

THE UNIVAC SCIENTIFIC
GENERAL PURPOSE COMPUTER SYSTEM
(MODEL 1103 A)

PRELIMINARY INFORMATION

1 December 1955

Remington Rand, Inc.

DIVISION OF SPERRY RAND CORPORATION

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MODEL 1103A

THE UNIVAC SCIENTIFIC GENERAL PURPOSE COMPUTER SYSTEM (MODEL 1103A)

GENERAL DESCRIPTION

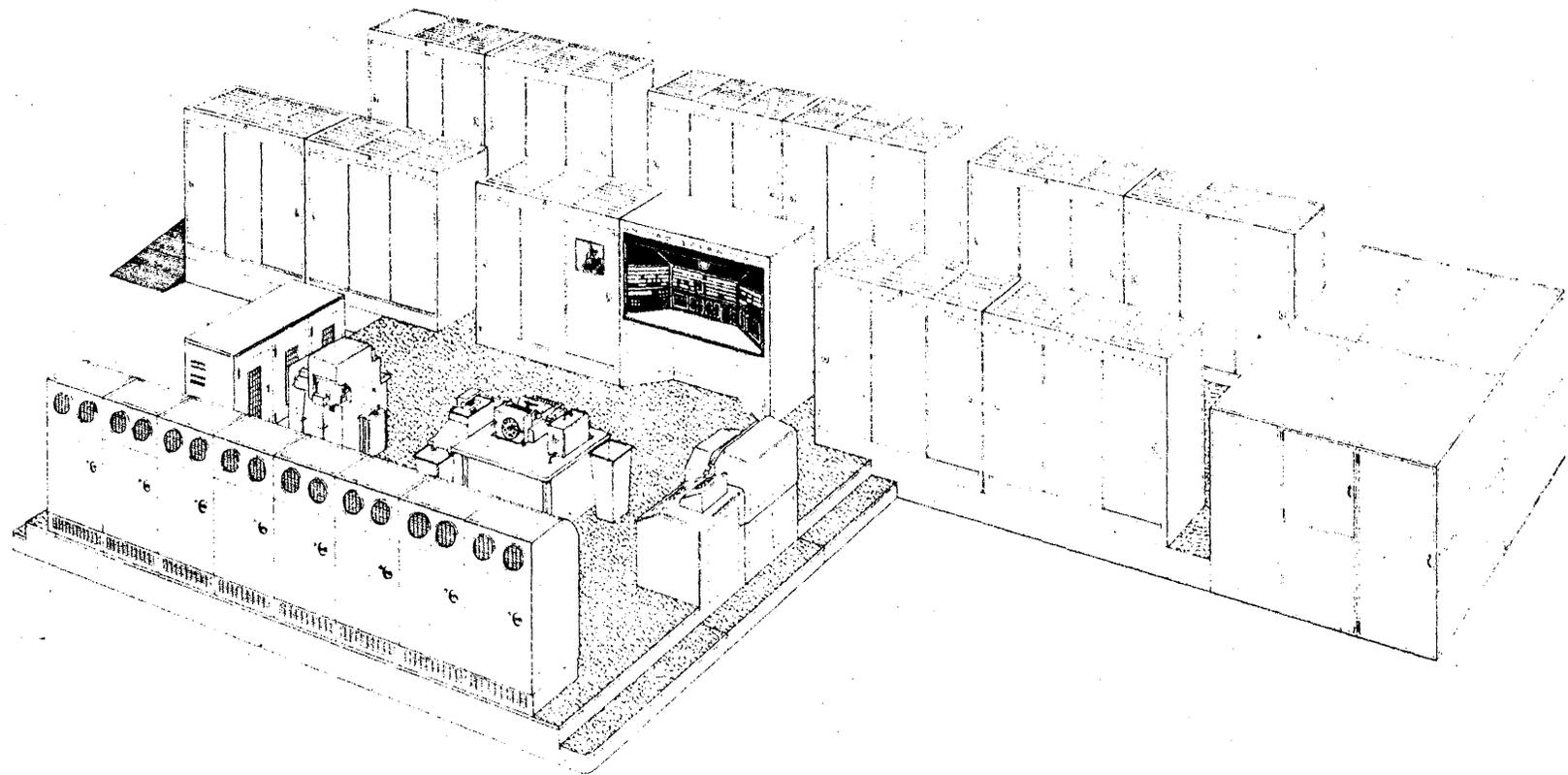
The Model 1103A is a general-purpose digital computing system for applications requiring large storage capacity, high operating speed, and programming versatility. Its internal memory consists of 16,384 registers of magnetic drum storage, 4,096, 8,192, or 12,288 registers of magnetic core storage, and the A and Q registers. Each of these registers is individually addressed and directly accessible. Supplementary storage is provided by up to ten Uniservo magnetic tape units.

Standard input and output equipments used with the computer consist of a photoelectric paper tape reader, a typewriter, and a high-speed paper tape punch. Communication with a wide variety of optional devices is made possible by use of an eight-bit input-output register, IOA, and a 36-bit input-output register, IOB. The choice of optional equipment is determined by the user's needs. Frequently included are: Univac magnetic tape units, a card reader and card punch, a line printer, and an oscilloscope display unit. Directly connected devices may also include: Teletype communication circuits, analog-to-digital converters (for use with sensing instrumentation), signal circuits to process-actuating mechanisms, etc. The computer's input-output system permits simultaneous use of several external units and allows computation to proceed while such terminal equipments are operating. The use of Unitapes permits off-line processing of information by a variety of Univac auxiliary equipments.

The computer performs 41 different arithmetic and logical operations. It is fully automatic in that the sequence of operations is determined by a program of internally stored instructions capable of self-modification. During the performance of the program, instructions are removed from storage, one at a time, in the order required. To attain high computational speed, the computer operates in the parallel mode; i.e., all digits of a number are operated upon simultaneously. Internal arithmetic operations are in the binary number system. The basic word size is 36 binary digits, or "bits". A word may be an instruction, a number, or an arbitrarily coded quantity.

A form of "two-address" logic is employed. An instruction word consists of a 6-bit operation code and two 15-bit execution addresses. The functions of the execution addresses are different for the various types of instructions, but, in general, they specify registers in the memory from which operands are obtained or in which results are stored.

The computer employs a "one's complement" system of notation in which the left-most bit of a number is the sign bit of that number, and the binary point is considered to be to the right of the lowest order bit. Thus, if the left-most



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bit of a number is "0", the number is said to be positive; if the left-most bit is a "1", the number is said to be negative. In the one's complement system, a negative number can be obtained from a positive number by complementing all the bits (including the sign bit) of the corresponding positive number. In the single-length, or 36-bit, register, integers from $1-2^{35}$ up to $2^{35}-1$ may be represented; in the double-length, or 72-bit, Accumulator integers from $1-2^{71}$ up to $2^{71}-1$ may be represented. In the one's complement notation, each of the integers has a unique representation with the exception of zero; zero has both a positive and negative notation; however, because of the nature of the arithmetic circuits, a negative zero cannot be generated as the result of arithmetic operations.

Integers not lying in the above range, as well as fractional quantities, can also be handled by suitably scaling such quantities so that the resulting quantity can be represented by machine numbers.

The basic computer weighs 33,747 pounds and occupies a space, including working space, of 26 by 60 feet. The power service required is 208 vac, 3-phase; the power factor is approximately 0.9 inductive with a power consumption of 55kw. The equipment contains approximately 4700 vacuum tubes, 6000 crystal diodes, and 150 relays, and consists of six large air-cooled cabinets containing electronic circuits, a photoelectric tape reader, an electric typewriter, a high-speed tape punch, a motor alternator, and an air conditioning cabinet.

REPertoire OF INSTRUCTIONS

The complete list of instructions which the computer performs is presented below. The instructions are arranged in 11 groups according to their basic characteristics. In each listing a code representing the instruction is enclosed in parenthesis after the name of the instruction. The operation code portion is designated by a two-number combination and the execution addresses by the letters u and v. In some cases u is replaced by the conditioning factors j, n, or k, as in the Repeat instruction or the Left Transmit instruction. In other cases v is replaced either by the repeat termination address, w, or in some shifting operations by the factor k. The repertoire of instructions is summarized in Table 1. To more fully comprehend the meaning of the symbols contained in the repertoire the following glossary of terms and abbreviations is given.

- Word. - A combination of 36 bits.
- Instruction. - A word, represented by $i_{35}, i_{34}, \dots, i_0$, which causes the computer to perform one or more of its operations. The instruction consists of an operation code and, usually, two execution addresses.
- Operation Code. - That six-bit part of an instruction, represented by $i_{35}, i_{34}, \dots, i_{30}$, designating the operation to be performed.
- u. - The first execution address of an instruction, represented by $i_{29}, i_{28}, \dots, i_{15}$.
- v. - The second execution address of an instruction, represented by $i_{14}, i_{13}, \dots, i_0$.
- operand. - A word on which an operation is performed.
- (). - Parenthesis, denoting "the contents of"
- A. - The 72-bit Accumulator, $A_{71}, A_{70}, \dots, A_0$.
- A_L . - The left-hand (most significant) 36 bits of A.
- A_R . - The right-hand (least significant) 36 bits of A.
- Q. - A 36-bit shifting register, $Q_{35}, Q_{34}, \dots, Q_0$.
- X. - A 36-bit exchange register, $X_{35}, X_{34}, \dots, X_0$.
- ()_i - The initial contents of a register before an operation has taken place.

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- ()_f - The final contents of a register after an operation has taken place.
- D(u). - A 72-bit word whose right-hand 36 bits are (u) and whose left-hand 36 bits are all alike and equal to the left-most bit of (u).
- S(u). - A 72-bit word whose right-hand 36 bits are (u) and whose left-hand 36 bits are all zero.
- L(Q)(u). - A 72-bit word whose left-hand 36 bits are zeros and each of whose right-hand 36 bits is given by the product of the corresponding bits of (u) and (Q).
- L(Q)^o(v). - A 72-bit word whose left-hand 36 bits are zeros and each of whose right-hand 36 bits is given by the product of the corresponding bits of (v) and the complement of (Q).
- j. - A one-digit octal number, represented by u₁₄, u₁₃, u₁₂.
- n. - A four-digit octal number, represented by u₁₁, u₁₀, ..., u₀.
- k. - The shift count, usually represented by v₆, v₅, ..., v₀, but in the Left Transmit instruction, represented by u₆, u₅, ..., u₀.
- F₁. - Fixed octal address 00000 (or address 40001 if so manually selected in the test mode).
- F₂. - Fixed octal address 00001.
- F₃. - Fixed octal address 00002.
- TWR. - A typewriter register of six bits.
- HPR. - The high-speed punch register of seven bits.
- CI. - The current instruction.
- NI. - The next instruction.

TABLE 1

A SUMMARY OF THE
REPERTOIRE OF INSTRUCTIONS

11	TRANSMIT POSITIVE (TPuv)	$(u) \rightarrow v$
12	TRANSMIT MAGNITUDE (TMuv)	$ u \rightarrow v$
13	TRANSMIT NEGATIVE (TNuv)	$(u)^{\circ} \rightarrow v$
14	INTERPRET (IPxx)	$y+1 \rightarrow F_1$, take (F_2)
15	TRANSMIT U-ADDRESS (TUuv)	$(u_{15-29}) \rightarrow v_{15-29}$
16	TRANSMIT V-ADDRESS (TVuv)	$(u_{0-14}) \rightarrow v_{0-14}$
17	EXTERNAL FUNCTION (EF-v)	Select Ext. Equipment and perform (v)
21	REPLACE ADD (RAuv)	$(u)+(v) \rightarrow u$
22	LEFT TRANSMIT (LTjkv)	Shift (A) by k; $j=0, (A_L)_f \rightarrow v$; $j=1, (A_R)_f \rightarrow v$
23	REPLACE SUBTRACT (RSuv)	$(u)-(v) \rightarrow u$
27	CONTROLLED COMPLEMENT (CCuv)	$(u) \oplus (v) \rightarrow u$
31	SPLIT POSITIVE ENTRY (SPuk)	$S(u) \rightarrow A$, shift (A) by k
32	SPLIT ADD (SAuk)	$(A)+S(u)$, shift (A) by k
33	SPLIT NEGATIVE ENTRY (SNuk)	$S(u)^{\circ} \rightarrow A$, shift (A) by k
34	SPLIT SUBTRACT (SSuk)	$(A)-S(u)$, shift (A) by k
35	ADD AND TRANSMIT (ATuv)	$(A)+D(u) \rightarrow v$
36	SUBTRACT AND TRANSMIT (STuv)	$(A)-D(u) \rightarrow v$
37	RETURN JUMP (RJuv)	$y+1 \rightarrow u$, take (v)
41	INDEX JUMP (IJuv)	$D(u)-1 \rightarrow A$; $(A)_f+, (A) \rightarrow u$ & take (v)
42	THRESHOLD JUMP (TJuv)	$(u) > (A)$, take (v)
43	EQUALITY JUMP (EJuv)	$(u) = (A)$, take (v)
44	Q-JUMP (QJuv)	$(Q)-$, take (u); $(Q)+$, take (v); (Q) left 1
45	MANUALLY SELECTIVE JUMP (MJjv)	$j=0$, or 1, 2, 3, & MJS=, take (v)
46	SIGN JUMP (SJuv)	$(A)-$, take (u); $(A)+$, take (v)
47	ZERO JUMP (ZJuv)	$(A) \neq 0$, take (u); $(A)=0$, take (v)
51	Q-CONTROLLED TRANSMIT (QTuv)	$L(Q)(u) \rightarrow v$
52	Q-CONTROLLED ADD (QAuv)	$(A)+L(Q)(u) \rightarrow v$
53	Q-CONTROLLED SUBSTITUTE (QSuv)	$L(Q)(u)+L(Q)^*(v) \rightarrow v$
54	LEFT SHIFT IN A (LAuk)	$D(u) \rightarrow A$, shift (A) by k, $(A)_f \rightarrow u$
55	LEFT SHIFT IN Q (LQuk)	$(u) \rightarrow Q$, shift (Q) by k, $(Q)_f \rightarrow u$
56	MANUALLY SELECTIVE STOP (MSjv)	$j=0$, stop; $j=1, 2, 3$ & MSS=, stop
57	FINAL STOP (FS--)	Stop and Indicate
61	PRINT (PR-v)	Typewriter performs code in v_{0-5}
63	PUNCH (PUjv)	Punch (v_{0-5}); $j=1$, 7th level
71	MULTIPLY (MPuv)	$(u)(v) = (A)$
72	MULTIPLY ADD (MAuv)	$(A)_f+(u)(v) = (A)_f$
73	DIVIDE (DVuv)	$(A)_f \div (u) = (Q)+(A)_f, (Q) \rightarrow v$; $[(A)_f \div R]$
74	SCALE FACTOR (SFuv)	Shift D(u) in A until $A_{34} \neq A_{35}$, (SK) $\rightarrow v$
75	REPEAT (RPinw)	Execute NI "n" times, jump to F_1
76	EXTERNAL READ (ERjv)	$j=0$, (IOA) $\rightarrow v$; $j=1$, (IOB) $\rightarrow v$
77	EXTERNAL WRITE (EWjv)	$j=0$, (v) \rightarrow IOA; $j=1$, (v) \rightarrow IOB

REPertoire OF INSTRUCTIONS

SEQUENCED INSTRUCTIONS

1. MULTIPLY (71uv): Form in A the 72-bit product of (u) and (v), leaving in Q the multiplier (u).

2. MULTIPLY ADD (72uv): Add to (A) the 72-bit product of (u) and (v), leaving in Q the multiplier (u).

3. DIVIDE (73uv): Divide the 72-bit number (A) by (u), putting the quotient in Q, and leaving in A a non-negative remainder R. Then replace (v) by (Q). The quotient and remainder are defined by: $(A)_i = (u) \cdot (Q) + R$, where $0 \leq R \leq |(u)|$. Here $(A)_i$ denotes the initial contents of A.

4. SCALE FACTOR (74uv): Replace (A) with D(u). Then left circular shift (A) by 36 places. Then continue to shift (A) until $A_{34} \neq A_{35}$. Then replace the right-hand 15 bits of (v) with the number of left circular shifts, k, which would be necessary to return (A) to its original position. If (A) is all ones or zeros, $k = 37$. If u is the address of the Accumulator, (A) is left unchanged in the first step, instead of being replaced by D(A_R).

5. REPEAT (75jnw): This instruction calls for the next instruction, which will be called NIuv, to be executed n times, its "u" and "v" addresses being modified or not according to the value of j. Normally n executions are made and the program is continued by the execution of the instruction stored at a fixed MC address F₁. The steps carried out are:

- a. Replace the right-hand 15 bits of (F₁) with the address w.
- b. Execute NIuv, the next instruction in the program n times.
- c. If $j = 0$, do not change u and v.
 If $j = 1$, add one to v after each execution.
 If $j = 2$, add one to u after each execution.
 If $j = 3$, add one to u and v after each execution.
- d. On completing n executions, take (F₁) as the next instruction.
- e. If the repeated instruction is a jump or stop instruction, the occurrence of a jump or stop terminates the repetition. In addition, if NIuv is a Threshold Jump or an Equality Jump, and the jump to address v occurs, (Q) is replaced by the quantity $j \cdot (n-r)$, where r is the number of executions that have taken place.

TRANSMISSIVE INSTRUCTIONS

1. TRANSMIT POSITIVE (11uv): Replace (v) with (u).
2. TRANSMIT NEGATIVE (13uv): Replace (v) with the complement of (u).
3. TRANSMIT MAGNITUDE (12uv): Replace (v) with the absolute magnitude of (u).
4. TRANSMIT U-ADDRESS (15uv): Replace the 15 bits of (v), designated by v_{15} through v_{29} , with the corresponding bits of (u), leaving the remaining 21 bits of (v) undisturbed.
5. TRANSMIT V-ADDRESS (16uv): Replace the right-hand 15 bits of (v) designated by v_0 through v_{14} , with the corresponding bits of (u), leaving the remaining 21 bits of (v) undisturbed.
6. LEFT TRANSMIT (22jkv): Left circular shift (A) by k places. Then replace (v) with (A_L) if $j = 0$, or replace (v) with (A_R) if $j = 1$.
7. ADD AND TRANSMIT (35uv): Add $D(u)$ to (A). Then replace (v) with (A_R).
8. SUBTRACT AND TRANSMIT (36uv): Subtract $D(u)$ from (A). Then replace (v) with (A_R).

Q-CONTROLLED INSTRUCTIONS

1. Q-CONTROLLED TRANSMIT (51uv): Form in A the number $L(Q)(u)$. Then replace (v) by (A_R).
2. Q-CONTROLLED ADD (52uv): Add to (A) the number $L(Q)(u)$. Then replace (v) by (A_R).
3. Q-CONTROLLED SUBSTITUTE:(53uv): Form in A the quantity $L(Q)(u)$ plus $L(Q)^v(v)$. Then replace (v) with (A_R). The effect is to replace selected bits of (v) with the corresponding bits of (u) in those places corresponding to 1's in Q.

REPLACE INSTRUCTIONS

1. REPLACE ADD (21uv): Form in A the sum of $D(u)$ and $D(v)$. Then replace (u) with (A_R).
2. REPLACE SUBTRACT (23uv): Form in A the difference $D(u)$ minus $D(v)$. Then replace (u) with (A_R).
3. CONTROLLED COMPLEMENT (27uv): Replace (A_R) with (u) leaving (A_L) undisturbed. Then complement those bits of (A_R) that correspond to ones in (v). Then replace (u) with (A_R).

4. LEFT SHIFT IN A (54uk): Replace (A) with D(u). Then left circular shift (A) by k places. Then replace (u) with (A_R). If u is the address of the Accumulator, the first step is omitted, so that the initial content of A is shifted.

5. LEFT SHIFT IN Q (55uk): Replace (Q) with (u). Then left circular shift (Q) by k places; Then replace (u) with (Q).

SPLIT INSTRUCTIONS

1. SPLIT POSITIVE ENTRY (3luk): Form S(u) in A. Then left circular shift (A) by k places.

2. SPLIT NEGATIVE ENTRY (33uk): Form in A the complement of S(u). Then left circular shift (A) by k places.

3. SPLIT ADD (32uk): Add S(u) to (A). Then left circular shift (A) by k places.

4. SPLIT SUBTRACT (34uk): Subtract S(u) from (A). Then left circular shift (A) by k places.

TWO-WAY CONDITIONAL JUMP INSTRUCTIONS

1. SIGN JUMP (46uv): If $A_{71} = 1$, take (u) as NI. If $A_{71} = 0$, take (v) as NI.

2. ZERO JUMP (47uv): If (A) is not zero, take (u) as NI. If (A) is zero, take (v) as NI.

3. Q-JUMP (44uv): If $Q_{35} = 1$, take (u) as NI. If $Q_{35} = 0$, take (v) as NI. Then, in either case, left circular shift (Q) by one place.

ONE-WAY CONDITIONAL JUMP INSTRUCTIONS

1. INDEX JUMP (41uv): Form in A the difference D(u) minus 1. Then if $A_{71} = 1$, continue the present sequence of instructions; if $A_{71} = 0$, replace (u) with (A_R) and take (v) as NI.

2. THRESHOLD JUMP (42uv): If D(u) is greater than (A), take (v) as NI; if not, continue the present sequence. In either case, leave (A) in its initial state.

3. EQUALITY JUMP (43uv): If D(u) equals (A), take (v) as NI; if not, continue the present sequence. In either case leave (A) in its initial state.

ONE-WAY UNCONDITIONAL JUMP INSTRUCTIONS

1. MANUALLY SELECTIVE JUMP (45jv): If the number j is zero, take (v) as NI. If j is 1, 2 or 3, and the correspondingly numbered MJ selecting switch is set to "jump", take (v) as NI; if this switch is not set to "jump" continue the present sequence.

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2. RETURN JUMP (37uv): Let y represent the address from which CI was obtained. Replace the right-hand 15 bits of (u) with the quantity y plus 1. Then take (v) as NI.

3. INTERPRET (14--): Let Y represent the address from which CI was obtained. Replace the right-hand 15 bits of (F_1) with the quantity Y plus 1. Then take (F_2) as NI.

STOP INSTRUCTIONS

1. MANUALLY SELECTIVE STOP (56jv): If $j = 0$, stop computer operation and provide suitable indication. If $j = 1, 2, \text{ or } 3$ and the correspondingly numbered MS selecting switch is set to "stop", stop computer operation and provide suitable indication. Whether or not a stop occurs, (v) is NI.

2. FINAL STOP (57--): Stop computer operation and provide suitable indication.

EXTERNAL EQUIPMENT INSTRUCTIONS

1. EXTERNAL FUNCTIONS (17-v): As designated by (v) select a unit of external equipment and cause it to perform a function.

2. EXTERNAL READ (76jv): If $j = 0$, replace the right-hand 8 bits of (v) with (IOA); if $j = 1$, replace (v) with (IOB).

3. EXTERNAL WRITE (77jv): If $j = 0$, replace (IOA) with the right-hand 8 bits of (v) ; if $j = 1$, replace (IOB) with (v) . Cause the previously selected unit to respond to the information in IOA or IOB.

4. PRINT (61-v): Replace (TWR) with the right-hand 6 bits of (v) . Cause the typewriter to perform the operation specified by the 6-bit code.

5. PUNCH (63jv): Replace (HPR) with the right-hand 6 bits of (v) . Cause the punch to respond to (HPR). If $j = 0$, omit seventh level hole; if $j = 1$, include seventh level hole.

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ADDRESS STRUCTURE

The standard address structure for the 1103A is as follows:

<u>Addresses in Octal Notation</u>	<u>Storage Class</u>
00000 - 07777	Magnetic Core (1st bank, 4096 Registers)
10000 - 17777	Magnetic Core (2nd bank, 4096 Registers)
20000 - 27777	Magnetic Core (3rd bank, 4096 Registers)
31000 - 31777	Q-Register
32000 - 37777	Accumulator
40000 - 77777	Magnetic Drum (16,384 Registers)

This is in contrast to the address structure which is standard for the Model 1103 which is as follows:

<u>Addresses in Octal Notation</u>	<u>Storage Class</u>
00000 - 01777	Magnetic Core (1024 Registers)
10000 - 17777	Q-Register
20000 - 27777	Accumulator
30000 - 37777	Unused
40000 - 47777	Magnetic Drum (16,384 Registers)

It is realized that some 1103A installations will prefer to use the 1103 address structure. The 1103 address structure will be provided on an optional basis upon request. In this case, only one bank of Core Storage (4096 Registers) is possible. The address range of the Core Storage extends from 00000 to 07777 to accommodate the 4096 Registers.

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INSTRUCTION EXECUTION TIMES

The following table contains execution times for the non-repeated instructions in the Model 1103A computer. In each case the instruction references are to the magnetic core storage. The times are given in microseconds.

With the exception of the Threshold Jump (42uv) and the Equality Jump (43uv) instructions, the execution times for repeated instructions can be determined by subtracting 14 microseconds from the non-repeated execution times with the exception of the last execution of the repeated instruction which takes the non-repeated duration. For example:

75jnw (Repeat)

1luv (Transmit Positive)

The execution times for the Repeat and Transmit Positive instructions are 42 microseconds and 40 microseconds respectively. The execution time for a repeated Transmit Positive is therefore 26 microseconds (40 microseconds minus 14 microseconds). The total time, therefore, is the sum of the times: $42 + (n-1) 26 + 40$ microseconds, or the Repeat time plus $n-1$ repeated Transmit Positive times plus a non-repeated Transmit Positive time. This expression may be reduced to $56 + 26n$ microseconds.

In the case of a repeated 42uv or 43uv instruction, ten microseconds must be added to the time of extracting the next instruction from v if a jump is executed. If these instructions are executed n times with a jump termination, 14 microseconds must be added to the last execution time as in the other instructions.

INSTRUCTION EXECUTION TIME
MC TO MC

INSTRUCTION	MICROSECONDS
11uv	40
12uv	42
13uv	40
14--	34
15uv	40
16uv	40
17-v	32
21uv	66
22kv	34+2k
23uv	68
27uv	58
31uk	34+2k
32uk	34+2k
33uk	36+2k
34uk	36+2k
35uv	48
36uv	50
37uv	38
41uv-Jump	58
41uv-No J.	48
42uv-Jump	46
42uv-No J.	46
43uv-Jump	58
43uv-No. J.	58
44uv	20
45jv-Jump	20
45jv-No J.	20
46uv	20
47uv	32

INSTRUCTION	MICROSECONDS
51uv	48
52uv	50
53uv	80
54uk	48+2k
55uk	46+2k
56jv-Stop	4
56jv-No S	20
57--	2
61jv	38 (note 1)
63jv	38 (note 2)
71uv	$122+10(u)_{35} + 8 \sum_{i=0}^{35} (u)_i$
72uv	$194+10(u)_{35} + 8 \sum_{i=0}^{35} (u)_i$
73uv-Max.	$486 + 8(A)71$
73uv-Min.	$480 + 8(A)71$
74jv	$124 + \gamma$ (note 3)
75jnw	$42 + R_n + P$ (note 4)
76jv	32 (note 5)
77jv	32 (note 5)

NOTES:

1. Plus a lockout time of 105ms for successive prints.
2. Plus a lockout time of 16.6ms for successive punches.
3. Where $\gamma \equiv 2[36-k \pmod{72}]$ and k is the scale factor: $0 \leq k \leq 71$. For $k = 37$, use value for $k = 38$.
4. Where P = time for jump to F₁ and R_n = execution time of repeated instruction; if $n = 0$, R_n = 0.
5. Plus some lockout time for successive reads or writes

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LEFT TRANSMIT INSTRUCTION
COMMAND TIMING

1 December 1955

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Instruction: Left Transmit (LTj_kv)

OPERATION CODE: 22

Left circular shift (A) by k places. Then replace (v) with (A_L) if j = 0; or replace (v) with (A_R) if j = 1.

MP	COMMAND		SOURCE	DEST
0	Clear X		CTC-AR	X
	Transmit UAK to SAR		CTC-PCR	UAK
1	Initiate Shift A		CTC-SKC	SKC
	Wait Internal Reference (See Note)		CTC-PDC	PDC
2	If j = 0	If j = 1		
	Transmit (A _L) to X Clear SAR	Transmit (A _R) to X Clear SAR	CTC-AR CTC-SAR	A SAR
5	Transmit VAK to SAR		CTC-PCR	VAK
	Initiate Write 0-35		CTC-SCC	SCC
	Wait Internal Reference		CTC-PDC	PDC

Note: No wait is generated if "k" is zero.

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PROGRAM INTERRUPT

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PROGRAM INTERRUPT

GENERAL

The program interrupt permits external equipment to automatically interrupt a program when the equipment is ready to communicate with the computer. The computer, upon receipt of an interrupt signal, completes the current instruction and procures the next instruction from the fixed address F_3 . Normally F_3 contains a Return Jump instruction which causes a return to the main program after execution of some subroutine. Usually such a subroutine will provide for transfer of information between the computer and the interrupting equipment.

In the case of free running external equipment such as the punched card equipment and the lineprinter use of the program interrupt permits maximum computation between transfers of information. Terminal equipment requiring sporadic input/output may operate in the interrupt mode so as to free the computer to execute other programs when not processing information for the interrupting equipment. A pushbutton on the control console is available for manual interruption of a program.

THE PROGRAM INTERRUPT FEATURE

A computer operation consists of two parts:

- Part One - the execution of the current instruction.
- Part Two - the acquisition of the next instruction.

At the start of Part One, the Program Control Registers already contain the current instruction as a result of the second part of the previous operation, and the contents of the Program Address Counter is $y+1$, where y is the address from which the current instruction was obtained. Unless the current instruction changes the contents of the Program Address Counter, the next instruction will be obtained from address $y+1$. Thus, in a normal program sequence successive instructions are obtained from consecutive addresses.

A computer operation is effected by a series of wired-in commands. During an operation from one to eight Main pulses are generated, the number of Main Pulses being commensurate with the number of non-simultaneous commands required to execute the operation. The execution of the current instruction is performed by those commands initiated by Main Pulses MP0 through MP5; Main Pulses MP6 and MP7 are reserved for the procurement of the next instruction. MP6 and MP7 are the same for all instructions except a repeated instruction.

MAIN PULSE

COMMANDS

MP 6

Transmit the contents of the Program Address Counter to the storage Address Register

Advance the Program Address Counter

Initiate Read (read the contents of the address in the Storage Address Register and transmit these contents to the X-Register)

MP 7

Transmit the contents of the X-Register to the Program Control Registers.

Thus as the following MP 0 is issued the execution of the next instruction begins.

However, if the interrupt is activated during the execution of an instruction, an "interrupt" signal changes the series of commands issued on MP 6.

MAIN PULSE

COMMANDS

MP 6

Set the Storage Address Register to fixed address $F_3 = 00002$.

Initiate Read (read the contents of address F_3 and transmit these contents to the X-Register)

There are no changes in the MP 7 commands. It should be noted that the Program Address Counter still contains the address of the next program instruction; this address will be placed in storage by the execution of a Return Jump instruction stored at address F_3 . The u-address of the Return Jump instruction specifies wherein the contents of the Program Address counter are to be stored for future reference, and the v-address of the Return Jump instruction specifies the starting address of the subroutine to be used in operating the interrupting external equipment.

The program interrupt is activated by a signal on an interrupt line in the computer. This signal may originate in any external equipment whatsoever. There is also an INTERRUPT pushbutton on the Supervisory Control Panel together with an INTERRUPT ENABLE switch and ENABLE INDICATOR. With this INTERRUPT button a program may be manually interrupted by an operator.

USE WITH FREE-RUNNING EXTERNAL EQUIPMENTS

The program interrupt can be used to advantage with free-running external equipments which do not stop after processing each word of information. The punched card equipment and lineprinter fall in this class. Using the interrupt

feature, the external equipment automatically interrupts the program when it is ready to communicate with the computer. Thus the programmer need not carefully determine the division of computer time between computing operations and external operations.

At the time the external equipment is ready to transfer information between itself and the computer, a subroutine is initiated whose purpose is to obtain a word from storage or to place a word into storage. The subroutine must be completed in a specified time called the "receptive time" of the free-running external equipment. For instance, the receptive time of the punched card equipment is 1.5 milliseconds for a punching operation and 10 milliseconds for a reading operation. As an automatic precaution against errors arising from programs which violate these restrictions, an IO FAULT occurs.

In the case of external equipment with a limited receptive time, restrictions are imposed on (a) the length of time it takes the computer to execute the subroutine which processes information for the interrupting equipment and (b) the length of time it takes the computer to finish executing the current instruction and issue MP 6. The later restriction will in many cases preclude references to the magnetic drum since it may take as long as 34 milliseconds to access a drum address. Similarly, the use of the Repeat instruction is limited. For if the instruction being executed at the time the external equipment is ready to communicate is a repeated instruction, MP 6 is bypassed. Only when the Repeat sequence has been completed and MP 6 is issued during execution of the jump instruction in F_1 will the program be interrupted.

USE FOR INTERMITTANT INPUT

It is evident that the program interrupt facilitates sporadic input from either on-line equipment or high priority problems which demand immediate access to the computer. The routines for such may be stored in the computer memory at all times and entered by means of the program interrupt. Such a routine may initially store the status quo of the interrupted program. Later the interrupted program may be restored and the computer will resume executing that program at the point of interruption. The program interrupt may also be used to facilitate changing parameters in a program which is being executed by the computer. For instance, if it is desired to adjust a program on the basis of observed output, the adjusting parameters may be set up in some external device and inserted in the program by actuating the program interrupt.

THE UNIVAC SCIENTIFIC
MAGNETIC TAPE STORAGE SYSTEM
(MODEL 1103A)

1 December 1955

Remington Rand

DIVISION OF SPERRY RAND CORPORATION

ENGINEERING RESEARCH ASSOCIATES DIVISION

1902 WEST MINNEAPOLIS AVE. ST. PAUL, MINN. 55102

THE UNIVAC SCIENTIFIC
MAGNETIC TAPE STORAGE SYSTEM

GENERAL DESCRIPTION

The Magnetic Tape Storage System of the Model 1103A Computer System comprises a number of Uniservo tape handling mechanisms, which are located externally to the computer, and an electronic control section which is located within the computer structure. The number of Uniservos used is optional up to a maximum of ten functional units. By means of manual selections the unit designations may be assigned in any manner to the functional units. Use of the Uniservo units makes possible off-line processing of information by a variety of Univac peripheral equipments.

TAPE CHARACTERISTICS

Eight-channel recording is employed with the Unitapes; six channels contain data, one channel contains a parity check bit on the six data channels, and one channel is used to record a sprocket, or timing, signal.

Information is recorded in blocks of 720 hexabit characters or lines on the tape, each block thus containing 120 complete 36 bit computer words. A recording density of 128 lines per inch is standard. The blocks are normally separated by a "dead" space of one inch on the tape. Up to 325,000 computer words may be stored on a standard 1500-foot reel of tape.

To provide tapes which can be used with all the Univac auxiliary equipments, several optional recording formats can be selected by program control. Optional selections include an interblock space of 2.4 inches and a subdivision of a block into six blockettes each containing 120 hexabit characters and having a one-inch, one-tenth-inch, or zero spacing between blockettes. In addition, an optional recording density of 50 lines per inch is permissible.

The magnetic tape is always stopped in the "dead" space between blocks. A block of information is recognized by means of the timing signals. The end of a block is detected by a timing device, actuated in the last blockette, which signifies the end of the block if the interval between timing signals exceeds a certain length of time.

A tape speed of 100 inches per second is standard. The free-running transfer rate of information between the computer and tapes is, therefore, about 1810 computer words per second using a one-inch interblock spacing and zero blockette spacing.

SELECTION AND INSTRUCTION CONTROL

The External Function instruction (17-v) is used to initiate the various reading, writing, and positioning operations of the Uniservos through the Selection and Instruction Control portion of the electronic control section. Coded information provided by the External Function instruction includes the following: (1) designation of the selected Uniservo, (2) type of recording format, i.e., which block and blockette spacing is to be used and which recording pulse density is to be used, and (3) type of tape operation to be performed.

TAPE OPERATIONS

An External Function instruction is programmed to initiate a tape operation. In the case of a reading or writing operation, the External Function instruction which initiates the operation must be followed by an appropriate number of External Read (76jv) or External Write (77jv) instructions to transfer the information between the Input/Output Register and the computer memory.

1. READ FORWARD. - Read data from the magnetic tape, assemble into 36-bit computer words, and transfer the words to the Computer Input/Output Register, IOB.

The initiation of this operation causes the designated Uniservo to read a number of blocks from the tape. The reading operation must be terminated by a "Stop" External Function instruction which is programmed immediately following the External Read instruction used to read the last word in the final block. If it is desired to read one block only, the "Stop" code is included in the "Read Forward" External Function instruction which precedes the 120 External Read instructions.

2. WRITE FORWARD. - Transfer words from the computer Input/Output Register, IOB, and record on the Uniservo tape in six segments of six bits each.

The initiation of this operation causes the Uniservo to write a number of blocks on the tape and the writing must be terminated by a "Stop" External Function instruction which must be programmed immediately following the External Write instruction used to write the last word in the final block. If it is desired to write one block only, the "Stop" code is included in the "Write Forward" External Function instruction which precedes the 120 External Write instructions.

3. READ BACKWARD. - Identical to "Read Forward" except that the tape is moved in the reverse direction. Computer words are assembled in the same order as for the Read Forward operation.

4. MOVE FORWARD (n BLOCKS). - Move the tape forward n blocks without a read or write operation ($0 \leq n \leq 2^{12}-1$).

5. MOVE BACKWARD (n BLOCKS). - Move the tape backward n blocks without a read or write operation ($0 \leq n \leq 2^{12}-1$).

6. STOP. - Stop the tape after the current block has been completed.

The stop is used to terminate a reading or writing operation. A "Stop" External Function instruction must be programmed immediately following the terminal External Read or External Write instruction used to read or write the last word in the final block. In the case of reading or writing a single block, the "Stop" code is included in the initiating External Function instruction.

7. REWIND. - Rewind the tape to the leader position.

8. REWIND INTERLOCK. - Rewind the tape to the leader position and set an interlock which prevents further references to that tape unit.

More than one Uniservo cannot perform an operation at any one time with the exception of the "Rewind" and "Rewind Interlock" operations. After one of the rewind operations is initiated, the Uniservo proceeds under its own control until the operation is completed; therefore, an operation on another unit may be performed before rewinding is completed. Any number of functional units may be rewinding concurrently.

TRANSFER CONTROL, PARITY CHECK, AND 720 CHECK

The Transfer Control portion of the Magnetic Tape Control System controls the transfer of information between the computer and the magnetic tapes through a 36-bit Tape Register, TR. The writing operation involves the breaking down of the 36-bit computer word in six 6-bit characters and the generation of a parity check bit for each character. The parity check bit is a "0" if the number of "1"s in the character is odd, and the parity check bit is a "1" if the number of "1"s in the character is even; this always results in an odd sum if the character and parity bits are added together. During the reading operation the parity check is made on each character read from the tape. A "zero" sum indicates a parity error. When a parity error is detected, a "1" is placed in bit IOA₀ of the IOA Register and the tape unit stops at the end of the block.

When a block of information is read from magnetic tape, a check is also made to determine if the proper number of lines are recorded in the block. As each line is read from tape, a counter is tallied. Since a properly recorded block contains 720 lines, any variation from this causes a 720 check failure. This stops the tape unit and places a one in IOA₃.

The contents of IOA must be examined by the program immediately following the execution of the External Read instruction used to read the last word in the final block. If no error occurred, the program proceeds. If an error did occur, the tape unit is stopped automatically at the end of the block, and a standard subroutine in the computer can be used under control of the main program, to perform re-reading operations in an attempt to read the block correctly.

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The Uniservos have two features which may permit proper reading of marginal signals which have resulted in a parity check failure. These are (a) the ability to read the magnetic tape backward and (b) the ability to change the voltage bias. Since these changes may be made under program control, it is possible to use a reread subroutine without stopping the computer.

METHOD OF RECORDING

An "erase before writing" method of recording is employed by the Uniservo tape units. That is, the tape is first "erased" to all "0"s and information is then written by recording only the "1"s. This is achieved by means of an erase head which is placed in front of the read-write head in the Uniservo. Since tape is erased several inches in advance of the writing head, in writing a block, part of the succeeding block is destroyed. Not only the information channels but also the timing channel is erased. Thus any later attempt to either read or move over the partially erased block will lead to a 720 check failure.

TABLE 1

EXTERNAL FUNCTION BIT ASSIGNMENT
FOR UNISERVO CONTROL

The Uniservos are controlled by the External Function instruction (17-v). The External Function instruction transfers the contents of the v-address to the Input/Output Register, IOB. The 36-bit word thus introduced into IOB designates the magnetic tape operation to be performed. This IOB word is interpreted by the Selection and Instruction Control portion of the Magnetic Tape Control System.

IOB ₃₁	- = 1 - Select Magnetic Tape Storage
IOB ₂₃ -IOB ₂₂	- Select Rewinding and Stopping = 01 - Rewind = 10 - Rewind Interlock = 11 - Stop
IOB ₂₁	- Select Block Spacing = 0 - 1" interblock spacing = 1 - 2.4" interblock spacing
IOB ₂₀ -IOB ₁₉	- Select Blockette Spacing = 00 - zero spacing = 01 - 0.1" spacing = 10 - 1.0" spacing
IOB ₁₈ -IOB ₁₆	- Select Tape Operation = 001 - Read Forward = 010 - Move Forward = 011 - Write Forward (128 lines/inch) = 101 - Read Backward = 110 - Move Backward = 111 - Write Forward (50 lines/inch)
IOB ₁₅ -IOB ₁₂	- Select Uniservo unit or bias level = 0001 - Uniservo 1 = 0010 - Uniservo 2 . . . = 1010 - Uniservo 10 = 1101 - Normal bias = 1110 - Low bias = 1111 - High bias
IOB ₁₁ -IOB ₀	- Select the number of blocks to be moved.

TABLE 2

UNITAPE STANDARDS

<u>Equipment</u>	<u>Tape Length (feet)</u>	<u>Density (Characters/inch)</u>	<u>Inter-Blockette Space-inches</u>	<u>Inter-Block Space-inches</u>
Unityper II	200	50	2.4	2.4
Uniprinter II	1500	50	0	2.4
Univac I Internal	1500	128	0	2.4
Card-to-Tape II	1500	128	1.2 - 2.2	2.4
Tape-to-Card I	1500	128	.1	2.4
High Speed Printer	1500	128	1.0	2.4
	1500	50	2.4	2.4
Teletape-to* Unitape	200	128	1.0	1.0
Unitape-to* Teletape	1500	128	1.0	1.0
Unitape Trans-* mission	1500	128	1.0	1.0
Univac Scientific- internal	1500	128	0	1.0

*Under Development

VARIABLE BLOCK LENGTH
ON THE
1103A UNISERVO TAPE SYSTEM

1 December 1955

Remington Rand

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MODEL 1103A

VARIABLE BLOCK LENGTH ON THE 1103A UNISERVO TAPE SYSTEM

GENERAL

As an additional feature, extra control circuitry will be provided on an optional basis to allow a variable block length format on the 1103A Uniservo tape system. The standard fixed block length format mode of operation is not altered in any manner by the addition of variable block equipment.

Program selection of the variable block mode is accomplished by setting bits IOB₁₉ and IOB₂₀ both equal to one in the word issued by the External Functions Instruction. The control of the various tape functions is provided by the same control bits as for fixed block length format with three exceptions:

1. The variable block mode automatically selects the one inch interblock spacing.
2. Writing on tape in the variable block mode can be done at a pulse density of 128 pulses per inch only.
3. There is no provision for space between blockettes.

READING VARIABLE BLOCK

Variable block length reading is initiated, one block at a time, by an External Function (17-v) instruction with the following bits selected: IOB₁₉ = 1, IOB₂₀ = 1 (Variable Block); all other "selects" being the same as those for fixed block length reading. In the same manner as in fixed block reading an External Read instruction must be programmed to transmit each computer word from IOB into storage.

The tape unit will automatically stop at the end of the block. This control function is achieved by sensing the absence of sprocket pulses in the space between blocks. Specifically, the stop control is activated when the sprocket pulses have been absent for a period of time equal to that of 12 sprocket pulses. A code will be placed in IOA to indicate the end of block condition. This code consists of a one in IOA₁.

When writing on the tape, an erase head erases the tape a length of 5 inches ahead of the write head. Because of this, at the end of the last variable block, there will be a 5 inch end of variable record gap. An attempt to read in this gap will cause the tape unit to stop and an end of variable record indicator to be placed in IOA. This indicator consists of a one in IOA₂.

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In variable block reading, the hexabit character parity check is retained. A parity error causes an indicator to be placed in IOA. This indicator consists of a one in IOA₀.

It is possible to program an External Function instruction to stop tape reading during the reading of a variable block. In this case, the tape unit is braked to a stop. The exact distance the tape will coast cannot be precisely determined and if the read operation is again resumed information will be lost.

WRITING VARIABLE BLOCK

Variable block writing is initiated by an External Function (17-v) instruction, with the following bits selected:

IOB₁₉=1, IOB₂₀=1; all other "selects" being the same as for fixed block writing. As with fixed block writing, an External Write instruction must be programmed for each word transmitted from storage to the tape unit.

At the end of the writing operation, a stop External Function selection must be issued immediately following (within 25 microseconds) the terminal External Write instruction.

There is an erase head spaced approximately five inches preceding the read/record heads, thus the five inch space following the last written block will be blank. This space is used to sense the end of variable record condition when reading.

An odd-even check bit is automatically recorded with each hexabit character on the tape.

THE UNIVAC SCIENTIFIC
INPUT/OUTPUT INTERLOCK SYSTEM
ON IOA AND IOB

1 December 1955

Remington Rand

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DESCRIPTION OF THE
INPUT-OUTPUT INTERLOCK SYSTEM
ON IOA AND IOB

A functional part of each of the input-output registers IOA and IOB is a flip-flop interlock.

1. Transmissions from IOB or IOA to external equipment.

When an External Write instruction causes IOB or IOA to be loaded from storage, the flip-flop interlock is set to the "one" state. The removal of this word from IOA or IOB by a piece of external equipment sets the interlock back to the "zero" state. In the event that a second External Write instruction is executed before the external equipment has obtained the previous word from IOA or IOB, the execution of the External Write instruction is held up until the interlock is cleared (at the time the previous word is transmitted to the external equipment).

However, if the external equipment calls for the next word from IOA or IOB before IOA or IOB has been loaded by an External Write instruction, an IO FAULT will occur. This is a class B computer fault.

2. Transmission to IOB or IOA from external equipment.

When a transmission from a piece of external equipment to IOA or IOB occurs, the flip-flop interlock is set to the "one" state; the execution of an External Read instruction causes the flip-flop to be set back to the "zero" state. If an External Read instruction attempts to read from IOA or IOB before the flip-flop has been set to the "one" state by the external equipment the execution of this instruction is held up. When the next word is transmitted from the external equipment, the flip-flop is set to the "one" state and the External Read instruction is completed. If the external equipment attempts to transmit a word to IOB or IOA when the flip-flop is in the "one" state (the last word is still in IOA or IOB), an IO FAULT will occur. This is a class B fault.

The general principle which is achieved by the interlock system is that if the computer is proceeding at a rate faster than the peripheral equipment, the computer waits at each input or output operation for the peripheral equipment. On the other hand, if the computer cannot keep up with the peripheral equipment, the IO FAULT occurs.

THE UNIVAC SCIENTIFIC
STORAGE OF LOADING ROUTINES

10 December 1955

Remington Rand

DIVISION OF SPERRY RAND CORPORATION

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MODEL 1103A

THE UNIVAC SCIENTIFIC STORAGE OF LOADING ROUTINES

General

Programs may be loaded into the Univac Scientific, Model 1103A by means of the Uniservo tape units, the punched card equipment or the photoelectric reader. Since each of these input devices is controlled by the External Function instruction, a short stored program is required to read information into the computer. A program for loading from magnetic tape, punched cards or paper tape can be more or less permanently stored on the magnetic drum. However, the loading routine is subject to obliteration by programming or operating errors and tests of the drum system.

The need for manually reentering a loading routine may be avoided by storing a copy of the routine in the relatively invulnerable "dead space" on the magnetic drum. Should the loading routine in the normal drum storage be damaged, it may be restored by a transfer from the dead space.

The Magnetic Drum Dead Space

In addition to the tracks on the drum which are used for storage of information there is a timing track and a mark track. The timing track notches are used to identify discrete angular positions of the drum. The mark track contains a single notch which serves as a reference point during each drum revolution from which angular positions are counted. The first 4096 timing notches following this mark indicate the lines on the drum which are normally addressable. Those positions between angular position 4095 and the mark at angular position 0 are called the "dead space". Every drum has a dead space of at least 128 lines.

The angular position of the drum corresponding to a program address is identified by a coincidence between the contents of the Angular Index Counter and the interlaced address. Normally there is no communication with the dead space since when the Angular Index Counter reaches 4095 the next timing pulse produces an "end carry" which disables the coincidence detector until the mark is reached. The Angular Index Counter continues counting. At the mark the Angular Index Counter is reset to zero and the coincidence detector enabled.

By means of an ABNORMAL/NORMAL DRUM switch on the Supervisory Control Panel the lockout on the coincidence detector may be reversed. When this switch is set to ABNORMAL, the lockout is established by the mark pulse. The coincidence detector then remains disabled until the Angular Index Counter counts up to 4096. In this case there is no communication with the normal 4096 lines of drum storage but the lines of the dead space are addressable.

ADDRESSING THE DEAD SPACE

The addresses available in the dead space duplicate the normal drum addresses but because of interlace are not completely consecutive. For example, assuming 128 lines are used in the dead space, the addresses available with an 8 interlace are:

40000 - 40017

41000 - 41017

42000 - 42017

- - -

47000 - 47017

with comparable sets for groups 5, 6, and 7. When the ABNORMAL DRUM is selected references to these addresses will result in communication with the dead space. References to other addresses will cause the computer to "hang up". When the NORMAL DRUM is selected there is no communication with the dead space.

A relatively inaccessible switch is available for disabling the MD WRITE VOLTAGES except during normal operation. This is to insure that operating errors will not affect programs stored in the dead space.

UNIVAC PERIPHERAL EQUIPMENT
FOR USE WITH THE
UNIVAC SCIENTIFIC, MODEL 1103A

1 December 1955

Remington Rand

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UNITAPE

UNITAPE

PURPOSE

The Unitape is used to record data, instructions, or constants for the Univac Scientific System.

BASIC SPECIFICATIONS

The tape is metallic, 1/2" wide and approximately 0.002" thick. It is supplied in 1500', 500', 200' or 100' lengths as ribbon wound on reels 8" in diameter. The shorter reels, 200' and 100' are primarily for use with the Unitypers. A reel 6" in diameter is used with Unityper II.

The plated surface of the tape will withstand at least 700 passes over a magnetic reading-recording head without destroying or causing appreciable deterioration of the magnetic properties. Under normal conditions several times as many passes may be expected.

RECORDING

Information is recorded on the tape by the Unityper, Card-To-Tape Converter and by Univac Scientific. The density at which the characters are recorded depends upon the component or in the case of Univac Scientific upon the instructions used. Characters may be recorded at a density of 100 to 128 pulses per linear inch or 50 pulses per linear inch.

CAPACITY

The tape capacity of a 1500' reel depends upon the density of the recording.

High Pulse Density

1,440,000 characters
240,000 words
2,000 blocks

Low Pulse Density

288,000 characters
120,000 words
1,000 blocks

The equivalent capacity of the tape is approximately 16,000 to 25,000 punched cards.

TAPE ERASURE

The metallic tape may be erased as often as desired and new information recorded on it.

SPECIAL FEATURES

A joint is provided at the end of the tapes to permit the quick connecting or disconnecting of tapes without rethreading.

Rubber bumps near each end of the tape provide for automatic stopping of the tape. A metal ring inserted in the inside rim of the reel prevents the operation of the "Write" instruction providing a safety feature against accidental erasure of the tape. When the recording on the tape is to be preserved, this ring is inserted by the operator. Its use still permits the tape to be read. A rubber plug prevents the tape from unwinding.

Tapes are carefully tested to ensure proper recording surfaces. Holes are punched before and after any imperfect areas and additional tape length allowed for the punched areas. For example, 1625' are supplied for a 1500' tape. The punched holes are sensed and passed over by the components on which the tape is used.

UNISERVO

THE UNISERVO

PURPOSE

The Uniservo transports tape over a standard magnetic head (for reading and recording) under the control of Univac Scientific Computer System.

BASIC SPECIFICATIONS

The Uniservo is housed in a cabinet, the upper section of which contains the reel mounts and is covered by a sliding plastic door. The door cannot be opened without turning off the main operating switch on the front panel of the Uniservo. The entire front panel is easily removed, giving access to the loops.

Height	61"
Width	30"
Depth	21-3/4"
Working Space	6'5" by 5'9"-3/4"
Weight	463 lbs.

OPERATION

INPUT FUNCTION

A Uniservo may be used to read the coded, magnetic dots on the tape moving forward or backward and transfer the data in the form of electronic pulses to Univac Scientific.

OUTPUT FUNCTION

A Uniservo may be used to record the results of Univac Scientific processing in the form of coded, magnetic dots on a metallic tape moving forward.

REEL MOUNTS

The reel mounts hold the standard 6 inch or 8 inch reel of tape.

TAPE HANDLING SYSTEM

There are 3 independent servo systems - the center drive and the reel motor servos. The center drive is controlled by Univac Scientific. The tape around the center drive hub is isolated from the tape reels by two loops of tape. The reel servos are controlled by loop size detectors.

MYLARTAPE CONTROL

Mylartape is used between the reading and writing head of the Uniservo and the magnetic tape. The Mylartape moves at approximately 10 inches per hour. It prevents the reading head from wearing and drastically reduces magnetic tape wear.

STANDARD MAGNETIC HEAD

The standard magnetic head reads from or records in 8 channels. Seven of the channels are used for the six data bits and a parity bit of the Univac Scientific System and the 8th channel is a sprocket channel.

TAPE SPEED

100" per second.

SAFETY SWITCHES

The Uniservo is fully equipped with safety switches which stop all motors and apply brakes if either of the two loops exceeds the prescribed limits.

CONTROL

The control of a Uniservo is maintained by Univac Scientific and exercised during a program by the following types of instructions:

- Read Forward
- Read Backward
- Record at high pulse density
- Record at low pulse density
- Rewind without interlock
- Rewind with interlock
- Move Forward
- Move Backward

CONNECTION TO UNIVAC SCIENTIFIC

As many as 10 Uniservos may be connected to Univac Scientific at any one time. Uniservos may be electrically interchanged without affecting the program.

POWER REQUIREMENTS

Power for the Uniservos is supplied by Univac Scientific.

UNITYPER II

UNITYPER II

PURPOSE

Unityper II records on metallic magnetic tape the coded symbols of the alphabetic and numeric characters of a standard typewriter keyboard as well as certain symbols used by the Univac System and prints simultaneously a typed copy of the recording.

PHYSICAL CHARACTERISTICS

Unityper II consists of three units assembled together: a modified Remington Electric Typewriter, a Tape Panel, and a Power Supply.

Height	14-1/4"
Width	17"
Depth	24"
Weight	100 lbs.

The Unityper II is a self-contained, portable unit which is intended for operation on a regular drop-center typewriter desk of suitable center depth. The working space required for a Unityper II is the same as that allowed for a typewriter. A tape panel is placed on top of a special case-work extending to the rear of the basic typewriter unit. The power supply is located under the tape panel and contains all the necessary circuitry to provide voltages for recording and erasing.

OPERATING CHARACTERISTICS

A. The Remington Electric Typewriter

The Remington Electric Typewriter keyboard includes all the standard alphabetic and numeric characters and punctuation marks. The letter spacing is 12 characters per inch. Certain modifications to the standard keyboard and type font have been made which are as follows:

1. All alphabetic characters are represented by capital (upper case) letters.
2. The numerals appear on the top row of keys in their usual lower case position and include a key for the figure 1 located to the left of the key for figure 2.
3. A standard ten key numeric bank (3 keys wide and 4 keys high) is superimposed on the right half of the alphabetic keyboard in the upper case positions. Other upper case positions either duplicate the alphabetic characters in the lower case positions or carry special Univac Symbols for editing and controls, and additional punctuation symbols.

4. Operation of the space bar places a caret (^) on the copy.

B. The Tape Panel

The Tape Panel houses the following:

1. the take-up reel with a fixed length of leader attached to it.
2. the supply reel mount on which the operator places the tape before recording. Unityper II uses a reel, six (6) inches in diameter. It holds 200 feet of tape on which more than 55,000 characters can be recorded.
3. a magnetic head for recording.
4. an erasing head which obliterates previously recorded information before the new recording takes place.
5. other electrical and mechanical devices required to control the direction and timing of the tape motion.
6. the operating lever which controls the cycle of LOAD LEADER, TYPE, REWIND and UNLOAD operations.

C. The Power Supply

Unityper II operates from 115 volt, 60 cycle, AC single phase power lines. Its power consumption is 75 watts. Line voltage variations of as much as + 10% are permissible.

D. Recording Operation

1. Typing Rate

A mechanical bail interlock system is incorporated in the typewriter to prevent the striking of two keys at once. This device limits the typing rate to a maximum of twelve (12) characters per second.

2. Pulse Density

The coded symbols are recorded by Unityper II on the metallic tape at a density of 50 characters per linear inch.

3. Line Length

A ten-inch carriage travel is permitted, allowing 120 digits to be placed on a line. A line guide with 120 numbered divisions indicates to the typist the digit position at any point in the line. Each line of 120 digits is referred to as a "blockette" and occupies 2.4 inches on the tape. When the carriage reaches the 121st digit position, the operator may then operate the TRIP Key which will print an underscore and return the carriage. As the carriage is returned, an additional 2.4 inches of tape move by the head to allow for space between blockettes.

4. Block Length

A block of information consists of six (6) blockettes (including the space between blockettes) or 720 digits and occupies 28.8 inches on the tape. Space between blocks is the 2.4 inches between the 6th blockette of one block and the 1st blockette of the next.

E. Control Keys

1. Operating Lever

A mechanical operating lever is mounted on the left side of the Tape Panel and controls the cycle of LOAD LEADER, TYPE, REWIND and UNLOAD. The lever is pulled by the operator to perform two types of operation: to load the leader or to rewind the tape. The tape moves during these operations without motion of the carriage. The lever is inoperative, when the access door to the Tape Panel is open, when the carriage is not in the first character position, or when a Load or Rewind operation is in progress.

LOAD LEADER

As the operating lever indexes the control cam into the LOAD LEADER positions, Unityper II automatically loads fifteen feet of tape as a leader on the takeup reel.

REWIND

In the first-digit position of any line or blockette, an operator may choose to type or to REWIND. To REWIND the operator pulls the operating lever.

2. Fill Selector Switch

The operator may select, with the use of the Fill Selector Switch, either zeros or space symbols to fill in the rest of the field, blockette or block (See Tabulator or FILL Key).

3. Backspace Key

The backspace key moves the carriage and tape backwards one digit-space at a time, erasing the information on the tape at the same time.

4. Erase Key

Operation of the erase key returns the carriage to the beginning of the line, advances the paper feed, moves the tape backwards to the beginning of the blockette, and erases all recorded information in that blockette.

5. Fill Key

Operation of the fill key causes the carriage to move to the next tabular stop. As it does so, the tape is also moved a corresponding distance and fill-in characters are recorded on the tape. The tabular stops are set manually and function in the same manner as those on a standard typewriter.

6. Trip Key

When the TRIP Key is depressed at the 121st digit position, it will:

- a. print an underscore
- b. return the carriage
- c. move the tape forward 2.4 inches to allow for space between blockettes and blocks.
- d. advance the paper feed.

No information is recorded on the tape during the TRIP operation.

CHECKING FEATURES

1. The access door to the Tape Panel is locked while the operator loads the leader, types and rewinds the tape.
2. The keyboard is locked during the LOAD LEADER, REWIND and UNLOAD operations.
3. The operator cannot move the carriage in either direction except from the keyboard, in which case there is either some symbol printed on the paper, or a blank area of paper which indicates a fill-in operation.
4. The TRIP Key may be depressed at any position other than the 121st digit position, but will merely print an underscore without moving either carriage or tape and without recording any character on the tape.
5. If a REWIND operation is attempted when the carriage is in any but the first-digit position, the operating lever turns freely, but neither the tape nor the carriage moves.

UNIPRINTER

UNIPRINTER

PURPOSE

The UNIPRINTER converts the coded, magnetic dots recorded on a metallic tape to a typewritten copy.

BASIC SPECIFICATIONS

The UNIPRINTER consists of two assemblies connected together by a cable: the Tape Reader and the Printing Unit.

	<u>Tape Reader</u>	<u>Printing Unit</u>
Height	47-1/2"	44-1/2"
Width	29"	29"
Depth	21-1/2"	21-1/2"
Working Space	6'5" by 5'9-1/2"	6'5" by 5'9-1/2"
Weight	410 lbs.	244 lbs.

OPERATION

TAPE READER

The Tape Reader contains the motors and standard magnetic reading head over which the tape passes. It also contains its own power supply and other electronic components.

PRINTING UNIT

The Printing Unit is an integral part of the UNIPRINTER. It prints the letters, numbers and symbols that are read from a tape mounted on the Tape Reader and performs the typewriter actions such as Carriage Return, Tabulator Key, etc., in accordance with pulse combinations on the tape (See Printing Unit).

SPEED

About 10 characters per second.

CONTROL SWITCHES

A set of switches for control of power and starting and stopping the operation of the UNIPRINTER are found on the top at the right hand side. A forward and rewind switch controls the direction of the tape. An operate and clear switch clears the circuits prior to operation. (See also Control Switches for Printing Unit).

UNIPRINTER

POWER REQUIREMENTS

The UNIPRINTER operates from 110 volt 60 cycle AC single phase power lines.
The current rating is about 9 amperes.

THE UNIVAC
HIGH SPEED PRINTER

THE UNIVAC
HIGH SPEED PRINTER

PURPOSE

The High Speed Printer is a device for transcribing data, read by a Uniservo from Univac magnetic tape, to paper.

PHYSICAL CHARACTERISTICS:

The High Speed Printer is housed in four cabinets one of which contains a modified Uniservo, another of which contains the paper supply and feed system and the printer unit, and the other two of which contain the electronic circuitry necessary to control the tape and printing unit.

	<u>Height</u>	<u>Width</u>	<u>Depth</u>	<u>Weight</u>	<u>Floor Area</u>
Printer Unit	48"	47-1/2"	32"	800 lbs.*	10.9 sq. ft.
Electronic Unit (PS)	66-1/2"	50-7/8"	32"	2000 lbs.*	11.1 sq. ft.
Electronic Unit (MEM)	66-1/2"	50-7/8"	32"	1200 lbs.*	11.1 sq. ft.
Tape Unit (Servo)	60"	30"	24"	650 lbs.	5.0 sq. ft.

* Approximate

OPERATING CHARACTERISTICS:

A. The Tape Unit

The magnetic tape unit for the High Speed Printer is a clutch-operated Uniservo. It reads the blockettes from the tape to the electronic unit according to the requirements of the printing unit. The Uniservo operates with the standard 1500 ft. reels of magnetic tape. The pulse density can be either that produced by the Unityper II (about 50 per inch), or the Card-To-Magnetic-Tape Converter (about 120 per inch), or by the Computer System Uniservo (about 128 per inch). In the latter case each block of data should occupy about 13.4 inches of which 2.4 inches is the space between blocks, 5 inches are the 5 spaces (of 1" each) between the blockettes, and 6 inches are the spaces occupied by the 6 blockettes. Up to 7500 blockettes can be put on each High Speed Printer reel of tape.

B. The Printing Unit

1. Printing Speed - The optimum balance between speed and quality of printing is attained by running the High Speed Printer at 400 lines per minute. However, the printer is supplied with pulleys to provide a selection of printing speeds of 200, 400 or 600 lines per minute. Since print quality is improved at lower speeds, it is

recommended that the printer be run at 200 or 400 lines per minute. If an unusually heavy printing load is encountered the 600 lines per minute speed can be used to handle these transient loads.

2. Character Span - 130 per line.

Although each blockette contains only 120 characters, the printer has 130 wheels, the additional ten of which may be used also by proper wiring of a plugboard. These 10 additional characters when used, are duplicate printings of characters elsewhere in the blockette.

3. Characters Spacing

10 per inch horizontally; 6 per inch vertically.

4. Characters Available

26 alphabetic capitals;

10 numerals;

15 miscellaneous symbols and punctuation marks as follows:

* \$ % . , - * ° + : ; () & /

Total - 51 characters.

5. Lines Per Inch

6 for single space;

3 for double space;

2 for triple space;

6. Paper

The paper feed will handle any sprocket fed paper up to cardstock, either blank or preprinted, from 4" to 27" in overall width. At least 4 carbon copies and one original copy can be made using paper between 11 and 13-1/2 pounds in weight.

7. Plugboards

The High Speed Printer contains a two-panel plugboard with a total of 1632 hubs. The function of the plugboard is to control the format of the printed page. One section of the plugboard controls the relationship between the position of a character on the tape and its printing position in normal printing. Other sections of the plugboard are required in multi-line printing to select the characters to be printed on each line and to place them in the desired positions. Some or all of the above sections are also brought into use for multiple printing. Other sections are involved with zero suppression and finally, one small section controls the line spacing (single, double, or triple space).

8. Fast Feed

Operating synchronously with the paper is a paper loop on which up to 7 channels can be punched with holes. When the paper feed is under the control of the paper loop, the paper is advanced at the rate of 20" per second until a hole appears in the controlling channel. The particular arrangement of holes on the paper loops is governed by the particular layout or form. Four of the channels are responsive respectively to the symbols @, /, ?, and = previously recorded on the tape. The appropriate symbol is placed in the first digit position of the blockette concerned. The fifth and sixth channels are self-responsive. Whenever a hole appears in the fifth channel, the fast-feeding starts and continues until a hole is encountered in the sixth channel. The fifth channel is overridden if a symbol calling any of the first four channels into operation is received simultaneously. A fast feed symbol must cause at least one line to be skipped. The seventh channel responds to the paper homing operation.

9. Multi-Line Arrangement

Any blockette of 120 characters may be multi-line fed through operation of the multi-line feeding plugboard instead of the normal plugboard. The appearance of a carriage return symbol (r) in the first or second digit position of the blockette depending upon absence or presence of a fast-feed symbol initiates this mode of operation. The blockette may be printed in as many as 6 continuous lines arranged in any way desired as set up by the plugboard.

10. Zero Suppression

Zeros to the left of the first significant digit can be suppressed in up to 18 fields. A minus sign is considered a significant digit. Different zero suppression fields can be observed on normal printing from those on multi-line printing.

11. Printer Breakpoint

The appearance of the printer breakpoint symbol (β) will stop the machine and prevent the printing of the blockette in which the printer breakpoint symbol appears provided the breakpoint switch has been set to observe the breakpoint.

12. Printer Stop

The appearance of the printer stop (Σ) will stop the machine and prevent the printing of the blockette in which the printer stop symbol appears.

13. Multiple Plugging

Characters may be plugged so as to print up to three times on the same line for normal printing. In multiline printing a character may be printed up to three times on each line of the group.

C. Control Keys

1. Start Mode Switch

The Start Mode Switch has three positions: start initial, start continuous and single line. The start initial position causes the printer to clear the memory, read in a new blockette, print it and continue to cycle thereafter. The start continuous picks up wherever the printer may have stopped, prints the contents of the memory and continues from there. The single line start prints the memory and then stops, leaving the memory intact.

2. Breakpoint Switch

By means of this switch breakpoint symbols recorded on the tape may be either observed or ignored.

3. Home Paper

Under the control of the paper loop the "home paper" circuit advances the paper to a position of readiness for the first line.

4. Tape Load

The tape load key causes the tape leader to move over the reading head but to stop before the first blockette appears.

5. Read, No Print Switch

The Read, No Print Switch causes the printer to read successive blockettes in either direction without printing them. In conjunction with the Breakpoint Switch, the Read, No Print Switch is useful for searching through a tape. The Printer Stop symbol stops the Read, No Print operation in any event, as does a tape error.

6. The Manual Stop Switch

The Manual Stop Switch stops the printer after the reading operation but before printing. The switch may be operated at anytime. In particular, the read, no print operation may be used to search a reel lacking breakpoint symbols, in conjunction with the manual stop operation. This may be followed by a single-line start operation.

7. Read One Block Forward or (Backward)

The Read One Block switches causes the printer to read one blockette from the tape in either direction and then stop. If used in conjunction with the Read No Print Switch, however, reading continues until an FFI symbol is encountered. Normally, an FFI symbol marks the beginning of a form.

8. Print, No Read Switch

The Print, No Read Switch causes the printer to print the blockette in the memory repeatedly. The tape does not move.

9. Computer Digit Switch

Under normal operating conditions, the printer interprets as functions or ignores the various non-printing symbols, as the case may be. However, by setting the computer digit switch to computer digit copy and using a plugboard which is set up with a basically one-to-one wiring, the printer can be made to produce a copy from which all tape characters can be interpreted. Since only 51 characters of a possible 63 appear on each type wheel, dual purpose is assigned to certain characters. In order to distinguish printing characters from non-printing characters in computer digit copy, two lines are used: the first line contains only normal copy, the second line contains only the substitutive symbols for non-printing symbols. A table of equivalents can be supplied.

10. Paper Spacing

By means of the paper spacing control key the paper may be advanced one line (single, double, or triple space, as set up).

11. Paper Position

Fine adjustment of the paper position (particularly for positioning the printing with respect to pre-printed lines on forms) may be done while the printer is in operation.

12. Impression Control

Impression control permits variation in the strength of the printing hammer stroke.

D. Power Requirements

Approximately 15.2 kva of 60-cycle AC plus about 1 kva of power at convenience outlets are required by the High Speed Printer. This power can be taken from any two wire input in the range of 190 to 250 volts. Basically designed for a single phase power input, the power can be obtained also from either a 2- or 3- phase system. No external regulation is necessary.

CHECKING FEATURES

The following checking features are provided:

1. Each coded combination from the tape is subjected to an odd-even check. Each combination from the memory is also checked. Any even combinations at either point stop the printer.

2. The number of characters within each blockette from the tape is counted; if any blockette contains more or less than 120 characters, the printer stops.
3. The address lines going into the gas-tube type memory for storing each blockette between reading and printing are checked in order to ensure that every address is used at least once.
4. The driving circuit for each printing hammer is checked for failure to fire or spurious firing.
5. A fast-feed symbol from the tape overrides a fast-feed signal from the loop. If both signals should occur simultaneously, the single-digit memory for the loop fast-feed must be cleared before fast-feeding can occur. A check circuit inhibits further operation if the loop fast-feed memory is not cleared in the presence of a fast-feed signal from the tape.
6. The printer stops if the tape reached its end.
7. The printer stops when the paper supply runs out.
8. The printer stops when the ribbon supply runs out.

THE UNIVAC
MAGNETIC TAPE-TO-PUNCHED CARD
CONVERTER

THE UNIVAC

MAGNETIC-TAPE-TO-PUNCHED-CARD CONVERTER

PURPOSE

The Magnetic Tape-To-Punched-Card Converter is used to read data from Univac magnetic tape and convert that data into standard 12 row 80 column punched cards. Various checking circuits observe the process and give warning in the event of fault or error.

PHYSICAL CHARACTERISTICS:

The Magnetic Tape-To-Punched-Card Converter consists of three cabinets, one of which contains a modified Uniprinter Tape Reader, one of which contains a card punch and the third of which contains the electronic circuitry necessary to control the tape and card punch units in addition to the equipment for reading, punching and checking. In addition a small motor generator set is provided as part of the equipment.

	<u>Length</u>	<u>Width</u>	<u>Height</u>	<u>Weight</u>	<u>Floor Area</u>
Card Punch	38"	36"	48"	800 lbs.	9.4 sq. ft.
Tape Unit	30"	24"	60"	400 lbs.	5.0 sq. ft.
Electronic Unit	190"	*40"	**90"	3,000 lbs.	39.5 sq. ft.
Motor Generator Set	56"	18"	20"	600 lbs.	7.0 sq. ft.

* with air conditioner

** with air conditioner duct work

The three units and the motor generator set are appropriately cabled together. Cooling is provided by a commercial air conditioning unit which is furnished with the system. The commercial air conditioner must be supplied with ordinary tap water at a rate depending upon the water temperature and varies approximately as follows:

45 F	125 gal./hour
60 F	165 gal./hour
70 F	225 gal./hour
80 F	355 gal./hour
90 F	855 gal./hour

Complete air conditioning equipment weighs approximately 750 pounds. On later production models the converter may be designed to allow an option for cooling directly from 50 degrees F water without the air conditioning unit. This modification will reduce space, weight, and power requirements slightly.

Power requirements are as follows: Single phase 220 volts \pm 10%, 70 amperes, and single phase 115 volts \pm 10%, 20 amperes, or three phase 220 volts \pm 10%, 35 amperes, and single phase 115 volts, 20 amperes.

OPERATING CHARACTERISTICS

A. Card-Punching Unit

The Card-Punching Unit will punch an 80 column card providing for the numbers 0 through 9 and the letters A through Z. If required the equipment may be furnished to include tabulator characteristics. The blank card feeding magazine has capacity for 800 cards. The receiving magazine also has an 800 card capacity. A magnetic drum unit is used for storing the data read from the tape and transferred to the cards.

B. The Tape Unit

The magnetic tape drive unit is a modified Uniprinter Center Drive Tape Panel. The tape unit accepts the standard Univac magnetic tape reel holding 1500 feet of tape.

C. The Conversion Process

1. Conversion Rate: 120 cards per minute maximum.

2. Data Allocation:

- a. One blockette on the tape (120 columns) produces one punched card.
- b. One column on the tape is punched in only one card column and one card column is punched from only one tape column.
- c. A removable plug board permits the selection and rearrangement of fields.

3. Unplugged Card Columns

The converter regards an unplugged card column as a blank column while a plugged card column, which receives a code combination for which there is no punch hole combination, will cause an error and stop the converter.

4. Reel Capacity

A 1500 foot magnetic tape reel prepared for use with the Tape-To-Punched-Card Converter holds approximately 1850 blocks of data, of six blockettes each.

CHECKING FEATURES

The basic sequence of operations of the Magnetic Tape-To-Punched Card Converter is to read the tape, punch a card, read the card punched, and compare this latter reading with the information read from the tape. Any detected error causes the converter to stop. The reason for the stoppage is indicated and a simple systematic routine for restart (at the point of error) is provided.

1. Comparison Check

Each card is read after it is punched to obtain the data that has been punched and compare it with that recorded on the tape. If the comparison fails to give complete equality the card is rejected and the converter stops.

2. Odd-Even Check

The blockette being read into the converter and the recording on the magnetic drum are subjected to an odd-even check. If any plugged digit of the 120 digits does not pass the odd-even check the converter stops.

3. The 120-Digit Check

The number of digits in the blockette is counted. If the count finds either greater than or less than 120 digits the converter stops.

4. Magazine Check

The converter will stop if the receiving magazine is full or the feeding magazine empty.

5. End of Tape Checking

The converter will stop when the end of information on the tape is reached. (This requires a properly placed stop code on the tape.)

THE UNIVAC
PUNCHED CARD-TO-MAGNETIC TAPE
CONVERTER

THE UNIVAC

PUNCHED-CARD-TO-MAGNETIC-TAPE CONVERTER

PURPOSE: The Card-To-Magnetic-Tape Converter is a device for reading data from standard 12-row 80-column punched cards and converting that data into a recording on Univac magnetic tape. Various checking circuits observe the process and give warning in event of fault.

PHYSICAL CHARACTERISTICS:

The Card-To-Magnetic-Tape Converter consists of three cabinets, one of which contains a modified Uniservo, one of which contains a card-feed and the third of which contains the electronic circuitry necessary to control the tape and card-feed units in addition to the equipment for reading, recording and checking.

	<u>Height</u>	<u>Width</u>	<u>Depth</u>	<u>Weight</u>	<u>Floor Area</u>
Card-Feed	36"	30"	30"	320 lbs.	6.2 sq. ft.
Tape Unit	60"	30"	24"	650 lbs.	5.0 sq. ft.
Electronic Unit	77"	50"	32"	2,265 lbs.	11.1 sq. ft.

OPERATING CHARACTERISTICS:

A. Card-Feed Unit

The punched-card feeding unit consists of an input bin with 1000 card capacity, two brush-type card-reading stations in which electrically common brushes rest over electrically isolated segments, a reject bin of 400 card capacity, an output bin of 1000 card capacity and a magnetic drum for recording and playing back a tailor-made row-sprocket signal for each card.

B. The Tape Unit

The magnetic tape unit for the Card-To-Magnetic-Tape Converter is a clutch-operated Uniservo. The tape unit accepts the standard Univac magnetic tape reel holding 1500 feet of tape.

C. The Conversion Process

1. **Instantaneous Conversion Rate:** 240 cards per minute.
2. **Pulse Density:** The recorded symbols are recorded on the tape at a density of 120 pulses per inch.

3. Data Allocation:

Each card is assigned 120 digit spaces (one blockette) on the tape. The 80 digits from the card may be rearranged in any way desired by proper wiring of a plugboard unit. If desired, up to 24 overpunched (X or Y) columns on a card may be separately recorded as minus and ampersand, respectively for the overpunches and as appropriate numerals for any other punch in the column. Further, these overpunch symbols may be distributed as desired. Thus the card data may be spread over as many of 104 digit spaces within the 120. The remaining unplugged columns are recorded as zeros or space symbols as determined by the plugboard and the blank column selector switch.

4. Unpunched (Blank) Columns:

A column carrying no hole may be recorded either as a zero or a space symbol depending upon the position of the blank column selector switch. The plugboard carries a blank column control hole by which all unpunched columns up to and including a prespecified digit in the item may be recorded as one symbol and after which as the other symbol. The choice of which symbol occurs first depends upon the blank column selector switch.

5. Reel Capacity:

Each reel of tape (1500 ft.) can hold the information from a maximum of 4000 cards.

6. Symbols Available:

The Converter can accept combinations of holes representing 26 alphabetic symbols, 10 numerals and 4 miscellaneous symbols (/,-, space, and &). The ampersand and minus signs are generated by the Y and X overpunch, respectively, the vinculum (/) by a (0-1) and the space by a nil column provided the blank column selector switch so indicates.

D. Control Keys

1. Fill-In Key:

Each operation of the fill-in key inserts an entire block of minus signs on the tape or completes a partially filled block so as to indicate the end of the information on the tape.

2. Leader Key:

Each operation of the leader key inserts about 15 feet of blank leader.

3. Rewind Key:

The rewind key causes the Uniservo to rewind the tape.

4. Blank Column Selector Switch:

The blank column selector switch has two positions marked "0" and space (Δ). Whichever symbol is indicated by the switch pointer is used to record any unpunched holes unless the blank-column control hole of the plugboard is connected to one of the item positions (2 to 120) of the Column Split Control section of the plugboard. In the latter case the opposite nil symbol is used from the item position prior to the position plugged to the blank column control hole through the rest of the blockette.

E. Power Requirements:

The Card-To-Magnetic-Tape Converter requires approximately 11KVA of 60-cycle A.C. This power can be taken from a 208-volt source (across two lines of a three-phase system) or a 230-volt source. Line voltage variations of as much as $\pm 10\%$ are permissible.

CHECKING FEATURES:

The basic mode of operation of the Card-To-Magnetic Tape Converter is to record on the tape, read backward and read forward from the tape, the last operation taking place in conjunction with a second reading of the card through a second and independent set of brushes into circuitry which, although the same as used on the first reading, has been so shifted in relation to the brushes that each punch position is handled by a different memory element.

1. Mispunch Detector:

This mispunch detector examines each column for more than one punch in each of three domains: (X, Y, 0) and (1-9). If either of these domains contains more than one punch the card is rejected.

2. Misfeed Detector:

Each card as it passes the first reading station generates the feed signal for the next card. If ever a card fails to feed, the Converter no longer attempts to feed cards until the operator provides another start signal.

3. Comparison Check:

Each card is read twice, the first time to obtain the data that is recorded on the tape, the second time to provide again the card data for comparison with the data recorded on the tape from the first reading. During the time between the two card-reading operations, the tape is reversed and repositioned at the beginning of the current blockette. If the comparison fails to give complete equality, the card is rejected, the Converter stops feeding cards, and the tape is repositioned for recording over the same area of tape.

4. Odd-Even Check:

During the reverse cycle between record and comparison, the newly recorded blockette is subjected to an odd-even check; during the forward comparison the data are given another odd-even check. If any of the 120 digits do not pass the odd-even check the card is rejected and the Converter stops.

5. The 120-Digit Check:

During the backward read and the forward comparison check, the number of digits in the blockette is counted. If either count finds either greater than or less than 120, the card is rejected, the tape is repositioned, and the Converter stops.

6. Card Counter:

The Card Counter is advanced each time all other checks applied to a card conversion have been met. If any check fails, the counter is not permitted to move. In addition, the counter itself is checked to ensure its operation.

7. Recording Level Check:

Separate signal and noise checks are made on each recording by switching the tape amplifier gain between the backward and the forward cycles.

THE HIGH SPEED PRINTER
DIRECTLY CONNECTED
TO THE
UNIVAC SCIENTIFIC

1 December 1955

Remington Rand

DIVISION OF SPERRY RAND CORPORATION

ENGINEERING ***R***ESearch ***A***SSOCIATES DIVISION

1402 WEST MINNEHAPA AVE ST PAUL WA MINNESOTA

Remington Rand High Speed Printer
Directly Connected
to the
Univac Scientific Computer
Model 1103A

The Remington Rand High Speed Printer is normally operated off-line by means of Univac tape. It is optionally available to be directly connected to the Univac Scientific, Model 1103A, computer system.

In this on-line mode, information is transmitted to the buffer storage of the high speed printer through IOB. The high speed printer buffer storage has a capacity of twenty 1103A words (one blockette of information on the Univac tape.) This buffer store must be loaded with twenty words for each line that is printed.

Control of the high speed printer on the on-line mode is by means of the External Function instruction. The printing operation is initiated by the presence of a bit in IOB₃₀ placed there by the execution of the External Function instruction. Following this, twenty External Write instructions must be executed to set up the printing of one line. Succeeding lines are printed by the transmission through IOB of twenty words per line.

To drop the High Speed Printer selection, an External Function instruction must set bits IOB₃₀, IOB₂₃ and IOB₂₂ equal to one.

The time of execution of the twenty External Write instructions will be approximately ten milliseconds. There is then a 90 millisecond interval for the printing operation. The input-output interlock functions in the normal manner to allow synchronization and under standard mode the computer would be locked out for the 90 millisecond period. However the high speed printer will be capable of using the program interrupt feature which will free the computer for other computation during the 90 millisecond period.

EXTERNAL FUNCTION BIT ASSIGNMENT
FOR THE
UNIVAC SCIENTIFIC
(Model 1103A)

1 December 1955

Remington Rand

DIVISION OF SPERRY RAND CORPORATION

Engineering Research Associates DIVISION

1902 WEST MINNEHAHA AVE. ST. PAUL W4 MINNESOTA

Model 1103A

Univac Scientific

External Function Bit Assignment

Certain external equipments are controlled by the External Function instruction (17-V). At present these are the Ferranti Tape Reader, the punched card equipment, the Lineprinter, the Oscilloscope Display Unit and the Uniservo tape units. The External Function instruction transfers the contents of the V-address to the Input/Output Register IOB. The 36-bit word thus introduced into IOB designates the external equipment operations to be performed.

The following is the assignment of master bits for selecting existing external equipments: The master bit must be used with each External Function instruction to select a particular equipment.

- IOB₃₅ - Card Unit*
- IOB₃₄ - Line printer
- IOB₃₃ - Ferranti Tape Reader*
- IOB₃₂ - Oscilloscope Display Unit
- IOB₃₁ - Uniservo Tape Units

Specific functions of the external equipment are selected as follows:

CARD UNIT

- IOB₀ - Read
- IOB₁ - Punch
- IOB₂ - Pick Read Card
- IOB₃ - Pick Punch Card
- IOB₄ - Stop (drop selection)
- IOB₅ - Free Run
- IOB₇ - Interrupt
- IOB₃₅ - Start Cycle (master bit)

LINEPRINTER

- IOB₉ - Stop Paper
- IOB₁₀ - Print

*This master bit differs from that assigned to equipment used with Model 1103 computers

- IOB₁₁ - Interrupt
- IOB₁₂ - Skip
- IOB₁₃ - Jump
- IOB₃₄ - Start (master bit)

FERRANTI TAPE READER

- IOB₁₅ - Stop Reader
- IOB₁₆ - Start Reader (Free run)
- IOB₃₃ - Select Reader (Master bit)

OSCILLOSCOPE DISPLAY UNIT

- IOB₁₈ - Close Shutter
- IOB₁₉ - Open Shutter
- IOB₂₀ - Operate Shutter
- IOB₂₁ - Stop Display
- IOB₂₂ - Initiate Display
- IOB₃₂ - Select (Master bit)

UNISERVO TAPE UNITS

- IOB₀ . . . IOB₁₁ - Block Count (Tape movement)
- IOB₁₂ . . . IOB₁₅ - Uniservo Selection and Bias Selection
- IOB₁₆ . . . IOB₁₈ - Read, Write, Move Selection
- IOB₁₉ . . . IOB₂₀ - Blockette Spacing, Variable Block Length Selection
- IOB₂₁ - Block Spacing
- IOB₂₂, IOB₂₃ - Rewind and Stop Selection
- IOB₃₁ - Select Uniservo Units (Master bit)

PUNCHED PAPER TAPE EQUIPMENT
FOR USE WITH THE
UNIVAC SCIENTIFIC, MODEL 1103A

(An excerpt from PX 71905)

1 December 1955

Remington Rand

DIVISION OF SPERRY RAND CORPORATION

ENGINEERING RESEARCH ASSOCIATES DIVISION

1902 WEST MINNEHAHA AVE ST. PAUL W4, MINNESOTA

TELETYPE BRPE² HIGH SPEED TAPE PUNCH
EQUIPMENT FUNCTIONAL CHARACTERISTICS

Designed for use with: High speed message traffic or data handling systems where all impulses of each permutation code signal are conveyed to the Punch simultaneously. Used with seven-level perforated tape.

Functional
Characteristics:

This equipment consists of a motor driven, magnet controlled, perforating device for preparing fully perforated tape. It is equipped with a tape reel and brake assembly which controls the tape tension during the rapid acceleration and deceleration of the tape that occurs during the rapid starting and stopping of the tape feed.

Operating Speeds: Maximum of 60 tape frames per second.

Approx. Physical
Characteristics

Dimensions: Approximately 7-1/2 x 11 x 17 inches

Power: 110/120-volt, 50/60-cycle, single-phase

Finish: Grey Crackle

Theory of Design: The motor of this equipment is connected to the punching mechanism without the interposition of a clutch. An eccentric on the main shaft is connected

with a punch bail. This punch bail is connected to a number of drag links (which operate the punch pins) through sets of two toggle arms. In no signal operation, the toggle joint of the two arms is broken by a blocking bawl, and no holes are punched. When a signal is received for a particular level of the tape, an appropriate armature is energized, removing its respective blocking bawl. A hole is then punched for that level.

A similar arrangement is used to drive the tape feed mechanism. A drag link, not under the control of a blocking bawl, is used for punching the feed hole in the tape.

Start-stop and information signals used to operate this equipment are received from the auxiliary control circuitry but are synchronized by an impulse originating in the Punch unit itself.

Operation:

An 8-inch tape reel is used for supplying tape to the unit. Means are provided for indicating tape supply still on reel. A drawer is provided for chad disposal. Output tapes may go into baskets or onto takeup reels.

FERRANTI MARK II TAPE READER
EQUIPMENT FUNCTIONAL CHARACTERISTICS

Designed for use with: High-speed electronic digital computers. It may be used with a 5 or 7 unit standard teleprinter tape.

Functional Description: This equipment consists of a photoelectric perforated tape reader with a friction type tape drive. No lens are used in the photoelectric system. The drive mechanism is controlled by auxiliary circuitry.

Operating Speeds: Maximum of 200 tape frames per second.

Approx. Physical Characteristics

Dimensions: 9 x 11-1/2 x 11-1/4 inches, 37 pounds

Power: 115/230-volt, 50/60-cycle, single-phase

D. C. Voltages ($\pm 4\%$ Stabilized)

+300 volts (5 ma.)

+150 volts (20 ma.)

-150 volts (20 ma.)

-300 volts (5 ma.)

Finish: Grey Crackle

Theory of design: This equipment is designed for long life, reliable operation, and minimum tape wear. The drive mechanism is designed for fast starting and stopping. Since no

sprocket wheels are used, tape damage is minimized.

A friction drive is used for feeding the tape through the Reader, the driving roller forming part of a differential gear system whose cage is driven continuously by an induction motor. The roller is started and stopped by the application of electromagnetically operated brakes to one or the other of the output shafts of the differential.

The outputs of the photocells of the photoelectric system are amplified before being presented to the auxiliary equipment. A feed-hole pulse, coincident with the other outputs and obtained from the photocell associated with the tape sprocket hole, may be used in controlling the tape movements.

Operation:

The equipment is designed for rapid loading of paper tapes. Tapes may be supplied from either baskets or supply reels. The output tape may go into a basket or onto a takeup reel.

FERRANTI SPOOLER

EQUIPMENT FUNCTIONAL CHARACTERISTICS

Designed for use with: Ferranti Mark II Tape Reader specifically, but is suitable for many other applications. Tape widths of 11/16 to 1 inch may be used.

Functional Description: The equipment is a dual purpose unit designed to feed tape either to or from a reel under low tension.

Operating Speed: Maximum of 25 inches per second.

Approx. Physical Characteristics:

Dimensions: Approximately 12 x 10 x 7 inches

Power: 115-volt, 60-cycle, single-phase

Finish: Grey Crackle

Theory of Design: The tape is passed over guide pillars, and looped around a sensing arm, free to move under its own weight up and down in a slot. The relatively light weight of the arm produces the only tension on the tape. Depending on which mode of operation is used, the spool motor is driven or braked when the arm reaches its upper position. The reverse action occurs when the spool is in its lower position.

Operation:

This equipment is suitable for paper tape of any width between 11/16 and 1 inch which is wound on a 2 inch diameter hub. The maximum capacity is a reel of 8 inch outside diameter, representing a length of nearly 1000 feet of tape 0.004 inch thick.

The changeover from take-up to supply is made by a two-position switch, and in either mode the tape may be let out on either end of the unit.

The unit is provided with a convenient carrying handle.

REMINGTON RAND PERFORATED TAPE COMPARATOR

EQUIPMENT FUNCTIONAL CHARACTERISTICS

Designed for use with: Seven level perforated paper tape.

Functional Description: This equipment contains a dual tape drive which allows two perforated tapes to be read in synchronism. The data in corresponding frames of the two tapes are compared. The tapes are driven at full speed until a difference is detected, whereupon they stop. This allows an operator to inspect tapes and mark the faulty frame.

Operating Speeds: Each tape runs at 3 inches per second or 30 frames per second.

Approx. Physical Characteristics

Dimensions: Do not exceed 12 x 12 x 12 inches, 3 pounds.

Power: 115-volt, 60-cycle, single-phase.

Type of Cabinet Work: Compatible with Tape Printer in appearance.

Finish: Remington Rand Grey Crackle.

Theory of Design: This equipment is designed for long life, reliable operation and minimum tape wear. The reader is driven by a motor and a clutch designed for fast stopping when an error is found. The tape sensing

pins drive type C or transfer contacts to allow direct comparison of the two sets of pins when they are sensing holes. Contacts are closed for full 180° of cycle. A common contact provides proper timing for the flow of sensing current.

Operation:

This equipment is designed for easy loading and unloading of paper tapes. It is arranged such that tapes can be supplied from either baskets or supply reels. Likewise, the output tapes may go into baskets or onto takeup reels.

The tapes will stop in a known position after an error is detected so that there is no question as to which frames contain the discrepancy which has been detected.

The comparison is independent of tape code but will allow the comparator to disregard one or more levels in the tape if required. This feature is handled internally and is accessible from the outside of the case.

REMINGTON RAND PERFORATED TAPE PRINTER

EQUIPMENT FUNCTIONAL CHARACTERISTICS

Designed for use with: Seven level perforated tapes containing information in binary code. Six of the seven levels are to be interpreted as biocctal numbers and the seventh level may contain control punchings. Printing is on standard 2-inch adding machine tape.

Functional Description: This equipment consists of an electromechanical perforated tape reader and a 12 digit printer of the type frequently used on adding machines. Six positions in each frame are interpreted as two octal digits so that two print bars are set for each frame of tape read. In the usual situation there is a seventh level punching in every sixth frame of tape. This punching is adjacent to the last frame of each six frame word. A counter will cause the print mechanism to be actuated every sixth frame and a comparison circuit will cause the printer to stop when there is no seventh level punching coincident with the count of six. There is an internal disconnect to allow overcoming this checking feature.

Operating Speeds: At least three frames per second.

Approx. Physical
Characteristics

Dimensions:	Do not exceed 12 x 12 x 18 inches and 15 pounds
Power:	115-volt, 60-cycle, single-phase.
Type of Cabinet Work:	Compatible with Tape Comparator.
Finish:	Remington Rand Grey Crackle.
Theory of Design:	This equipment is designed for long life, reliable operation and minimum tape wear. The nature of the tape reader to typebar translation equipment is simple and reliable.
Operation:	The equipment is designed for easy loading and unloading of paper tapes. It is such that the tape may be supplied from a reel or a basket and taken up on a reel or dumped into a basket.

ELECTRODATA MODEL 453 MANUAL TAPE PUNCH

EQUIPMENT FUNCTIONAL CHARACTERISTICS

Designed for use with: Perforated Tape. Tape may have up to eight levels.

Functional Description: The equipment is a mechanism used in punching miscellaneous holes in a paper tape.

Approx. Physical Characteristics:

Dimensions: 3-1/4 x 5 x 3-1/2 inches

Power: None required

Finish: Blue-grey crackle

Theory of Design: The unit contains the necessary parts to align and position a tape such that the desired levels of a tape frame may be punched by means of a pin inserted in the proper guide holes. Alignment of the tape is obtained by placing feed holes in the tape over guide pins mounted in the base plate.

Operation: The unit is manually operated.

GRISWOLD FILM SPLICER MODEL R-2 MODIFIED

EQUIPMENT FUNCTIONAL CHARACTERISTICS

Designed for use with: Films and tapes with a maximum width of 1-3/8 inches.

Function Description: The equipment is a mechanism used in the splicing of a perforated tape.

Approximate Physical Characteristics

Dimensions: 3-1/2 x 5 x 8-1/4 inches

Power: Non required

Finish: Black enamel

Theory of Design: The equipment contains the necessary parts required to align and cut two tapes which are to be spliced together, and to hold the ends of the two tapes together while the adhesive used is drying. Two sets of clamps, hinged to the base plate, are used to hold the tapes. Properly spaced pins in the lower jaws of the clamps are used for alignment of the tapes. Edges for cutting the tapes are mounted on the lower jaws of the clamps, the mating edges being on the base plate. When the tapes have been cut and adhesive has been applied, the tapes are held in place against the base until dry.

Operation: This equipment provides a quick, efficient means of splicing two perforated tapes.

Preliminary Characteristics
Floating Point Arithmetic
Optionally Available
on the
Univac Scientific Computer
Model 1103A

November 1, 1955

Remington Rand

DIVISION OF SPERRY RAND CORPORATION

ENGINEERING ***R***ESearch ***A***SSOCIATES DIVISION

1902 WEST MINNEHABA AVE ST. PAUL W4, MINNESOTA

Preliminary Characteristics
 Floating Point Arithmetic
 Univac Scientific Computer
 Model 1103A

As an optional feature, additional control and arithmetic circuitry will be provided to perform Floating Point Arithmetic. The repertoire of floating point instructions is as follows:

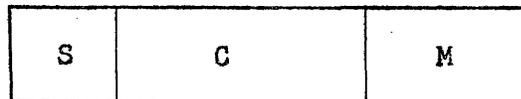
1. Floating Add (FAuv) Form in Q the normalized rounded packed floating point sum of the contents of u and the contents of v.
2. Floating Subtract (FSuv) Form in Q the normalized rounded packed floating representation of the contents of u minus the contents of v.
3. Floating Multiply (FMuv) Form in Q the normalized rounded packed floating point product of the contents of u by the contents of v.
4. Floating Divide (FDuv) Form in Q the normalized rounded packed floating point quotient obtained by the division of the contents of u by the contents of v.

The Floating Point Word

The floating point word used is a packed, normalized number, using a base 128 characteristic and a fractional mantissa. More specifically, any real number can be represented, at least approximately, by $(x \cdot 2^{27}) \cdot 2^y$, where x is a 27-bit real number such that $1/2 \leq |x| < 1$, and where y is an integer or zero. The 1103A packed normalized floating point representation selects that subset of the above approximations such that $-128 \leq y \leq 127$.

The floating point word structure is:

1 8 27



S and M denote the 1's complement representation of $x \cdot 2^{27}$, while C is the representation of $y + 128$, or, when $S = 1$, C is the 1's complement form of $y + 128$.

That is, for $x \neq 0$,

$$S = 0 \text{ if } x > 0, S = 1 \text{ if } x < 0;$$

$$x = (-1)^S \left[(1 - 2^{-27}) S + (-1)^S M \cdot 2^{-27} \right] \text{ and}$$

$$y = \left[(2^8 - 1) S + (-1)^S C \right] - 128,$$

while if $x = 0$ then $S = C = M = 0$.

If the mantissa becomes zero, or if the characteristic becomes negative, as the result of one of the four floating point instructions, the result left in Q is a positive zero.

If the characteristic exceeds 255, an alarm is initiated.

Using this word format, comparisons between two floating point numbers can be achieved by the ordinary comparison instructions. Furthermore, by using the complement form of the characteristic, instructions (Transmit Magnitude and Transmit Negative) can be used for floating point transmission.

Timing

The time required for each of the four floating point operations is given below. These times include operand access and next instruction acquisition.

<u>Floating Add</u>	Minimum	136 microseconds
	Average	181 "
	Maximum	234 "
<u>Floating Subtract</u>	As above	
<u>Floating Multiply</u>	Minimum	178 microseconds
	Average	262 "
	Maximum	392 "
<u>Floating Divide</u>	Minimum	652 microseconds
	Average	664 "
	Maximum	676 "

Registers

Besides the registers now found in the arithmetic section of the 1103A, the Floating Point modification will involve the following additional registers and transmission paths. These are internal to the Floating Point sequence control.

C register, an 8-bit register, the contents of which are always treated as non-negative. It carries no sign bit. The bit positions of the C register are designated

C₇ C₆ C₅ C₄ C₃ C₂ C₁ C₀.

D register, an 8-bit register similar to C. Its bit positions are denoted

D₇ D₆ D₅ D₄ D₃ D₂ D₁ D₀.

S register, a 9-bit subtractive accumulator. The bit positions of S are denoted

S₈ S₇ S₆ S₅ S₄ S₃ S₂ S₁ S₀.

The arithmetic in the S register is ones complement. Sg is used as both an overflow bit and a sign bit. This register is able to be complemented.

Transmission Paths

- From $(X_{34} \text{ --- } X_{27})$ to C.
- From $(S_7 \text{ --- } S_0)$ to $(X_{34} \text{ --- } X_{27})$.
- From C to D.
- From C subtractively to S.
- From D to C.
- From A_L to X.

Timing Tables

In the tables given below, it will be noticed that for each operation, the main bifurcation point has been the sign of a and c. In addition, it is possible that the exponents of the two operands differ by more than 27. If this is the case, there is said to be no intersection between a and c. If this is not the case, there is said to be intersection between a and c.

For addition, the average time has been derived by considering only the intersecting cases. The average time was computed as follows:

If a and c agree in sign,

<u>Minimum</u> add time	= 78 c.p.
<u>Maximum</u> add time	= 87 c.p.
<u>Average</u>	= 83 c.p. or 166 microseconds

If a and c are of opposite sign:

<u>Minimum</u> add time	= 79 c.p.
<u>Maximum</u> add time	= 117 c.p.
<u>Average</u>	= 98 c.p. or 196 microseconds

The average of these two figures is 181 microseconds.
The other averages are straightforward.

The reason for more than one number in certain entries (as in add, intersection, $|\text{sum}| < 1$) is that if a rounding overflow occurs, one shift may be saved.

All entries in the charts are in clock pulses, each of which is approximately 2 microseconds.

NOTE: All entries in the tables should be increased by 4 clock pulses.

Floating Add FAuv: $(u) = a \cdot 2^b$, $(v) = c \cdot 2^d$, packed and biased.

Case I a and c of the same sign

	No intersections		Intersection			
	b > d	b < d	b > d		b < d	
			Sum > 1	Sum < 1	Sum > 1	Sum < 1
a > 0	64	67	74	75 or 76	77	79 or 80
a < 0	67	70	77	78 or 79	80	82 or 83

Case II a and c of opposite sign

In the following table, s is the number of normalizing shifts required in the event that the first sum is not greater than or equal to $\frac{1}{2}$; $1 \leq s \leq 25$.

	No intersection		Intersection			
	b > d	b < d	b > d		b < d	
			Sum > $\frac{1}{2}$	Sum < $\frac{1}{2}$	Sum > $\frac{1}{2}$	Sum < $\frac{1}{2}$
a > 0	65	68	75 or 76	83 + s or 84 + s	78 or 79	86 + s or 87 + s
a < 0	66	69	76 or 77	84 + s or 85 + s	79 or 80	87 + s or 88 + s

Floating Multiply FMuv: $(u) = a_1 2^b$, $(v) = c_1 2^d$, packed and biased.

If $b + d > 127$, or if $b + d < -128$, the operation requires:

	$b \geq 0$	$b < 0$
$a \geq 0$	25	26
$a < 0$	27	28

If the multiplier is negative, its complement is entered into Q, and the characteristic position of Q is set to 0. If the multiplier is not negative, it is entered into Q, and the characteristic position set to 0. The multiply time of the mantissas is then given by the formula

$$36 + 4 \sum_{i=0}^{26} q_i, \text{ where } \sum_{i=0}^{26} q_i \geq 1.$$

The following table is the case when $b + d$ is in proper range, that is,

$$-128 \leq b + d \leq 127.$$

	<u>a and c same sign</u>			<u>a and c opposite sign</u>		
	54 bit product	53 bit product		54 bit product	53 bit product	
		Rounds to 54 bits	Rounds to 53 bits		Rounds to 54 bits	Rounds to 53 bits
$a \geq 0$	$81 + 4 \sum q_i$	$81 + 4 \sum q_i$	$82 + 4 \sum q_i$	$82 + 4 \sum q_i$	$82 + 4 \sum q_i$	$83 + 4 \sum q_i$
$a < 0$	$84 + 4 \sum q_i$	$84 + 4 \sum q_i$	$85 + 4 \sum q_i$	$83 + 4 \sum q_i$	$83 + 4 \sum q_i$	$84 + 4 \sum q_i$

Floating Divide FDuv: $(u) = a \cdot 2^b$, $(v) = c \cdot 2^d$, packed and biased

The basic divide time used in this chart is 217 clock pulses, plus 3 clock pulses if $(A_{71})_I = 1$, and plus 4 clock pulses if there is an end correction. Thus for negative dividends, the time is 220 plus perhaps 4 clock pulses; while for positive dividends, the basic time is 217 plus perhaps 4 clock pulses.

	$b - d > 127$	$b - d < -128$	
$a < 0, c < 0$	32	33	
$a < 0, c \geq 0$	31	32	
$a \geq 0, c < 0$	27	28	
$a \geq 0, c \geq 0$	26	27	

If, however, $-128 \leq b - d \leq 127$, the following times prevail.

	<u>a and c same sign</u>		<u>a and c opposite sign</u>	
	$ \text{Quotient} \geq 1$	$ \text{Quotient} < 1$	$ \text{Quotient} \geq 1$	$ \text{Quotient} < 1$
$a \geq 0$	$322 + 4e^*$	$326 + 4e$ or $327 + 4e$	$323 + 4e$	$327 + 4e$ or $328 + 4e$
$a < 0$	$328 + 4e$	$329 + 4e$ or $330 + 4e$	$327 + 4e$	$328 + 4e$ or $329 + 4e$

*e = 0 if there is no end correction; e = 1 if there is an end correction