146	
Transistors	
2N559	20,000
Magnetic Cores	
General Ceramics	
5040-A	37,584

All words and parity in the Permanent (Z) Memory (256,000 digit locations) are stored in alnico magnets that are imbedded in Special Program cards.

CHECKING FEATURES

Program indicates and analyzes all detectable errors. Parity checking on data transfers, address transfers, and word locations. Also checked on overflows, critical commands, timing, program sequences, input/output and operator errors. Routines for extensive exercising and checking can be run at the discretion of the operator.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	2.5 Kw	2.5 KVA	1 pf
Volume, computer		210 cu ft	
Area, computer		69.5 sq ft	
Room size		36 ft x 10.5 ft minimum	
Floor loading		150 lbs/sq ft	
Weight, computer		5,200 lbs	

Installation must meet all normal requirements of cleanliness; a normal working environment is satisfactory for the computers; i.e., its operating range is between 60° and 100°F (16-38°C). Air-conditioning is provided, though not essential; forced-air cooling is the minimum requirement.

PRODUCTION RECORD

Number produced to date	1
Number in current operation	1
Number in current production	1

PERSONNEL REQUIREMENTS

Written publications on description, theory, operation, and maintenance; orientation courses conducted by training department; staff of Field Service Personnel maintain computer at site.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

System features and construction techniques utilized by manufacturer to insure required reliability include:

- Computer isolates and indicates its own failures
- Error routine locates failed modules
- Failures indicated visually
- Non-redundancy of hardware
- Module layout by computer function
- Hardware detection of errors
- Program interpretation of and recovery from errors
- Permanent storage of critical instructions and constants.

ADDITIONAL FEATURES AND REMARKS

Outstanding features include permanent storage of critical instructions and constants, overlapped instruction repertoire, automatic start of next program, interrupt control of scattering and gathering of data, and non-stop transfer of control an errors.

INSTALLATIONS

Remington Rand Univac
 Univac Park
 St. Paul 16, Minnesota

TELEREGISTER MAGNETRONIC BID ASKED MANUFACTURER

Teleregister Magnetronic Bid-Asked Stock
Quotation System

The Teleregister Corporation

APPLICATIONS

Data processing associated with stock exchange bid-asked price quotations

PROGRAMMING AND NUMERICAL SYSTEM

Binary digits per word 24

ARITHMETIC UNIT

Timing Synchronous
Operation Sequential

Five seconds of additional time are required for a transaction when input/output data are transmitted over teletype lines.

STORAGE

A single magnetic drum storage unit is utilized. The drum capacity is 100,000 binary digits. The system is designed to handle a maximum of 8 million average transactions/hour. Relays are used for temporary storage of information.

INPUT

There are 200 special input/output devices located in Toronto, Canada. These are located near the printing mechanisms. For remote locations, special transceivers are utilized to serialize and check data.

OUTPUT

Visual verification of input/output data (response) is possible at the originating input point. Input error or data rejection is immediately signalled to the originating input device. Automatic checking and data verification controls are built into the system.

PRODUCTION RECORD

Number produced to date	1
Number in current operation	1

COST, PRICE AND RENTAL RATES

Cost was dependent upon customer requirements. System was installed but is not being maintained by the manufacturer.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Operating ratio (Good/Attempted to run time) 0.999
The system is operated on line 7 hours/day, 5 days/week.

ADDITIONAL FEATURES AND REMARKS

Special purpose system.
System is operated "on line" with current updating features.
Status reporting feature included.
Control is possible from all input transactions recording locations.
System incorporates remote control of the data processor from input/output stations.
The following is a technical, operational and historical description of the system:

The electronic equipment at the Toronto Stock Exchange represents the first use of electronic digital computer techniques for the storage and dissemination of stock quotations.

In 1937 The Teleregister Corporation installed for the Toronto Exchange an automatic, electro-mechanical system for displaying, storing and disseminating bid-asked prices on the more actively traded stocks. Bid-asked prices, generated at the trading posts on the floor of the Exchange from orders placed on the outside, were transmitted by reporters over an interphone system to keyset operators in the basement of the Exchange building. These keyset operators entered the bid-asked prices into the automatic system. The prices were displayed on electro-mechanical indicator units located at the posts on the floor for the information of the traders at that location. Simultaneously, the same prices were posted on indicators in a "check-board" located in front of the keyset operators.

The system also included a Canadian National Telegraphs network from the common equipment at the Exchange to broker' offices in the Toronto area, who were provided with dial-ticker units. A broker desiring the current bid-asked prices for a particular stock, looked up the three digit code number for the stock in a code-assignment register. When he was ready to dial, he pressed a request button on

his dial set. The operation of this button connected his dialing circuit and ticker line, through the line connecting equipment, to one of 24 transmitters which may be idle at the time. When the connection to the transmitter was completed, a ready lamp lighted on the broker's dial set, telling him that the equipment was ready to receive his dialing. The operation thus far is similar to that of a telephone exchange when the subscriber picks up the hand set and receives a dial tone. The dialed code numbers were stored in the transmitter, which was conditioned to extract the requested bid-asked price from the system's memory.

Up until several years ago the display indicators in the check board served a dual purpose in that they were also used as storage devices or memory units. These indicators were pulse actuated mechanisms which display the digits 1 through 0 and blank, on a 11-position rotatable drum. An indicator was set to display the desired digit by transmitting counted pulses to its winding after it has first been pulsed to its blank display position. In order to respond to a broker's dialed request, the indicators displaying the selected stock prices were actuated by exactly 11 pulses. This would leave the indicators in the same display position as before, but since it was possible to determine the number of pulses required to move each unit from its display position to its blank position, a coded read-out of the stored prices was accomplished. These prices were then automatically sent by one of the 24 transmitters to a ticker at the calling broker's office.

After careful engineering analysis of the problem, it was decided to use electronic techniques and a non-volatile magnetic drum storage to process the 50,000 daily requests which were being received from broker's offices. Since the existing display posting system represented a major capital investment, it was necessary to integrate much of the old electro-mechanical system with the new electronic data processing equipment. This integration presented the major engineering problem, since the electronic components had already been developed and proven in service in an American Airlines reservation system, which processes an inventory of airlines seats in place of stock bid-asked prices. It was also decided to use the old price storage circuitry as a fall-back, so that a manual switch-over system had to be provided.

The magnetic drum storage equipment is time shared between the 24 transmitters and the 6 operators positions by the seeker equipment. The purpose of the operators' positions is to keep the prices displayed at the Exchange and stored on the magnetic drum up to date with the trading. The seeker is a relay switching device which connects the next transmitter or operator's position awaiting access to the drum storage, which is time-shared to all positions. When a transmitter gets access to the storage, the 3-digit code number, dialed by a subscriber and stored in the transmitter, is translated by the selector into the energization of one of 600 single-wire selection leads which were previously used to connect the transmitters to a specific section of the check-board display when that unit was used as the system's memory. In the new system these 600 leads are coded by use of a diode matrix with the position code of the same information on the magnetic drum storage. The output of the diode matrix is connected through drum selection coding relays to the drum connecting relays which, in turn,

select one of 40 channels on the drum. If one of the six operators' positions has been given access to the storage drum, the electronic equipment is used to write the new price information stored on the operators' keyset in the section of the drum selected by one of 100 keys on the operators' keyset.

The magnetic storage unit consists of a solid aluminum billet, eight inches in diameter and fifteen inches high, coated with an iron oxide film about 0.003 inches thick. The drum has capacity for storing approximately two thousand sets of prices, six hundred being the initial usage. Prices are stored in permutation code on the drum coating as positively or negatively magnetized spots, the coding being changed as the prices alter. The drum is divided into circumferential tracks, or channels, each channel providing price storage for twenty-five stocks. The packing factor for this application is approximately 40 bits (or code elements) per inch along the track. A read-record head is mounted over each channel with a clearance of .001 inch from the drum surface. In recording, these heads polarize the magnetic coating as the drum rotates at a speed of 1,450 RPM beneath them, under control of electronic writing and gating circuits which are triggered off as the operators send in new prices. In a reading operation resulting from a broker's dialed request, the selected magnetized spots passing under the read-record head induce positive and negative pulses which are amplified and shaped into usable dynamic pulses.

The electronic equipment is under control of a program unit which is basically divided into seven circuits; starting, function determination, counting, 1 of 25 stock selection, 1 of 6 stock digit selection, read gating and write gating. Counting is in binary code and under control of three permanently magnetized tracks on the drum which are called synchronizing or "clock" tracks. These tracks deliver 1,256 and 600 pulses, respectively, for each revolution of the drum. The clock pulses to the electronic counters of the program unit open electronic gates at the precise instant that the desired storage area on the drum is passing beneath the selected read-record head. There is a reference pulse from the drum which assures that the electronic counting will always start in synchronism with the drum rotation. There are pulses which are used to select one or a combination of the six digits representing a bid-asked price. Since each price digit has a 4 element permutation code, there are $25 \times 6 \times 4$, or a total of 600 storage bits in use on each drum track. The function of the shift registers is to read the amplified serial bid-asked price pulses from the drum and send the price in parallel to the transmitters, 24 elements at a time. In the case of a write operation, the shift registers control serial writing into the drum from parallel price code inputs from the operators' keysets. The electronic equipment contains approximately 400 tubes envelopes, of which about half are Western Electric 396-A twin triodes and the remainder Western Electric 415-A pentodes. A few 6Y6 tubes are used in the drum record circuits. All electronic components are mounted on functional plug-in sub-assemblies, using printed wiring techniques. An open construction is employed for better heat dissipation and lower operating temperature.

INSTALLATIONS

Toronto Stock Exchange
Toronto, Canada

TELEREGISTER MAGNETRONIC INVENTORY CONTROL

Magnetronic Inventory Control System

MANUFACTURER

The Teleregister Corporation

APPLICATIONS

Industrial inventory control
B. F. Goodrich Company, Footwear and Flooring
Division
Finished goods inventory control

PROGRAMMING AND NUMERICAL SYSTEM

Binary digits per word 37

ARITHMETIC UNIT

Construction	Vacuum tubes
Arithmetic mode	Serial
Timing	Synchronous
Operation	Sequential

The time required for the completion of an average transaction from the completion of the input to the answer is 600 milliseconds. The system has a designed maximum capability of handling 6,000,000 average transactions per hour.

The operator has one master control panel for his use. A sub-supervisory control position is located at the data processor.

STORAGE

A single 1,500,000 binary digit capacity magnetic drum is utilized. The number of bits per standard item stored is 37 (comparable to a "word" in general purpose systems). Random access to the drum is possible.

The temporary storage medium is relays.

INPUT

One input/output device is located at the data processor.

One input/output device is located at the printing mechanism.

Paper tape is utilized as an input/output medium.

Electric office machines are controlled and driven by the system.

Punched cards are utilized.

B. F. Goodrich Company, Footwear and Flooring
Division

Tape reader speed is 10 char/sec and tape punch speed is 20 char/sec. A digital display unit is utilized.

OUTPUT

Visual verification of input/output data (response) is possible at the supervisory station.

Input error data rejection is signalled immediately at the supervisory station.

Automatic checking and data verification controls are built into the system.

PRODUCTION RECORD

Number produced to date	1
Number in current operation	1

COST, PRICE AND RENTAL RATES

Prices of this special purpose system are based on customer requirements and are established by negotiation.

System is installed and is maintained by the manufacturer on a service contract basis.

B. F. Goodrich Company, Footwear and Flooring
Division

Approximate cost of basic system was \$300,000.

PERSONNEL REQUIREMENTS

B. F. Goodrich Company, Footwear and Flooring Division	
Daily Operation	One 8-Hour Shift
Engineers	1
Technicians & Operators	3

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

System is installed, operating, and in use. It is operated for 8 hours/day on line and 2 hours/day off line, on a 5 day/week basis.

ADDITIONAL FEATURES AND REMARKS

Special purpose system.

System is operated partially on an on-line basis.

System has combined on-line and off-line operating features.

The supervisory station permits stock status reports to be obtained, utilizing "tailored" functional input/output devices for completing transactions.

B. F. Goodrich Company, Footwear and Flooring
Division

This piece of equipment is of a special purpose nature designed specifically in answer to our finished goods footwear problem. Its outstanding feature is random access to any one of many thousands of separate items of either inventory or sales. An additional feature is the display of inventory or orders on a digital display console, one item at a time.

FUTURE PLANS

B. F. Goodrich Company, Footwear and Flooring
Division

The future expansion of this system depends largely upon its current performance on the job for which it was built. Integration of our branch warehouse will be the next possible application.

INSTALLATIONS

B. F. Goodrich Footwear and Flooring Company
Division of the B. F. Goodrich Company
Watertown 72, Massachusetts

TELEREGISTER TELEFILE MANUFACTURER

Teleregister Telefile Data Processing System

The Teleregister Corporation

Control Console of Telefile Data Processor

Photo by The Teleregister Corporation

APPLICATIONS

Manufacturer

System is performing the following applications:

- Banking Systems - On line - Real Time
- Airlines Reservations - On line - Real Time
- Communications switching On-line Real Time
- Off-line General Purpose Data Processing
- Passenger Record Retrieval - Real Time

These systems are constructed to operate on-line with nation-wide data communications networks consisting of high speed (1000 bit/sec) and low speed (75 bit/sec) facilities. The switching, terminating and transceiver apparatus to equip these networks are provided by the manufacturer.

Society for Savings

Savings accounting and mortgage accounting.

Special Window Machine for Telefile On-line
Savings Bank Accounting System

Photo by The Teleregister Corporation

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system Binary Coded Decimal
 Decimal digits/word one
 Decimal digits/instruction 8
 Instructions per word Digit. Addressable
 Instructions decoded Over 200, depending on system
 Arithmetic system Fixed point
 Variable length fields up to 100 digits.
 Instruction type One address
 Sequential; first four digits can be considered an instruction
 Number range $10^0 - 10^{99}$
 absolute magnitude

Instruction word format

1	2	3	4	5	8
Order	Length of Field		Memory Address		

Automatic built-in subroutines include Automatic Rerun in the event of certain failures and programmable separation of dual system.

Registers include the Accumulator Control (ACR), Memory Control (MCR), Instruction Control (ICR) and Quotient Control (QCR) registers.

All orders are performed by defining field lengths in the core memory. The addressable classification

is digits. Instructions can be performed on from one to a hundred digits per operand.

ARITHMETIC UNIT

Operation	Including Storage Access Time
Time	Microseconds
Add	160 + 16 (No. of augend + addend digits)
Mult	80 + 16 (Sum of product digits)(3 x No. of Multiplier + Multiplicand digits)
Div	80 + 16 (Sum of quotient digits)(No. of digits in dividend)
	Excluding Storage Access Time
	Microseconds
Add	80 + 16 (No. of augend + addend digits)
Construction (Arithmetic unit only)	
Unit consists of transistors, diodes and modular packages.	
Arithmetic mode	Serial by digit, parallel by bit.
Timing	Synchronous
Operation	Sequential

Agent Set is Special Input-Output Device for use
with the Telefile On-line Reservations System
for United Airlines

Photo by The Teleregister Corporation

STORAGE

Media	Dec Digits	Access Microsec
Magnetic Cores	15,000	16
Magnetic Drums	1,050,000/drum	17,000
Discs	15,000,000/assembly	100,000
Magnetic Tape		
No. of units that can be connected		54 Units
No. of chars/linear inch of tape		200 Chars/inch
Channels or tracks on the tape		6 Tracks/tape
Blank tape separating each record		1/2 Inches
Tape speed		150 Inches/sec
Transfer rate	12,000 Chars/sec	
Start time		5 Millisec
Stop time		5 Millisec
Average time for experienced operator to change reel of tape		15 Seconds

Physical properties of tape

Width	1/2 Inches
Length of reel	2,400 Feet
Composition	Mylar sandwich

INPUT OUTPUT

Teleregister systems are primarily on-line rapid access business computing systems. Up to 29 sub-systems can be connected to any single main frame.

The system can consist of any number of processors each acting independently or with any two processors corss checking each other. The systems have been designed to accommodate any conventional input-output media.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Diodes	15,500
Transistors	3,500
Magnetic Cores	50,000 - 75,000

Above applies to a single Central Data Processor (TELEFILE). Similar proportion of diodes and transistors applies to other sub-systems.

CHECKING FEATURES

System has parity checking in and out of the core memory and in and out of any subsystem. Duality cross checks are available between processors and/or drums. Checks may also be programmed.

COST, PRICE AND RENTAL RATES

Prices are available on request. Teleregister has a full scale field-service operation in more than 100 cities in U. S., servicing all installations. This service organization has been in existence for 30 years.

PERSONNEL REQUIREMENTS

Personnel requirements vary with the complexity of any given system application.

Teleregister trains customer personnel at Stamford plant and provides on-site training as long as required.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Teleregister on-line systems have been operating with a record of 99.8% up-time since 1952. They employ duality and built-in controls to maintain this high degree of reliability, coupled with a rigid preventive maintenance program. They have proven on-line capability for 22 hour per day, 7 day per week service.

INSTALLATIONS

Society for Savings
31 Pratt Street
Hartford 1, Connecticut

The Howard Savings Institution
Newark 1, New Jersey

TELEREGISTER UNIFIED AIRLINE

Teleregister Unified Airline Processor

MANUFACTURER

The Teleregister Corporation

Typical Teleregister Unified Airline Data Processing Center

Photo by The Teleregister Corporation

APPLICATIONS

Special purpose, on-line, real-time wired program data processor, designed for inventory applications with a high volume of random, undisciplined, on-demand inquiries and transactions. Approximately 12,000 such transactions can be processed in one hour.

The term "Unified" stems from the unification of design requirements which enabled Teleregister to provide similar systems now in use by TWA, Western, National and Northeast Air Lines. These systems permit the airlines to process requests for reservations very quickly, and have measurably improved load factors and customer relations. A Unified system also handles hotel reservations for the Sheraton Corporation.

Forerunners of the Unified Systems were Teleregister's Magnetronic Reservoirs which have been serving American Airlines since 1952, and a similar system used by Braniff International Airways since 1957. Pan American World Airways and United Air

Lines also use Teleregister systems, and United has ordered a new one (see TELEREGISTER TELEFILE) for installation in the next few months.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system Binary
All logic and programs are wired into the processors by Teleregister. Additional programs and changes in logic are made by the manufacturer on a charge basis at the customer's request.

ARITHMETIC UNIT

	Incl Stor Access	Exclud Stor Access
	Microsec	Microsec
Add	17,010	10

Construction (Arithmetic unit only)
Vacuum-tubes and relays
Arithmetic mode Parallel

Supervisor's console of the TWA Teleregister data processor in the West Side Airlines Terminal, New York. TWA has three of the Teleregister Unified systems with data processors at New York, Chicago and Los Angeles

Photo by The Teleregister Corporation

Timing
Operation

Synchronous
Sequential

Medium
Magnetic Drums

STORAGE

No. of Binary
Digits/Drum
1,300,000

Access
Microsec
17,000

Teleregister Distant Central Office Transceiver (DCOT) at West Side Airlines Terminal is the automatic data message director through which all agent set traffic is channeled to and from the TWA Unified data processor at New York

Photo by The Teleregister Corporation

INPUT

Media	
Keysets	Parallel input
Punched Tape	200 words/min
Teletype	200 words/min

OUTPUT

Media	
Keysets	Parallel output
Punched Tape	200 words/min
Teletype	200 words/min
Printer	100 words/min

The principal input/output device used with the Teleregister Unified Airline Processor is the special purpose agent's keyset. To make an inquiry or initiate an inventory transaction, the agent selects and inserts a patented code plate in a slot in the agent

set. The plate lists a total of 64 flights or segments thereof, but only a single row listing eight flights is visible at the time. On an availability inquiry the processor reply causes a display on the agent set by eight lamps associated with the eight flights listed on the code plate. Four conditions can be shown for each flight, such as lamp on - "open for sale", lamp out - "flight closed", fast flash - "wait list open", and slow flash - "special, check further". Keys on the agent set are used to designate month, date, and number of persons in the party, and one of ten command keys is used to initiate the call. Besides availability inquiries and sell and cancel transactions, the command keys include requests for departing a arriving flight information and the print out at the processor location of wait list requests.

There are approximately 800 keysets of the unified type, shown in the photograph, in use. They are compatible with the 600 keysets of the earlier "Reservisor" type.

Human engineering principles contributed to the design to give accuracy and speed in use. The code

TWA ticket agent using a Teleregister agent set to check availability for customer. Over 1000 similar agent sets are in operation for 8 major airlines.

plate eliminates the keying in of flight numbers and gives a positive reference for all replies. The set is rugged and compact.

The processors include a teletype message editor, which scans incoming messages for data on seats sold or canceled. When the editor finds a transaction affecting inventory, it bids for the processor and passes on the data so that inventory is updated.

Similarly, when variable inventory control levels are reached, teletype status messages are automatically generated and transmitted to the interested stations.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Tubes	4,500
Diodes	3,000

Quantities dual processors and teletype translator at central location.

Photo by The Teleregister Corporation

CHECKING FEATURES

Checking features include checks on magnetic drum recording and checks input data codes. Read back check on translation is optional. Also two processors are supplied with each system. They operate in "dual" mode, meaning that they operate simultaneously on the same problem, and cross check each other.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Volume, System	6,400 cu ft
Area, System	800 sq ft
Room size	1,000 sq ft including benches and cabinets
Floor loading	75 lbs/sq ft

Figures are for central equipment, including two processors and typical communications equipment.

All interconnections between processor units are made through overhead ducts. A false ceiling may be used if desired.

Air conditioner is supplied by customer.

PRODUCTION RECORD

Number produced to date	12
Number in current operation	12
Anticipated production rates	Two per year
Time required for delivery	18 months

COST, PRICE AND RENTAL RATES

Price varies with the number of modules required by the application. Attended maintenance for one, two, or three shifts is included in the service contract.

PERSONNEL REQUIREMENTS

One programmer is required.

Training made available by the manufacturer to the user includes training of an initial group in the operation of the agents key set and in the entering of basic data into the processor.

The logic and programs are wired in, therefore the only personnel required for operation, besides the reservation agents, is some one to assign inventory locations to flights and to enter the data that varies with schedule changes.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

System up-time has averaged 99.8%. This degree of reliability, necessary for a on-line, on demand system, is achieved by using dual processors. In the event of an error detected by cross-checking between processors, a test routine is initiated, and if one of the processors is faulty, it is cut out and the other processor carries the load until repair has been accomplished. Many components, such as seekers and communications terminating equipment, are furnished in duplicate for fallback.

ADDITIONAL FEATURES AND REMARKS

The outstanding feature of the Unified Airline Processor is its ability to handle inputs from several hundred remote devices on a random demand basis. Since it is a real-time system, it makes accessible to hundreds of agents current information on seats available, returning cancelled space to inventory immediately.

Reports on inventory, seats sold, status of flights, etc. can be printed out.

A Unified Airline Data Processing System almost always includes communications equipment so that input/output sets may be located at any distance from the central equipment. Agent sets for Tele-register airline systems are located in more than 100 cities in the United States and Canada. For the Unified System, 75 or 100 words per minute telegraph circuits, leased by the customer, are used. Several drops can be located on one circuit through a speedy roll-call feature. Vertical parity checking is used to detect communication errors.

TRICE

Packard Bell Transistorized Real Time Incremental
Computer Expandable

MANUFACTURER

Packard Bell Computer Corporation

APPLICATIONS

The TRICE is a digital differential analyzer capable of solving directly any equations capable of being expressed in differential form at real time speeds. The TRICE may operate independently in the solution of these equations or it may be used with actual hardware or analog computers to perform real time simulation or test. The standard console can be supplied with up to 108 computing modules. Connection to additional consoles is provided for.

The TRICE consists of independent computing modules which, perform the operation of integration, summation and multiplication. These modules are interconnected by means of a removable patch panel to solve differential equations. The TRICE achieves real time speeds by means of a 3 Mc clock frequency and parallel organization. All computing elements operate simultaneously. The iteration rate of the TRICE is 100 KC. This is 1,000 times faster than

Photo by Packard Bell Computer Corporation

any previous DDA.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits per word	26 bits plus sign max.
Arithmetic system	Fixed point
	Incremental, ternary transfer (existence and sign)
	Programmed interconnection of independent computing modules

The TRICE has the following types of independent computing modules:

Integrator	ΔY Summer
Constant Multiplier	Servo
Variable Multiplier	Decision Servo

The TRICE is programmed much the same as an analog computer. The computing modules are connected directly to perform the operations indicated in the equations. This provides a "feel" for the problem and permits very rapid programming. The results of

a change in a problem parameter by the operator can be observed immediately in the form of X-Y plots, time history recordings, or digital readout. Thus the TRICE can be used as a design tool.

ARITHMETIC UNIT

Up to 100,000 iterations per second for all operations, including addition, multiplication and division.

An integrator uses 110 transistors.

Arithmetic mode Serial Incremental, ternary transfer

Timing Synchronous
Operation Sequential and concurrent

Integration can be performed with respect to any variable. The TRICE is not limited to integration with respect to time.

STORAGE

Medium	No. of Words	No. of Digits	Access Microsec
Delay Line (Electromagnetic)	1 word/module	26 bits + sign	10

A patch panel is used for "storage" of the program.

INPUT

Media	Speed
Keyboard	Manual

Either octal or decimal entry is possible.

Paper Tape 60 char/sec

A 108 module machine can be loaded in 30 sec.

A to D Converters Incremental up to 100 KC
Packard Bell Model M-1 standard equipment. Voltage input is from transducers, etc.

OUTPUT

Media	Speed
Registers (Octal or Decimal)	Updated at 100 KC rate

Visual readout of digital information in computing registers

Paper Tape 60 char/sec

Automatic on time basis or at maxima or minima, etc.

D/A Converters Incremental up to 100 KC
Voltage output to X-Y plotters, servo inputs, etc.
PB Model DA-3 standard

The TRICE has a Decimal to Binary - Binary to Decimal converter Scaler which converts to binary and automatically scales decimal information for entry into the machine. The same converter also converts the binary information to decimal for output. An off line automatic typewriter is used to prepare and read the paper tape. Tape can also be prepared from the control panel keyboard.

Any number of analog input and outputs may be handled, through A to D and D to A converters. These inputs and outputs may be from hardware under test or an analog computer.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Tubes	1/module
Diodes	400/module
Transistors	110/module

Above figures are approximate.

The tubes are Ampere indicators for overflow indication. These are the only tubes used in the machine. They are miniature CRT's used for register and overflow indicators.

The TRICE is constructed entirely of solid-state components. The TRICE has been in existence for over two years to date, and has proven to be extremely reliable with very little down time. Low power consumption and freedom from heating problems provide a long operating life. All components are derated by at least 50%.

CHECKING FEATURES

Checking features include automatic halt on overflow. Overflow indicator provided for each module. Digital operation permits a digit-by-digit check against previous runs or against check solutions run of a general purpose computer.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

KVA, computer	1 to 2 KVA
Volume, computer	70 to 108 cu ft
Area, computer	19 to 27 sq ft

PRODUCTION RECORD

Number produced to date	5
Number in current operation	4
Number in current production	1
Number on order	1
Anticipated production rates	3/year
Time required for delivery	6 Months

COST, PRICE AND RENTAL RATES

	Approximate Cost of Component
Console (Control Unit & Patch Bay)	\$ 23,000
Integrator (Max. of 65/console)	2,800 ea
Decision Servo (Max. of 12/console)	2,500 ea
Constant Multipliers (Max. of 30/console)	2,000 ea
Variable Multipliers (Max. of 6/console)	4,000 ea
Delta Y Summers 4 each	2,500 ea
Additional Equipment Cost of Equipment	
Paper Tape Input	\$ 8,000
Paper Tape Output	6,000
Binary Decimal Converter & Scales	10,000
A-D Converters (M-1)	10,000
1 DA-3 in M-1 case	2,500
3 DA-3 in separate case	10,500

PERSONNEL REQUIREMENTS

One operator is required for each 8-hour shift.

Formal training is not required. After reading the programming manual several hours of familiarization with the machine enables anyone with a knowledge of differential equations to program and operate the machine.

ADDITIONAL FEATURES AND REMARKS

A 3 Mc clock plus parallel organization of independent computing modules provide computation at real time speeds formerly ascribed to analog computers but with an order of magnitude greater accuracy and exact repeatability.

Any number of analog channels in and out may be connected to operate with hardware or analog computers at an effective sampling rate of 100 KC/channel.

A Digital/Analog Function Table (DAFT), a digital system for the generation of arbitrary or analytical functions for analog and digital computers, is available. The DAFT is incremental and completely compatible with the TRICE.

UDEC I II III

Unitized Digital Electronic Calculator Models I
II and III

MANUFACTURER

The Burroughs Corporation
Electronic Instrument Division

APPLICATIONS

Scientific computing and commercial data processing

PROGRAMMING AND NUMERICAL SYSTEM

UDEC I

Internal number system	Binary coded decimal
Decimal digits/word	10
Decimal digits/instruction	5
Instructions per word	2
Instructions decoded	34
Instructions used	34
Arithmetic system	Fixed point
Instruction type	One or two address
Number range	$10^{-9} \leq n \leq 10^9$

Program selection permits one- or two-address modes of operation. The decimal point may be manually set at any desired location. Two address operation is optional for optimum programming.

UDEC II III

Internal number system	Excess-three bin coded dec
------------------------	----------------------------

Photo by Burroughs Corporation

Decimal digits/word	9 plus sign digit
Decimal digits/instruction	5
Instructions per word	2
Instructions decoded	40
Instructions used	32
Arithmetic system	Fixed point
Instruction type	One address
Number range	Movable decimal point

Two address word possible if second instruction in each word is unconditional transfer. Each instruction is one half word, i.e. 5 digits. Of these, 3 digits specify address and 2 digits the command.

ARITHMETIC UNIT

UDEC I

	Incl Stor Access Microsec	Exclud Stor Access Microsec
Add time	176-264	88-176
Mult time	4,000	3,912 (avg)
Div time	6,000	5,912 (avg)
Construction		
Vacuum tubes	3,000	
Magnetic cores	320	

Rapid access word registers 2
 Basic pulse repetition rate 125 Kc/sec
 Arithmetic mode Serial-parallel
 Timing Synchronous
 UDEC II III

Exclud Stor Access
 Microsec
 Add time 680
 Mult time 30,000
 Div time 30,000
 Construction Vacuum tubes
 Basic pulse repetition rate 125 Kc/sec
 Arithmetic mode Serio parallel
 Timing Synchronous
 Operation Sequential

STORAGE

UDEC I

Media	Words	Digits	Access Microsec
Magnetic Drum	5,300	53,000	8,000(avg)
Magnetic Cores	100	1,000	88

UDEC II III

Magnetic Core	1,000	20/5 digits	
Magnetic Drum	10,000	8,500(avg)	

53,000 decimal digits total drum storage. Drum information contained in blocks of 200 words for transfer to and from core storage.

INPUT

UDEC I

Media	Speed
Paper Tape (Ferranti Photoelectric)	400 char/sec
Keyboard	Manual

UDEC II III

Paper Tape (Ferranti Photoelectric)	120 char/sec
Paper Tape (Potter magnetic tape handler modified for photoelectric input)	Magnetic Tape (Potter)

OUTPUT

UDEC I

Media	Speed
Printer	6 char/sec
Paper Tape	60 char/sec

UDEC II III

Paper Tape (Teletype) (2)	(5-level) 60 char/sec
Paper Tape (Teletype)	(7-level) 60 char/sec
Magnetic Tape (Potter)	

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

UDEC I

Tubes	3,000
Tube types	8
Crystal diodes	6,000
Magnetic cores	4,700
Separate cabinets	28 standard, 19 in x 7 ft, ea.
Tube types include	6CL6, 5687, 7AK7, 6197, 12AU7, 12AT7, 6BC5, 12BH7.

System is constructed of standard Burroughs pulse control equipment and interconnected with R662U coaxial cable.

UDEC II III

Tubes	3,000
-------	-------

Machine consists of Burroughs Pulse Control Equipment, approximately 600 units in all.

CHECKING FEATURES

UDEC I
 Modulo 3 arithmetic check
 Modulo 3 check on each word transferred to and from storage.
 Forbidden combination multiply and divide check.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

UDEC I

Power, computer	30 Kw	32 KVA
Space, computer	400 sq ft area, floor space	part of machine
Capacity, air condit	Blower-exhaust type	

System arranged in form of an almost closed rectangle.

UDEC II III

Power, computer	33 Kw
Space, computer	31 racks
Capacity, air cond.	15 Tons

PRODUCTION RECORD

Number produced	2 (Incl UDEC I)
Number in current operation	2
Delivery time	6 months

UDEC I located at Wayne University, Detroit, Michigan.
 UDEC II III located at Burroughs Corporation, Philadelphia, Pennsylvania.

COST, PRICE AND RENTAL RATES

UDEC I
 Approximate cost of basic system \$500,000.
 Approximate cost of modifications and additions \$200,000.

UDEC II III
 Approximate cost of basic system \$200,000.
 Additional equipment 100,000.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

UDEC I

Average error-free running period	7 Hours/8 Hour/shift
Good time	8.5 Hours
Attempted to run time	10 Hours
Operating ratio (Good/Attempted to run time)	0.85
Figures based on period	May 53 to Nov 56.
Passed Customer Acceptance Test	Dec 53.

Decimal-binary automatic conversion is utilized.

UDEC II III

Average error-free running period	6 Hours
Operating ratio	0.85
Passed Customer Acceptance Test	Oct 53

ADDITIONAL FEATURES AND REMARKS

UDEC II III
 Burroughs UDEC III is a general modification of UDEC II. UDEC III will consist of Burroughs pulse control equipment which has been used in UDEC II. The basic flexibility of this equipment provides for a maximum of modification with respect to special instructions and special input-output equipment which must be added as required.

INSTALLATIONS

Wayne University (UDEC I)
 Computational Laboratory
 Detroit 1, Michigan

Burroughs Corporation (UDEC II III)
 Electronic Instrument Division
 1209 Vine Street
 Philadelphia, Pennsylvania

APPLICATIONS

Manufacturer

Business and scientific data processing.

Joliet Arsenal, Comptroller, E.A.M. Systems Branch
Located at Joliet Arsenal, Joliet, Illinois, the system is used for civilian payroll, civilian personnel statistics, stock accounting, cost accounting, and procurement accounting.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Biquinary, decimal, and alphabetic
Decimal digits/word	Variable from 1 to 10 digits plus sign
Digits/instruction	Not internally programmed
Arithmetic system	Fixed point, variable
Instruction type	Three address
Number range	Variable

ARITHMETIC UNIT

The timing is synchronous.

The operation is sequential.

One full cycle on the computer requires 400 milliseconds. 75 milliseconds are required for feeding, sensing, and punching the card. 325 remain for calculation. If the calculation requires more than 325 milliseconds, the computer automatically waits until the end of calculation signal has been given before punching, feeding and sensing the next card. Buffering is not used.

The purpose of the electronic computing unit is: To connect card columns for sensing, punching, and reproducing.

To set constant values.

To set the machine for the operations to be performed and the sequence of the operations.

To perform all calculations with an electronic accumulator.

To store the values calculated.

To check each arithmetic step.

To visibly read all elements of all arithmetic steps.

The arithmetic unit uses floating point but storage uses a selected fixed point.

The biquinary code is as follows:

Digits	Biquinary Code
0	0
1	1,0
2	2
3	1,2
4	4
5	1,4
6	6
7	1,6
8	8
9	1,8

Alphabetic characters are wired to become two or three numeric characters at the input level. For example, an A becomes 111, a C becomes 99. See Storage.

Negative numbers are carried as the tens complement of the number. A negative sign indicates that the value is negative instead of positive.

The location of the decimal point is variable and may be arbitrarily assigned to each input and storage location.

There is only one arithmetic register, called the accumulator. It has a capacity of 22 digits. The computation of each program step takes place within the accumulator. For example, an addition would be performed as follows:

- 1) Clear the accumulator
- 2) Enter the first value according to its decimal location.
- 3) Enter the decimal location of the second value.
- 4) Shift the first value to align with the decimal of the second value.
- 5) Enter the second value, performing the process of addition.
- 6) Enter the decimal location of the result storage and shift the result to align with it.
- 7) Place the result in the result storage.
- 8) Subtract value two from the result.
- 9) Subtract value one from the result of 8).
- 10) Check to be certain that the accumulator is zero.

Each step is balanced to zero before the computer continues to the next step. The four possible steps and the method used to check each are:

Step	Proof
Value 1 + Value 2 = Result	Result - Value 2 - Value 1 = 0
Value 1 - Value 2 = Result	Result + Value 2 - Value 1 = 0
Value 1 x Value 2 = Result	Result/Value 2 - Value 1 = 0
Value 1/Value 2 = Result	Result x Value 2 - Value 1 = 0

The computer will not continue unless the step checks to zero.

The computer has automatic decimal alignment. Programs have been developed which use a floating point method, although the computer is operating with automatic alignment.

Scaling may be accomplished by multiplying or dividing the number by a factor, or changing the decimal location by a selector.

An overflow stops the computer.

The remainder is dropped off in the final result, although it is used during the proof of the step.

The round-off of sums, differences, products and quotients depends on the decimal location of the result storage. The accumulator unit has 22 positions, as follows:

M Sections										
1	2	3	4	5	6	7	8	9	10	11
A Sections										
11	10	9	8	7	6	5	4	3	2	1

All results are placed in storage from positions 10-1 of the A Section. Each storage is assigned a decimal location for the program involved. A loca-

tion of $\frac{4}{3}$ would mean that three places are to be retained in the result following the decimal. If the result of any step-addition, subtraction, multiplication, or division contains more places than those allowed in the result storage, the additional digits will be located in the M Section, beginning in column 11. When the result is placed in the storage unit, they are thereby rounded off. Rounding off requires an addition step.

Comparisons are made by two subtraction steps. Each step has two branchings, plus and minus. Zero is always considered plus. The first step of the two value 1 minus value 2. If the result is minus, value 2 is greater than value 1. If the result is plus, value 1 is equal to or greater than value 2. The second step would be value 2 minus value 1. If the result is minus, value 1 is greater than value 2. If the result is plus, value 1 and value 2 are equal.

Control Unit

The computer has no stored program.

The input-output panel indicates the card fields to be sensed, punched and reproduced. The constant program panel indicates the program to be followed, step by step, and the constant value which will be used.

The computer operates on a three address system. Each program step, which is externally wired, contains the following six instructions, in the following form:

V1	Pr	V2 = R - BR + BR
V1		The storage, constant, or card-read field to be used as value 1.
Pr		The process (+, -, x, /)
V2		The storage, constant, or card-read field to be used as value 2.
R		The storage into which the result is to be placed.
-BR		The next step or operational function to be performed if the sign of the result is minus.
+BR		The next step or operational function to be performed if the sign of the result is plus.

Breakpoint stops may be included in the program.

At the plus or minus branching of any step an instruction requiring a division of 0 by 0 or a number by 0 may be given. Both of these steps cause the computer to stop, and a corresponding light is lit.

The electronic computing unit contains a control panel with a dial. Each step may be dialed in turn. For each step value 1, value 2, the result, the process, the branching, all decimal locations and whether the step checks may be read from the panel.

The computer will stop under the following conditions:

- 1) Empty feeding magazine.
- 2) Full receiving magazine or chip pan.
- 3) Sensing of alpha.
- 4) Zero divided by zero.
- 5) Number divided by zero.
- 6) Incorrect voltage.
- 7) Temperature too high.
- 8) Overflow condition on a step.
- 9) Failure to check.

STORAGE

Medium	Words	Digits
Vacuum tube	6	60

The storage system used is biquinary. Each column of storage contains 5 tubes, representing the digits 1, 3, 5, 7, and 9. There is no tube for zero, which is represented by the fact that none of the tubes are lit. An odd digit is represented by the corresponding tube 1, 3, 5, 7, or 9. An even digit is represented by the odd digit which is immediately

lower in value, plus the 9. Therefore, a 2 is 1 plus 9, a 4 is 3 plus 9, a 6 is 5 plus 9 and an 8 is 7 plus 9.

The word length in storage is ten digits (columns) plus sign.

Alphabetic characters require five columns of storage for two characters, three columns for a single character. A single word can therefore contain 4 columns of alphabetic characters as opposed to 10 columns of numeric characters.

Storage is actually part of the computing unit. There is no buffering unit.

INPUT

Medium

Card Sensing-Punching Unit

The purpose of the Card Sensing-Punching unit is to sense and punch tabulating cards and to indicate and control general machine operation.

A maximum of 36 words (card read fields) may be used in one program. Up to 60 digits may be divided as necessary among 36 words. The sign of each field is in addition to the 60 digits.

A 90 column punched card code is used. This is the same biquinary code as is used in the storage unit. All 36 words are sensed simultaneously on one cycle. Five columns are required to sense two columns of alphabetic information; three columns are required to sense one column of alphabetic information.

Joliet Arsenal

Medium	Speed
Cards	150 cards/min

OUTPUT

Medium

Card Sensing-Punching Unit

Joliet Arsenal

Medium	Speed
Cards	150 cards/min

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Card Sensing-Punching Unit

The Card Sensing-Punching Unit measures 2 ft. 11 in. long, 2 ft. 6 in. wide, 5 ft. 9 in. high, and weighs 1,020 lbs. This unit may operate from any of the following power services:

- a) 208 volt single phase, 4 wire, 60 cycles
- b) 230 volt single phase, 3 wire, 60 cycles
- c) 220 volt single phase, 3 wire, 60 cycles
- d) 120 volt three phase, 4 wire, 60 cycles
- e) 220 volt three phase, 3 wire, 60 cycles
- f) 220 volt three phase wye system, 50 cycles.

The Electronic Computing Unit measures 7 ft. 2 in. wide, 2 ft. 6 in. deep, 5 ft. 9 in. high and weighs 2,210 lbs.

The unit operates from the same power sources as the Card Sensing-Punching Unit.

The unit is ventilated by fan forced room air.

Joliet Arsenal

Power, air conditioner	5 Kw	0.90 pf
Volume, computer	145 cu ft	
Volume, air conditioner	31.5 cu ft	
Area, computer	43 sq ft	
Area, air conditioner	4.75 sq ft	
Room size	16 ft x 10 ft 6 in	
Floor loading	80 lbs/sq ft	
Weight, computer	3,230 lbs	
Weight, air conditioner	500 lbs	

COST, PRICE AND RENTAL RATES

Approximate cost of basic system \$75,000.
Rental rate for basic system, standard shift \$690-\$1,050/month.

Second shift operation charge is an additional 50% of the Standard Rate.

Third shift operation charge is an additional 50% of the Standard Rate.

Maintenance, including cost of parts, except due to customer negligence, is included in the rental rates above.

The charge for maintenance to a customer who purchases, rather than leases, but who requires maintenance operations is \$3,750 per year for a machine less than 6 years old and \$4,500 for a machine 6 to 11 years old.

Customer's personnel are trained at no extra charge.

Joliet Arsenal

Basic system rents at \$740.

4 Key punches, 3 tabulators, 1 auto-verifier, 3 summary punches, 1 collator, 2 interpreters, 1 reproducer, and 3 sorters rents at \$2,594/month.

PERSONNEL REQUIREMENTS

Joliet Arsenal

One 8-Hour Shift

Supervisors	3
Programmers	2
Clerks	1
Operators	11

Operation tends toward open shop.

Methods of training used includes formal training furnished by the manufacturer and on-the-job training.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Joliet Arsenal

Good time	15 Hours/Week (Average)
Attempted to run time	18 Hours/Week (Average)

Above figures based on period from Jun 59 to Jun 60
Time is not available for rent to outside organizations.

ADDITIONAL FEATURES AND REMARKS

The Univac 60 and Univac 120 Systems are similar, except with regard to such items as storage capacity, price, rental rate, and service costs.

FUTURE PLANS

Joliet Arsenal

Continuation of improvements and refinement of present applications.

INSTALLATIONS

Joliet Arsenal

Comptroller, E.A.M. Systems Branch
Joliet, Illinois

PRODUCTION RECORD

Total number of Univac 60 and 120 Systems 1,000

UNIVAC 120

Universal Automatic Computer Model 120

MANUFACTURER

Remington Rand Univac
Division of Sperry Rand Corporation

APPLICATIONS

Manufacturer

Business and scientific data processing.

U. S. Bureau of Reclamation

Located at Ephrata, Washington, system is used for the solution of engineering, e.g., earthwork and subdivision of sections, and administrative problems, e.g. irrigation accounts, crop census, land ownership records, payroll, accounts receivable and payable, stock records, personnel roster, and vehicle utilization and costs.

U. S. Army Chemical Corps Proving Ground, Dugway
Located in the Computer Section, Test Design & Analysis Office, the system is used for calculation of results of various chemical and biological field tests, statistical and mathematical analysis of field test results, meteorological research, and cost accounting, payroll, property inventory, and other standard commercial type applications.

U. S. Bureau of Mines

Located at the Central Experiment Station, Bureau of Mines, Pittsburgh 13, Pennsylvania, the system is used in the Computation Laboratory. The Computation Laboratory is an internal service bureau whose facilities are made available to all organizational seg-

Photo by Department of Interior, Bureau of Mines

ments of the Bureau of Mines. These services can be divided into three major categories: technical, statistical and accounting. The technical calculations encompass many areas in the general field of numerical analysis such as determination of curves of best fit, rational approximations of a variety of functions, numerical integration and differentiation, matrix operations, interpolation and the solution of algebraic and transcendental equations. These calculations result from the desire for numerical solutions of some of the problems encountered by technical personnel in the Bureau's programs in combustion, explosive and mineral research, statistical services include those rendered to the film library and distributing group, Coal Analysis Section, and in basic data reduction and correlation studies for some of the Bureau's major canvasses. Accounting services include payroll and cost distribution, property inventory and transactions, and employee personnel records.

AIResearch Manufacturing Company of Arizona
Located at 402 South 36th Street, Phoenix, Arizona, the two systems are used for computation of payroll, earnings to date, accrual of vacation and sick leave hours and money, extension of labor charges and burden, production planning, production parts scheduling, parts issue, accounts payable, inventory accounting,

cost accounting, laboratory facility burden, quality control, and assets depreciation.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Biquinary, decimal, and alphabetic
Decimal digits/word	Variable from 1 to 10 digits plus sign
Number of digits/instruction	Not internally programmed
Arithmetic system	Fixed point, variable
Instruction type	Three address
Number range	Variable

ARITHMETIC UNIT

The timing is synchronous.

The operation is sequential.

One full cycle on the computer requires 400 milliseconds. 75 milliseconds are required for feeding, sensing, and punching the card. 325 remain for calculation. If the calculation requires more than 325 milliseconds, the computer automatically waits until the end of calculation signal has been given before punching, feeding and sensing the next card. Buffering is not used.

Photo by Department of Interior, Bureau of Reclamation

The purpose of the electronic computing unit is:
To connect card columns for sensing, punching, and reproducing.

To set constant values.

To set the machine for the operations to be performed and the sequence of the operations.

To perform all calculations with an electronic accumulator.

To store the values calculated.

To check each arithmetic step.

To visibly read all elements of all arithmetic steps.

The arithmetic unit uses floating point but storage uses a selected fixed point.

The biquinary code is as follows:

Digits	Biquinary code
0	0
1	1,0
2	2
3	1,2
4	4
5	1,4
6	6
7	1,6
8	8
9	1,8

Alphabetic characters are wired to become two or three numeric characters at the input level. For example, an A becomes 111, a C becomes 99. See Storage.

Negative numbers are carried as the tens complement of the number. A negative sign indicates that the value is negative instead of positive.

The location of the decimal point is variable and may be arbitrarily assigned to each input and storage location.

There is only one arithmetic register, called the accumulator. It has a capacity of 22 digits. The computation of each program step takes place within the accumulator. For example, an addition would be performed as follows:

- 1) Clear the accumulator.
- 2) Enter the first value according to its decimal location.
- 3) Enter the decimal location of the second value.
- 4) Shift the first value to align with the decimal of the second value.
- 5) Enter the second value, performing the process of addition.
- 6) Enter the decimal location of the result storage and shift the result to align with it.

Photo by U. S. Army Chemical Corps Proving Ground (Dugway)

- 7) Place the result in the result storage.
- 8) Subtract value two from the result.
- 9) Subtract value one from the result of 8).
- 10) Check to be certain that the accumulator is zero.

Each step is balanced to zero before the computer continues to the next step. The four possible steps and the method used to check each are:

Step	Proof
Value 1 + Value 2 = Result	Result - Value 2 = Value 1 = 0
Value 1 - Value 2 = Result	Result + Value 2 = Value 1 + 0
Value 1 x Value 2 = Result	Result ÷ Value 2 = Value 1 = 0
Value 1 ÷ Value 2 = Result	Result x Value 2 = Value 1 = 0

The computer will not continue unless the step checks to zero.

The computer has automatic decimal alignment. Programs have been developed which use a floating point method, although the computer is operating with automatic alignment.

Scaling may be accomplished by multiplying or dividing the number by a factor, or changing the decimal

location by a selector.

An overflow stops the computer.

The remainder is dropped off in the final result, although it is used during the proof of the step.

The round-off of sums, differences, products and quotients depends on the decimal location of the result storage. The accumulator unit has 22 positions, as follows:

M Sections
1 2 3 4 5 6 7 8 9 10 11

A Sections
11 10 9 8 7 6 5 4 3 2 1

All results are placed in storage from positions 10-1 of the A Section. Each storage is assigned a decimal location for the program involved. A location of 4/3 would mean that three places are to be retained in the result following the decimal. If the result of any step-addition, subtraction, multiplication, or division contains more places than those allowed in the result storage, the additional digits will be located in the M Section, beginning in column 11. When the result is placed in the storage unit, they are thereby rounded off. Rounding off requires an addition step.

Comparisons are made by two subtraction steps. Each step has two branchings, plus and minus. Zero is always considered plus. The first step of the two would be value 1 minus value 2. If the result is minus, value 2 is greater than value 1. If the result is plus, value 1 is equal to or greater than value 2. The second step would be value 2 minus value 1. If the result is minus, value 1 is greater than value 2. If the result is plus, value 1 and value 2 are equal.

Control Unit

The computer has no stored program.

The input-output panel indicates the card fields to be sensed, punched and reproduced. The constant program panel indicates the program to be followed, step by step, and the constant values which will be used.

The computer operates on a three address system. Each program step, which is externally wired, contains the following six instructions, in the following form:

V1 Pr V2 = R - Br. + Br.
V1 The storage, constant, or card-read field to be used as value 1.
Pr The process (+, -, x, ÷)
V2 The storage, constant, or card-read field to be used as value 2.
R The storage into which the result is to be placed.
-Br The next step or operational function to be performed if the sign of the result is minus.
+Br The next step or operational function to be performed if the sign of the result is plus.

Breakpoint stops may be included in the program. At the plus or minus branching of any step an instruction requiring a division of 0 by 0 or a number by 0 may be given. Both of these steps cause the computer to stop, and a corresponding light is lit.

The electronic computing unit contains a control panel with a dial. Each step may be dialed in turn. For each step value 1, value 2, the result, the process, the branching, all decimal locations and whether the step checks may be read from the panel.

The computer will stop under the following conditions:

- 1) Empty feeding magazine
- 2) Full receiving magazine or chip pan

- 3) Sensing of alpha
- 4) Zero divided by zero
- 5) Number divided by zero
- 6) Incorrect voltage
- 7) Temperature too high
- 8) Overflow condition on a step
- 9) Failure to check.

STORAGE

Manufacturer

Medium Vacuum Tube Words
12

The code system used is biquinary. Each column of storage contains 5 tubes, representing the digits 1, 3, 5, 7, and 9. There is no tube for zero, which is represented by the fact that none of the tubes are lit. An odd digit is represented by the corresponding tube 1, 3, 5, 7, and 9. An even digit is represented by the odd digit which is immediately lower in value, plus the 9. Therefore, a 2 is 1 plus 9, a 4 is 3 plus 9, a 6 is 5 plus 9 and an 8 is 7 plus 9.

The word length in storage is ten digits (columns) plus sign.

Alphabetic characters require five columns of storage for two characters, three columns for a single character. A single word can therefore contain 4 columns of alphabetic characters as opposed to 10 columns of numeric characters.

Storage is actually part of the computing unit. There is no buffering unit.

Bureau of Reclamation

Constant Storage 108 Digits

These digits may be grouped into as many as 36 elements or individual constant values from 1 to 10 digits.

Intermediate Storage 12 units of 10 columns each

Each unit related to accumulator columns 1 through 10.

INPUT

Manufacturer

Medium Card Sensing-Punching Unit

The purpose of the Card Sensing-Punching Unit is to sense and punch tabulating cards and to indicate and control general machine operation.

A maximum of 36 words (card read fields) may be used in one program. Up to 120 digits may be divided as necessary among 36 words. The sign of each field is in addition to the 120 digits.

A 90 column punched card code is used. This is the same biquinary code as is used in the storage unit. All 36 words are sensed simultaneously on one cycle. Five columns are required to sense two columns of alphabetic information; three columns are required to sense one column of alphabetic information.

Bureau of Reclamation

Input Storage - 90 columns: one for each column of a 90 column card.

Input - 120 columns from the 90 columns of input storage. Speed is 125 cards/min.

The input is grouped into 12 identical units of 10 columns each. Each unit is related to accumulator columns 1 through 10.

These 120 columns of input will accommodate as many as 36 elements or individual input values varying in size from one to 10 digits.

Dugway P. G.
 Medium Cards Speed
 150 cards/min
 AiResearch
 Cards 150 cards/min

OUTPUT

Manufacturer

Card Sensing-Punching Unit

The Card Sensing-Punching Unit measures 2 ft. 11 in. long, 2 ft. 6 in. wide, 5 ft. 9 in. high, and weighs 1,020 lbs. This unit may operate from any of the following power services:

- a) 208 volt single phase, 4 wire, 60 cycles
- b) 230 volt single phase, 3 wire, 60 cycles
- c) 220 volt single phase, 3 wire, 60 cycles
- d) 120 volt three phase, 4 wire, 60 cycles
- e) 220 volt three phase, 3 wire, 60 cycles
- f) 220 volt three phase wye system, 50 cycles

The Electronic Computing Unit measures 7 ft. 2 in. wide, 2 ft. 6 in. deep, 5 ft. 9 in. high and weighs 2,210 lbs.

The unit operates from the same power sources as the Card Sensing-Punching Unit.

The unit is ventilated by fan forced room air.

Bureau of Reclamation

Output Storage - 90 columns: one for each column of a 90 column card.
 Speed is 125 cards/min.

Output - 120 columns for the 90 columns of output storage. The output is from the twelve, 10 column Intermediate Storage Units, for the punching of the 10-digit maximum results.

Dugway P. G.

Medium Cards Speed
 150 cards/min
 AiResearch
 Cards 150 cards/min

This machine has only one card input/output device, therefore, the input and output cards are the same or must be interfiled prior to computing. The machine normally operates at the 150 cards/min speed, but does not have a post sensing station for verification. Two passes of the cards are required for verification.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Bureau of Reclamation

Power, computer 10 Kw 8.0 KVA
 Volume, computer 142.5 cu ft
 Area, computer 43 sq ft
 Room size, computer 143 sq ft (working area)
 168 sq ft (rectangular area)
 Floor loading 75.1 lbs/sq ft
 Weight, computer 3,230 lbs

Site preparation: Installation of 220-volt power junction box, acoustical tile (ceiling of EDP room only) and ventilating hood for the Univac 120. The building is of reinforced concrete construction with the EDP unit located in the basement.

The Univac 120 may be adjusted at the time of installation to operate from 208, 220, or 230 volts, alternating current, providing the regulation of the power source can be held to plus or minus 5% of any of the above voltages. This voltage must be measured at the junction of the power supply line and computer power line, and under normal line load conditions. In the event the regulation is not within the 5%, plus or minus, a voltage regulator is necessary.

The air conditioner is included in the Electronic

Computing Unit of the Univac 120 to assist in maintaining that unit at the most desirable operating temperature.

The air conditioner consists of four 15 inch fans in the base located above air filters. These fans operate at 1750 rpm to force air through the inside of the unit.

The heat dissipation is approximately 400 BTU/min. The air flow through the machine to affect cooling is 2500 cubic feet per minute.

Dugway P. G.

Power, computer 10.3 Kw 8 KVA 0.777 pf
 Volume, computer 142.5 cu ft
 Volume, air conditioner 61.25 cu ft
 Area, computer 25 sq ft
 Area, air conditioner 8.75 sq ft
 Room size, computer 22 ft x 27 ft
 Room size, air conditioner 22 ft x 27 ft
 Floor loading 75 lbs/sq ft
 Capacity, air conditioner 3 Tons
 Weight, computer 3,230 lbs
 Weight, air conditioner 700 lbs

The basic design of the building provided for a computer room and no special preparations were required.

Bureau of Mines

Power, computer 8 KVA 0.95 pf w/voltage regulator
 Volume, computer 142.5 cu ft
 Area, computer 43 sq ft
 Room size, computer 145 sq ft min.
 Floor loading 75.1 lbs/sq ft
 303.1 lbs concen max

Capacity, air conditioner 17 Tons

Weight, computer 3,230 lbs

Special voltage regulator and transformer required for efficient operation. Also, the 17 ton air conditioner cools the entire area.

AiResearch

Power, computer 8.3 KVA 208v at 38 amps
 Volume, computer 517.5 cu ft
 Area, computer 43 sq ft
 Room size, computer 16 ft x 10 ft
 Floor loading 75 lbs/sq ft
 267 lbs concen max
 Weight, computer 3,230 lbs

No special preparation except power requirements and voltage regulators.

COST, PRICE AND RENTAL RATES

Manufacturer

Approximate cost of basic system \$97,500.
 Rental rate of basic system, standard shift \$1,000-\$1,275.

Second shift operation charge is an additional 50% of the standard rate.

Third shift operation charge is an additional 50% of the standard rate.

Maintenance, including cost of parts, except due to customer negligence, is included in the rental rates above.

The charge for maintenance to a customer who purchases, rather than leases, but who requires maintenance operations is \$4,875 per year for a machine less than 6 years old and \$5,850 per year for a machine 6 to 11 years old.

Customer's personnel are trained at no extra charge.

Bureau of Reclamation

	Quantity	Monthly Rental
Univac 120	1	\$1,170.00
Keypunch, Type 306-2 alphabetical w/visible automatic feed, 90 column	3	120.00
Verifier, Type 313, 90 column	1	60.00
Sorter, Type 420, Electronic	1	87.50
Interpreter, Type 312-4 Posting	1	155.00
Collating Reproducer, Type 315-1	1	165.00
Alphabetical Tabulator, Series 3200 100 cards/min	1	475.00
Summary Punch, Type 311	1	85.00
Portable Card Punch, Type 102	2	20.00
Electronic Collator, Type 319-2	1	125.00

Maintenance service included.

Dugway P. G.

Calculating Unit and Reader-Punch Unit rent at approximately \$1,350 per month.

Tabulator, Interpreter, Sorter, 2 Collators, and 2 Key punches rent at approximately \$900 per month.

Bureau of Mines

Basic system cost \$95,783.53 + 5,850.00 excise tax.

Minimum capacity system \$1,125/month

Maximum capacity system 1,350/month

Bureau of Mines system 1,300/month

Maintenance service contract is included in rental.

AiResearch

	Qty Used	Cost Each	Monthly Rental
Univac 120 Computer	2	\$97,500	\$1,350
Collators	2	10,000	125
Interpreters	2	6,945	--
Tab/Sum	6	31,968	535
Sorters	8	5,600	85
Reproducers	4	9,376	125

Above rentals are for one shift. Second shift are 50% additional.

Maintenance service is included in rental.

PERSONNEL REQUIREMENTS

Bureau of Reclamation

	One 8-Hour Shift	
	Used	Recommended
Supervisors	1	1
Analysts	1	1
Operators	2	2
Keypunch Opera	2	2

Operation tends toward open shop.

Prior to installation of hardware at Ephrata, Sperry Rand conducted training seminars for the selected operators. Since installation, the training program has been on an on-the-job basis.

Dugway P. G.

	One 8-Hour Shift	
	Used	Recommended
Supervisors	1	1
Programmers	4	4
Clerks	1	1
Operators	1	1
Technicians	1	1

Operation tends toward closed shop.

On-the-job training and Remington Rand machine operation and programming classes are utilized for training.

Bureau of Mines

	One 8-Hour Shift	
	Used	Recommended
Supervisors	1	2
Analysts	2	2
Technicians	1	2

Operation tends toward open shop. Company sponsored and on-the-job training are utilized.

AiResearch

	Two 8-Hour Shifts	
	Used	Recommended
Supervisors	2	2
Analysts	1	1
Programmers	1	1
Operators	2	2
Engineers	1	1
Technicians	2	2

The supervisors supervise the entire Tab Room and not just the computer operations.

The analyst and the programmer are only part time for the computer.

All Tab Room personnel are capable of operating this equipment.

The engineer and technicians are furnished by the manufacturer and are responsible for all equipment.

Operation tends toward open shop.

Methods of training used include training by manufacturer's personnel and on-the-job training, closely supervised.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Bureau of Reclamation

Good time	20 Hours/Week (Average)
Attempted to run time	21 Hours/Week (Average)
Operating ratio (Good/Attempted to run time)	0.95
Above figures based on period 1 Jan 60 to 30 Jun 60	
Passed Customer Acceptance Test	1 Apr 59
Time is available for rent to qualified outside organizations.	

Since the volume of applications the unit now processes are of accounting nature, we have some peak periods that exceed the capacity of the machines. However, we do have the capacity to absorb considerable more work, provided the scheduling emphasis could be placed on the non-peaking periods.

Dugway P. G.

Average error-free running period	24 machine hours
Good time	15 Hours/Week (Average)
Attempted to run time	20 Hours/Week (Average)
Operating ratio (Good/Attempted to run time)	0.75
Above figures based on period 1 Aug 59 to 1 Aug 60	
Passed Customer Acceptance Test	Nov 54
Time is available for rent to outside organizations.	

Bureau of Mines

Good time	36 Hours/Week (Average)
Attempted to run time	40 Hours/Week (Average)
Operating ratio (Good/Attempted to run time)	0.90
Above figures based on period 1 Jan 60 to 30 Apr 60	
Time is not available for rent to outside organizations.	

AiResearch

Good time	58.5 Hours/Week (Average)
Attempted to run time	64.5 Hours/Week (Average)
Operating ratio (Good/Attempted to run time)	0.92
Above figures based on period 1 Jan 60 to 29 Apr 60	
Passed Customer Acceptance Test	Jan 56
Time is not available for rent to outside organizations.	

ADDITIONAL FEATURES AND REMARKS

Manufacturer

The Univac 60 and Univac 120 Systems are similar, except with regard to such items as storage capacity, price, rental rate, and service costs.

Bureau of Reclamation

The Univac 120 automatically checks each arithmetical step of each calculation before proceeding to the next step. Forty program steps of the Univac 120 may be used in any numerical sequence desired. Furthermore, one program step or series of steps can be reused or repeated as often as required in any calculation. Sperry Rand machines require more careful programming. There are dividends to this, though, in that often through more careful programming we can realize much greater efficiency.

As far as commercial applications are concerned, we find the size of a Univac 120 to be almost ideal. It is not so large as to lure us into over-programming an application; nor is it so small that we have to make repeated runs. Rather it seems to break our computations into sizes which can be effectively and economically handled.

Dugway P. G.

Outstanding features include low cost with punched card versatility. Although the present computer system was adequate for its original purpose, the problems being generated at Dugway are of such a nature that a plugboard programmed computer does not conveniently lend itself to their solution.

AIResearch

Outstanding features include internal checking of all computations, branching on each step, address instructions, and ample selectors give great versatility.

FUTURE PLANS

Bureau of Reclamation

Feasibility studies are being conducted in many areas of our Project Office to determine the applications that are necessary for the EDP unit to be of greater value in reporting to management. With these factors in mind, the equipment requirements could conceivably change. However, additional equipment is not contemplated in the near future.

Dugway P. G.

A local Data Processing Committee is currently studying proposals received from approximately 12 vendors with the view that a small stored program computer would provide Dugway with the programming flexibility that is required in statistical and mathematical research operations. A stored program computer will allow us to solve problems that are not economically feasible with our current system.

AIResearch

Our present system is over 4 years old and has been expanded to the limit of punched cards. To further advance our system, we now have on order two (2) Sperry Rand Univac Solid State Tape Computers (one 80 Col., one 90 Col.) with 5 tape servos each. These are scheduled for delivery in September and November 1960. Initially we are considering these computers as a natural expansion to our present punched card system. As soon as our present system (modified to take advantage of the computers capabilities and magnetic tape) is "on the air", we will start to integrate our runs into a more sophisticated system, but keeping the shock of a new system to a minimum.

INSTALLATIONS

U. S. Bureau of Reclamation
Region 1, Columbia Basin Project
Box 368
Ephrata, Washington

U. S. Army Chemical Proving Ground, Dugway
Test Design & Analysis Office
Dugway, Utah

U. S. Bureau of Mines
4800 Forbes Avenue
Pittsburgh 13, Pennsylvania

AIResearch Manufacturing Company of Arizona
402 South 36th Street
Phoenix, Arizona

PRODUCTION RECORD

Total number of Univac 60 and 120 Systems 1,000

UNIVAC 490

UNIVAC 490 Real-Time System

APPLICATIONS

UNIVAC 490 System is essentially a communications-computer network which provides instantaneous inventory and production control data to companies and government agencies having widely scattered offices, plants and warehouses. Hundreds of transmitting and receiving devices strategically located throughout the country can communicate directly with the central processor. As a result, the computer can receive real-time data from a transaction source, process the raw data and deliver the necessary answers in ample time to complete the original transaction. A wide variety of input and output devices are available to meet specialized requirements.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system Binary
 Binary digits/word 30
 Binary digits/instruction 30
 Instructions/word 1
 Instructions decoded 62 function code designators
 Arithmetic system Fixed point
 Instruction type One address
 Number range - 536,870,911 to + 536,870,911 Decimal
 Instruction word format

6	3	3	3	15
f	j	k	b	y

f - Function code designator
 j - Branch condition designator
 k - Operand-interpretation designator
 b - Operand address modification designator
 y - Operand designator

Automatic coding

Compiler and assembly routines will be supplied to all 490 users.

Arithmetic Registers

Seven B-registers (Address modifying registers 15 bits each)
 One A-register or accumulator 30 bits
 One Q-register and auxiliary arithmetic register 30 bits
 One P-register Program Address Counter 15 bits
 Transient Registers
 One X-register 30 bits
 One K-register 6 bits
 One S-register 15 bits
 One Z-register 30 bits
 One U-register 30 bits
 One R-register 15 bits
 One R¹-register 15 bits
 One D-register 30 bits
 One C⁰-register (Communication Buffer Register)
 One C¹-register (Communication Buffer Register)

ARITHMETIC UNIT

	Incl Stor Access Microsec	Exclud Stor Access Microsec
Add	7.2-12	4.8-12
Mult	19.2-84	7.2-72
Div	84	72

MANUFACTURER

Sperry Rand Corporation
 Remington Rand Univac Division

Construction (Arithmetic unit only)

Transistors 13,819
 Diodes 37,543
 Arithmetic mode Parallel
 Parallel one's complement binary notation
 Timing Synchronous
 Operation Concurrent

STORAGE

Media	No. of Words	Dec Digits	Access Microsec
Magnetic Core	16,384-32,768	491,520-983,040	1.9
Magnetic core cycle time is 6 microseconds.			
Magnetic Drum Type FH 500	327,680	9,830,400	8,500 avg
Magnetic Drum Type FH 880	786,432	23,592,960	17,000 avg

Magnetic Tape UNIVAC Uniservo IIA

No. of units that can be connected As many as 12
 Uniservo Model IIA Tape Units may operate through a tape control unit and a channel synchronizer connected to a single input-output channel. The 490 System provides 12 input-output channels. Uniservo Model III may also be used with 490 System.

No. of char/linear inch of tape 125 or 250 Char/inch
 Channels or tracks on the tape 8 Tracks/tape
 Tape speed 100 Inches/sec
 Transfer rate 25,000 Char/sec
 Start time 12 Millisec
 Stop time 9 Millisec
 Average time for experienced operator to change reel of tape 30 Seconds
 Physical properties of tape
 Width 0.500 Inches
 Length of reel 2,500 Feet
 Composition Metallic or Mylar

INPUT

Media	Speed
Magnetic Tape	125,000 Kilocycle/sec Model III
Card Reader	600 cards/min 80 Column
Read-Punch Unit	150 cards/min 80 Column
Keyboard and Printer	Printed-page output is 60, 75 or 100 words/minute depending on telegraphic service.

12 Model IIA Units can be connected to one input-output channel. Can be operated by remote control.

OUTPUT

Media	Speed
Magnetic Tape	125,000 Kilocycle/sec
High Speed Printer	600 lines/min On-line
Read-Punch Unit	150 cards/min
Keyboard and Printer	Because the central site equipment can communicate directly with nearly any type of external digital equipment, remote inquiry answering devices of many different designs can be a part of a 490 System. Usually remote inquiry answering units are especially designed to meet the requirements of a real-time application.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Diodes	37,543 All types
Transistors	13,819 All types

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Unit	KVA	Volt- age	Phase	Cycle	Volt- age Reg- ulator	Heat Dis- sipation BTU/Hr	Air Re- quirement Cu Ft/Min	(I N C H E S)			Weight Lbs.	Floor Loading Lbs/Sq Ft
								Width	Depth	Height		
M490 Computer w/Memory	4.0	208	3	60	± 5%	20,000	1,000	120	36	96	-	-
Flying Head Drum Control Unit (FH 500 and FH 880)	0.25	208	3	60	± 5%	1,000	50	24	30	21	180	36
Flying Head Drum Synchronizer	0.10	208	3	60	± 5%	400	50	24	30	14	120	24
Flying Head Drum Unit	1.3	208	3	60	0	-	-	36	30	40	400	55
Synchronizer, Tape	0.10	208	3	60	± 5%	400	50	24	30	14	120	24
Uniservo Con- trol Unit	0.20	208	3	60	± 5%	750	50	12	30	28	240	48
Uniservo IIA Console (Double)	2.0	208	3	60	± 5%	6,500 1,100	350 50	30 42	33 18	66 60	750 300	109 60
Receives from computer central processor												

PRODUCTION RECORD

Number produced to date Prototype 1
Time required for delivery 18 months

PERSONNEL REQUIREMENTS

Appropriate courses will be provided at no cost to the user.

ADDITIONAL FEATURES AND REMARKS

Specially designed for real-time use.
Solid state components with their inherent advantages.
Large expandable capacity high speed storage.
Fast access - high density drum storage.
High internal speed.
Utmost reliability.
Flexible input/output capabilities.
Minimum space.
Low power requirements.
Minimum air conditioning requirements.
Ease of maintenance.
Real-time and delta clocks.