APPLYING UNIVAC SYSTEM TO AN HOURLY PAYROLL
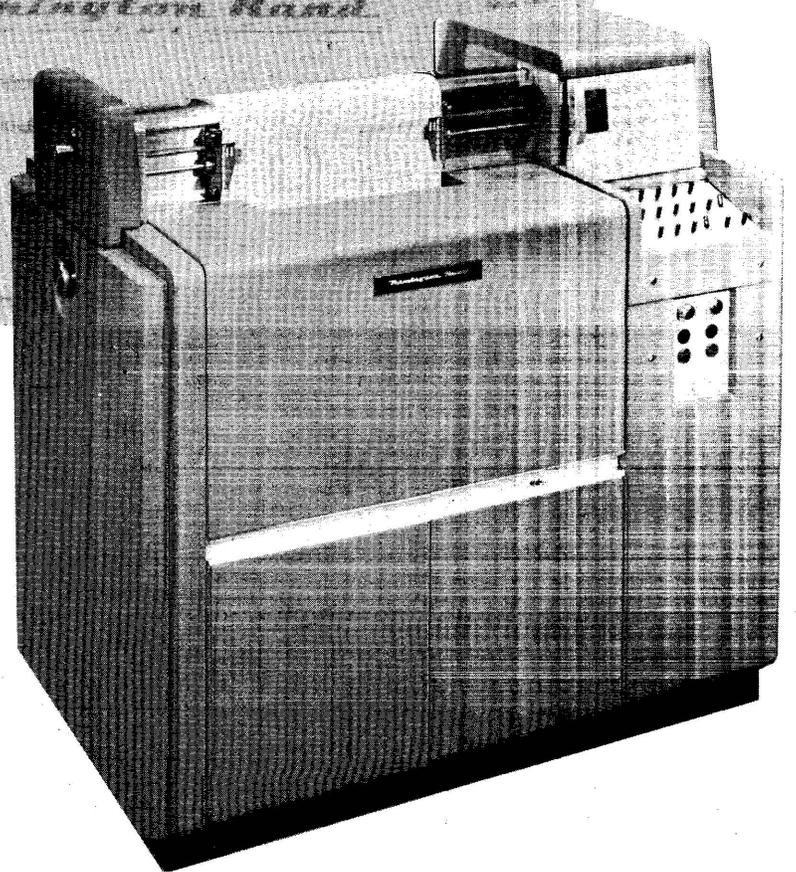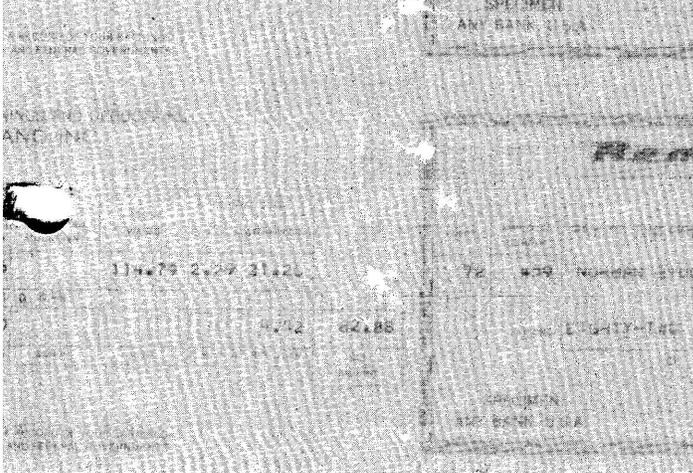
Remington Rand INC.

INTRODUCTION

This is a description of the solving of a payroll problem by the Univac System. Its purpose is to aid the student of electronic data-processing equipment in bridging the gap between his study of the B A C's of a computer code and the visualization of the computer's solving a realistic problem. The payroll problem offers an ideal bridge across this gap. The basic problem is familiar to everyone, and includes operations found in most other applications.

Although the payroll described was adapted from an actual survey, no attempt has been made to include everything found in the survey in this payroll analysis. Only those operations basic to the problem itself, or which need description, are included. To repeat, this is not a description of how a payroll *should* be done on a computer, but is a description of how a simplified payroll *could* be done.

The *unmeasured day-work payroll*, one of the many different payroll systems used by industry today, is used as an example. In this system, the employee is paid on the basis of hours in attendance rather than on performance. It is commonly used by heavy industries where the establishment of individual performance standards is not considered feasible. Such standards are essential to incentive systems. Furthermore, the payroll described here is handled in isolation from individual job-cost accounting. However, summaries of payroll data may be produced for selected clock-number groups (departments) as a by-product of the payroll operations.

Most payroll departments handle both salaried employees and employees paid by hourly wage. Salaried and hourly rolls would be prepared separately though in similar manner. This discussion is confined to the hourly roll.

In order that some practical orientation may be achieved, equipment time estimates are included. These figures relate to an hourly roll of 50,000 employees who are paid weekly.

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MASTER EMPLOYEE FILE

The master employee file tape is the basic functional record for all payroll operations. A one-block item is assigned to each employee. It includes the following fields:

FIELD	DIGITS ALLOWED
Badge number	8
Name	20
Address	28
Social Security number	9
Hourly rate	4
Days' absence allowed per year	3
Number of income-tax exemptions	2
Termination-of-employment key	1
Union dues key (indicates amount)	1
Blue Cross key (indicates amount)	1
Bond account number	6
Size-of-bond key (indicates amount)	1
Weekly bond deduction amount	4
Cumulative total of bond deductions	5
Number of days classified absence Weeks 1-13 (of a quarter)	26
Number of days personal absence Weeks 1-13 (of a quarter)	26
Number of days medical absence Weeks 1-13 (of a quarter)	26
Number of hours laid off Weeks 1-13 (of a quarter)	39
Total hours worked by week Weeks 1-13	78
Gross wages earned by week Weeks 1-13	78
Quarter-to-date total FICA- taxable earnings	6
Quarter-to-date total FICA tax	4
Year-to-date total FICA- taxable earnings	6
Year-to-date total FICA tax	4
Year-to-date gross earnings	8
Year-to-date income tax withheld	8
Available for modification of procedure	318
Total Digits	720

Note that the master file item includes basic information and certain subtotals which are maintained for quarterly and annual reports.

The master file items appear in order of the employees' eight-digit badge numbers. All items of input data pertaining to individual employees are identified and ordered by badge numbers. The first three digits of the badge number constitute the employee's clock or department number, and are changed when he is transferred from one department to another. The remaining five digits are permanently assigned to the individual employee.

The various payroll operations are performed in daily, weekly, quarterly and annual cycles. These are discussed separately, and additional details of the payroll system itself are supplied.
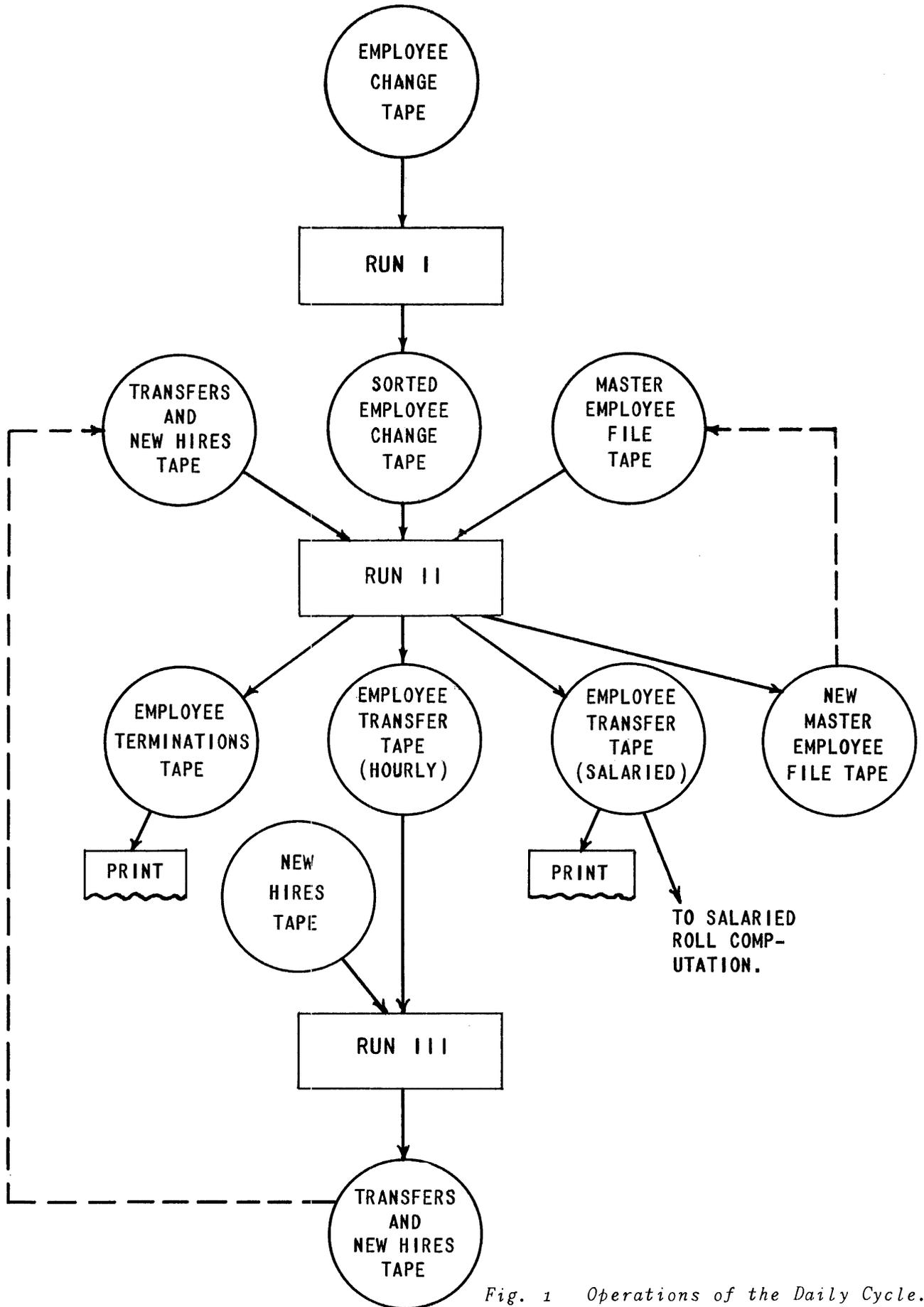
Fig. 1   Operations of the Daily Cycle.

The Daily Cycle, Fig. 1, is designed to effect changes in the master file. Changes fall into five categories:

> 1. Transfers from one department to another, the employee remaining on the hourly roll.
>
> 2. Transfers that place the employee on the salaried roll.
>
> 3. New hires.
>
> 4. Termination of employment.
>
> 5. Substitutions of new information (e.g., a wage raise, change of address, etc.)

Each change, except new hires, is represented by a two-word item, shown in Fig. 2. The first word contains the employee's eight-
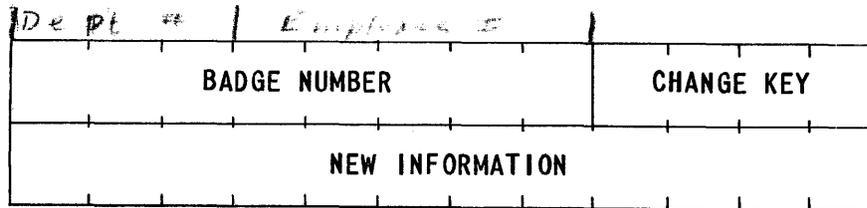

Fig. 2   Layout of Change Items

digit badge number and a four-digit key indicating the type of change (the field within the master-file item). The second word contains whatever new information is required (e.g., a new three-digit clock number in the case of a transfer). Most changes can be effected by a single change item on the employee change tape, but a change of address would require three (of the 48 digits allotted, 20 are for employee name and 28 for his address), since each change item can affect at most 12 digits.

Run I is a conventional two-word sort of the items recorded on the **employee change tape**, ordering them by the entire first word (badge number and type-of-change key). The **sorted employee change tape** is the output of Run I.

Run II accomplishes all changes in the master file. The inputs to this run are the **master file tape**, the **sorted employee change tape**, (output of Run I), and the **transfers and new hires tape** (the output of Run III from the previous day). Since the items in the master file are arranged in badge-number sequence, and since a transfer within the hourly roll involves changing the first three digits of the employee's badge number (the clock number), his
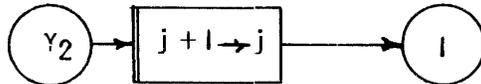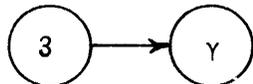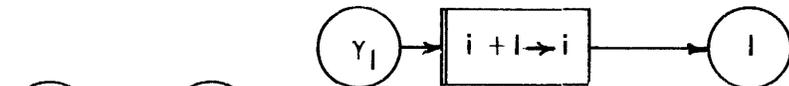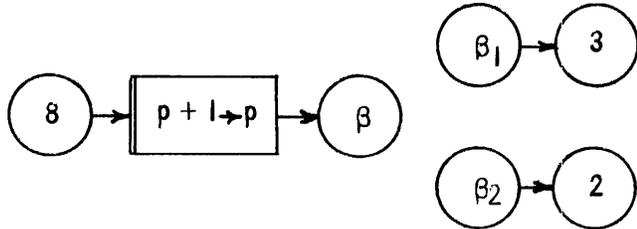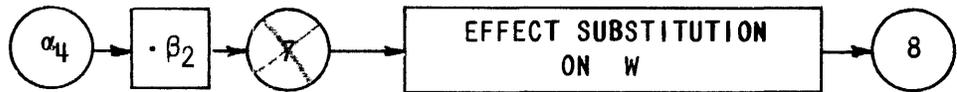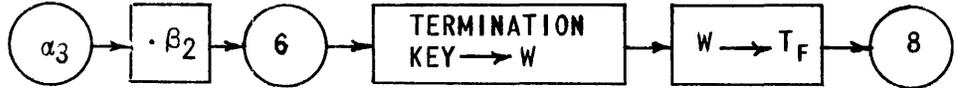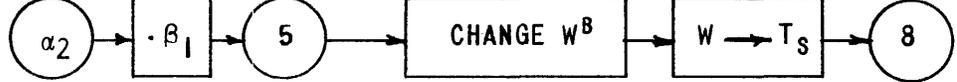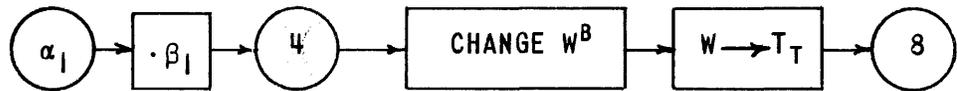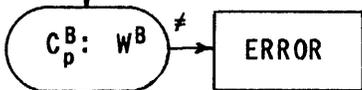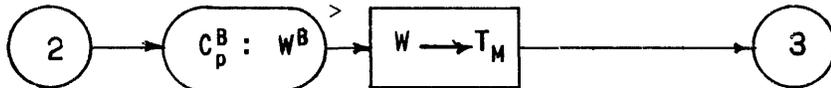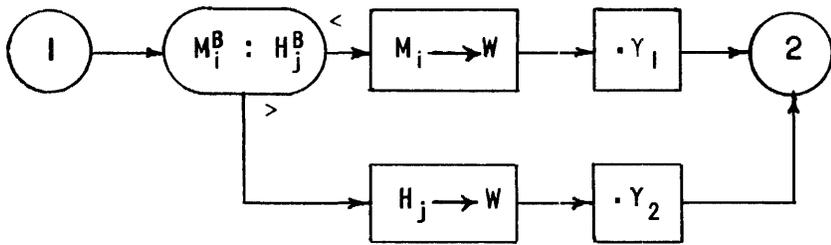
M_i : the ith item of the master employee file

M_i^B : the badge number of M_i

H_j : the jth item of the transfers and new hires tape

H_j^B : the badge number of H_j

C_p : the pth item of the sorted employee change tape

C_p^B : the badge number of C_p

K : the type of change key of C_p

T_M : the new master file

T_T : the employee transfer tape (hourly)

T_S : the employee transfer tape (salaried)

T_F : the employee termination tape

W : a master file item in working storage

$1 \rightarrow M_i^B : H_j^B$

$<$: $M_i \rightarrow W \rightarrow \cdot \gamma_1 \rightarrow 2$

$>$: $H_j \rightarrow W \rightarrow \cdot \gamma_2 \rightarrow 2$

$2 \rightarrow C_p^B : W^B$

$> : W \rightarrow T_M \rightarrow 3$

$\leq$

$C_p^B : W^B$

$\neq$: ERROR

$=$

$\cdot \alpha_K$

α

$\alpha_1 \rightarrow \cdot \beta_1 \rightarrow 4 \rightarrow$ CHANGE $W^B \rightarrow W \rightarrow T_T \rightarrow 8$

$\alpha_2 \rightarrow \cdot \beta_1 \rightarrow 5 \rightarrow$ CHANGE $W^B \rightarrow W \rightarrow T_S \rightarrow 8$

$\alpha_3 \rightarrow \cdot \beta_2 \rightarrow 6 \rightarrow$ TERMINATION KEY $\rightarrow W \rightarrow W \rightarrow T_F \rightarrow 8$

$\alpha_4 \rightarrow \cdot \beta_2 \rightarrow 7 \rightarrow$ EFFECT SUBSTITUTION ON $W \rightarrow 8$

$8 \rightarrow p + 1 \rightarrow p \rightarrow \beta$

$\beta_1 \rightarrow 3$

$\beta_2 \rightarrow 2$

$3 \rightarrow \gamma$

$\gamma_1 \rightarrow i + 1 \rightarrow i \rightarrow 1$

$\gamma_2 \rightarrow j + 1 \rightarrow j \rightarrow 1$

Fig. 3   Daily Cycle:
Flow Chart for Run II

master file item must be repositioned in the master file. Run II changes the badge number of the selected master item and writes it on the **employee transfer tape** (hourly) at the same time deleting it from the new master file tape.

Run III merges and sorts these items with the master file items of newly hired employees. The output of Run III is the **transfers and new hires tape** which will be merged with the master file during Run II on the succeeding day.

File maintenance is the basic operation of Run II and is worth a close inspection. Fig. 3 is an abbreviated flow chart of this run. It omits most of the procedure concerned with input and output. End-of-tape sentinels and end-of-block considerations are not shown. The counter operations:

$$i + 1 \longrightarrow i$$
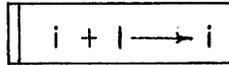
are meant to imply the input and output operations needed to make the next item available.

The first portion of Run II (operations between ① and ② accomplishes an item-by-item merge of the previous day's transfers and new hires tape with the master file tape. As each item is selected by the merge, its badge number, W^B, is compared with the badge number of the current sorted employee change tape item, C_P^B. If they are the same, the change is effected through the setting of the index **k** of the variable connector α:

α1. If the change is a transfer within the hourly roll, **k** is set to 1. This leads to the setting of the index of variable connector β to 1, and thence to ④. ④ to ⑧ changes the badge number of the master file item in working storage, W^B, and writes the item on the **employee transfer tape** (hourly), T_T.

α2. If the change is a transfer to the salaried roll, **k** is set to 2. This also sets the index of β to 1, and proceeds to ⑤. ⑤ to ⑧ changes the badge number of the master file item and writes the item on the **employee change tape** (salaried), T_S. This tape is used in the daily cycle of the salaried roll operations in a run analogous to Run III.

α3. If the change is a termination of employment, **k** is set to 3. This results in the setting of the index of β to 2, and then leads to ⑥. ⑥ to ⑧ inserts a one-digit termination key in the master file item, and writes the master file item on both the **new master file tape**, T_M, and the **employee termination tape**, T_F. The termination tape is later printed, providing information that permits paying the employee within twenty-four hours of termination. The item is retained in the master file so that it can be used in the quarterly and annual cycles.

α4. Any other changes are simple substitutions. In these cases, k is set to 4, setting β to 2 and proceeding to ⑦. ⑦ to ⑧ effects the substitution on the recorded file item.

The sequence from ⑧ to β permits making more than one change, where required, according to the setting of the index of β. Notice that termination and substitutions lead, through β, to ② , in order that the master file item may be written on the new master file tape. Transfers lead directly through β to ③ , thus deleting the item from the new master file. From ③ , the variable connector γ selects either a new master file item or a new item from the transfers and new hires tape (depending on the operations in①) ,and recommences the run with the new item.

If more than one change item applies to an employee, a sequencing of change items may be necessary. For example, if an employee's hourly rate is to be changed at the same time that he is transferred, the pay change must be effected before his master file item is written on the employee transfer tape. The first digit of the type-of-change key is the key to this sequence. Since Run I sorts the change items according to both badge number and type-of-change key, these items are sequenced in the required order.

The box labeled "error" is entered when there is a mismatch of input items. This would result from some incorrect manual operation, either in the recording on tape of change or new hire items, or an operator's error.

The equipment time estimates for the daily cycle are:

	Run I	Run II	Run III
Unityper:	3 hours		8 hours
Verifier:	3 hours		8 hours
Univac:	4 minutes	1 2/3 hrs.	5 minutes
High-Speed Printer:		6 minutes	

Assumptions: 150 new hires, 150 terminations, 200 transfers, and 600 other changes daily.

THE WEEKLY CYCLE

The weekly cycle, Fig. 4, is designed to compute the payroll, to produce related weekly reports, and to bring up to date the subtotals in the master file item that are used in the quarterly and annual cycles. Three types of input data are used:

1. Payroll adjustment tape
2. Clock card tape
3. Master employee file
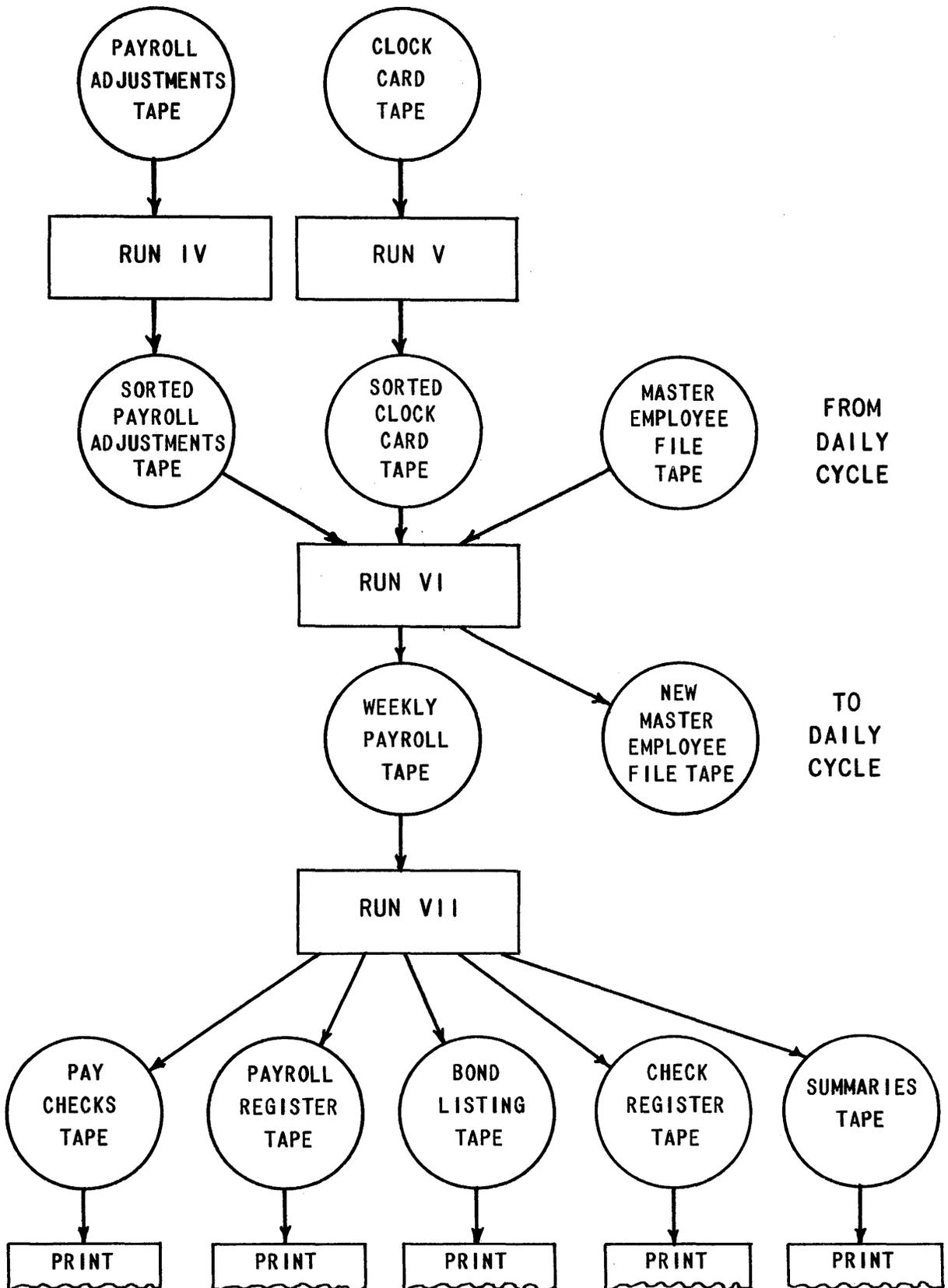
Fig. 4   Operations of the Weekly Cycle

Payroll adjustments include bonuses, deductions for merchandise, pay advances, etc. Payroll adjustments are typed onto the **payroll adjustment tape**, in the form of two-word items. Fig. 5 illustrates

BADGE NUMBER	ADJUSTMENT KEY
AMOUNT OF ADJUSTMENT	

Fig. 5   Layout of Payroll Adjustment Items

the layout of these payroll adjustment items. The first word contains the employee's badge number and a four-digit key indicating the type of adjustment. The second word contains the amount of the adjustment.

Run IV is a conventional two-word sort that orders the payroll adjustment tape items by badge number. The sorted items form the **sorted payroll adjustment tape.**

The clock-card items contain weekly time totals which are supplied by the timekeeping department. There is at least one clock-card item for each employee. Every clock-card item consists of two words, with the employee's badge number occupying the first eight digit-positions of the first word. Clock-card items may be of two types:

1. If the employee has worked a standard forty-hour week on straight time, a one-digit, non-zero key in the ninth digit-position of the first word indicates his shift. No further information is needed.

2. If the employee has not worked a standard forty-hour week, time totals in several categories may be necessary. These include four possible categories of absence, and the total of hours worked on straight time and on overtime for each of three shifts. All totals for absences appear in assigned locations in the employee's first clock-card item, shown in Fig. 6a. The ninth digit in the first word of the first item is zero, to indicate a non-standard work week.

There may be as many as six totals representing hours worked. Each total will appear in a six-digit field. The first digit in each field will indicate the shift worked, and whether straight time or overtime is involved. One such field will occupy the first six

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BADGE NUMBER					S *	HOURS LAID OFF	
K	HOURS WORKED, kth SHIFT			MEDICAL ABSENCE	PERSONAL ABSENCE	CLASSIFIED ABSENCE	

S (standard-work-week key) can be 0 for non-standard work-week, or 1, 2, or 3 for 40-hour week on shift 1, 2, or 3*

K (pay-category key) can be 1, 2, 3, 4, 5, or 6 (three shifts, three overtime categories).

Absences listed to the tenth of a day.

Fig. 6a   Clock-card: Layout of First Item

digit-positions of the second word of the first clock-card item. Two such fields will occupy the second word of each trailer item, as shown in Fig. 6b.

BADGE NUMBER					Z		
K	HOURS WORKED, kth SHIFT			K	HOURS WORKED, kth SHIFT		

Z in 9th digit-position ensures that Run V will place the trailer item following the first clock-card item.

Fig. 6b   Clock-card: Layout of Trailer Item

Run V is a conventional two-word sort that orders the items on the clock-card tape by the entire first word. The output of this run is the sorted clock-card tape.

Run VI uses the sorted payroll adjustment tape, the sorted clock-card tape, and the master file to produce the weekly payroll tape and a new master file. The weekly payroll tape contains all the information required on paychecks and the related weekly reports. It consists of a series of ten-word items. The new master file contains the up-to-date summaries.

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* The principal purpose of the standard-work-week key is to eliminate unnecessary typing in preparing the clock-card tape. But it also permits Run VI to by-pass lengthier computations when overtime and absences are not involved.

M_i Represents the ith master file item. To refer to a particular unit of information within that item, superscripts are used. For example, the symbol M_i^B stands for the badge number of ith master file item. The superscripts are interpreted as follows:

Personal Information –

B   Badge number
N   Name and address
D   Number of income tax exemptions
T   Termination-of-employment key
A   Days absence allowed
Y   Bond account number.

Computational –

R   Hourly rate of pay
U   Union dues key
X   Blue Cross key
YD   Weekly bond deduction
YB   Bond size key

Quarterly Summaries –

WC   Number of days classified absence by week
WP   Number of days personal absence by week
WM   Number of days medical absence by week
WL   Number of hours laid off absence by week
WW   Total hours worked by week
WG   Total gross wages earned by week
QF   Quarterly total of FICA-taxable earnings
QS   Quarterly total of FICA tax paid

Annual Summaries –

YF   Year-to-date FICA earnings
YS   Year-to-date FICA tax
YG   Year-to-date gross earnings
YI   Year-to-date income tax

Other Summaries –

YA   Cumulative total of bond deductions

C_j Stands for the jth clock-card item. The superscripts referring to fields within C_j are:

B Badge number
S Standard work week key
K Pay category of time worked
L Hours laid off
WK Hours worked on K^{th} shift (Note: since provision is made to represent two shifts on each trailer clock-card item, their pay category is K_1 or K_2 and hours WK_1 or WK_2 respectively.)
M Hours medical absence
P Hours personal absence
C Days' classified absence


Pay Adjustment Item

A_m Represents the mth payroll adjustment item. The following superscripts are defined:

B Badge number
TA Type-of-adjustment (on net or gross pay) key.
2 Amount of adjustment

Payroll Item

P_k Represents the kth payroll item. The fields making up this item are defined in the flow charts of computer Run VI, but are listed here for convenience:

		Use:	
B	Badge number		1, 2
N	Name and address		1, 2, 3
G	Gross pay		1
MP	Medical pay		1
NA	Adjustment on net pay		1
μ	This variable superscript stands for storage of pay adjustment information in P_k		
SS	FICA tax		1
IT	Income tax		1
YD	Bond deduction		1
U	Union dues deduction		1
X	Blue Cross deduction		1
NP	Net pay		1, 3
Y	Bond account number		2
YB	Bond size key		2

Since Run VI is the most important of all the payroll runs, it deserves close inspection. The normal path of computation is from connector ① to connector ⑫. .
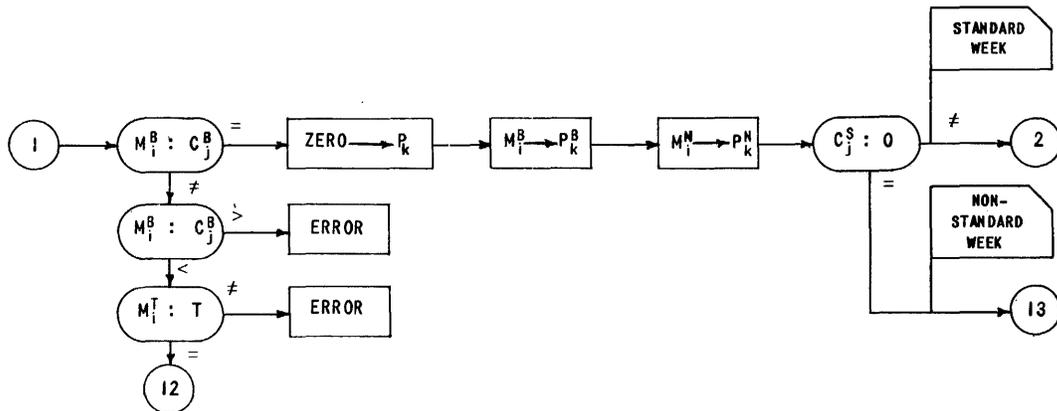

The first two operations serve to match the master file item with its appropriate clock-card item, and then to determine whether a standard work-week applies. The alternatives labelled "error" occur whenever a master-file item of a non-terminated employee has no clock-card item, or vice-versa.
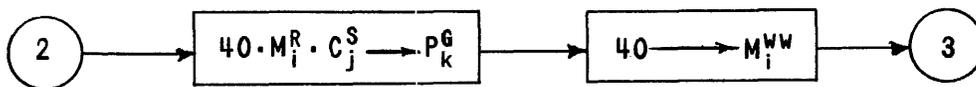

② to ③ calculates gross pay, and brings to date the weekly work summary in the master file, for standard-work-week employees.
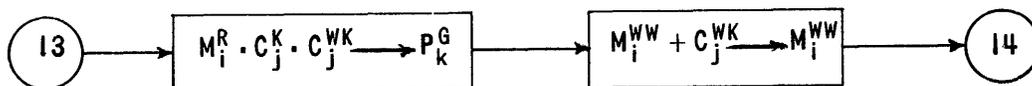

⑬ to ⑭ calculates gross pay for one shift of non-standard work.

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MEDICAL PAY

PERSONAL LEAVE PAY
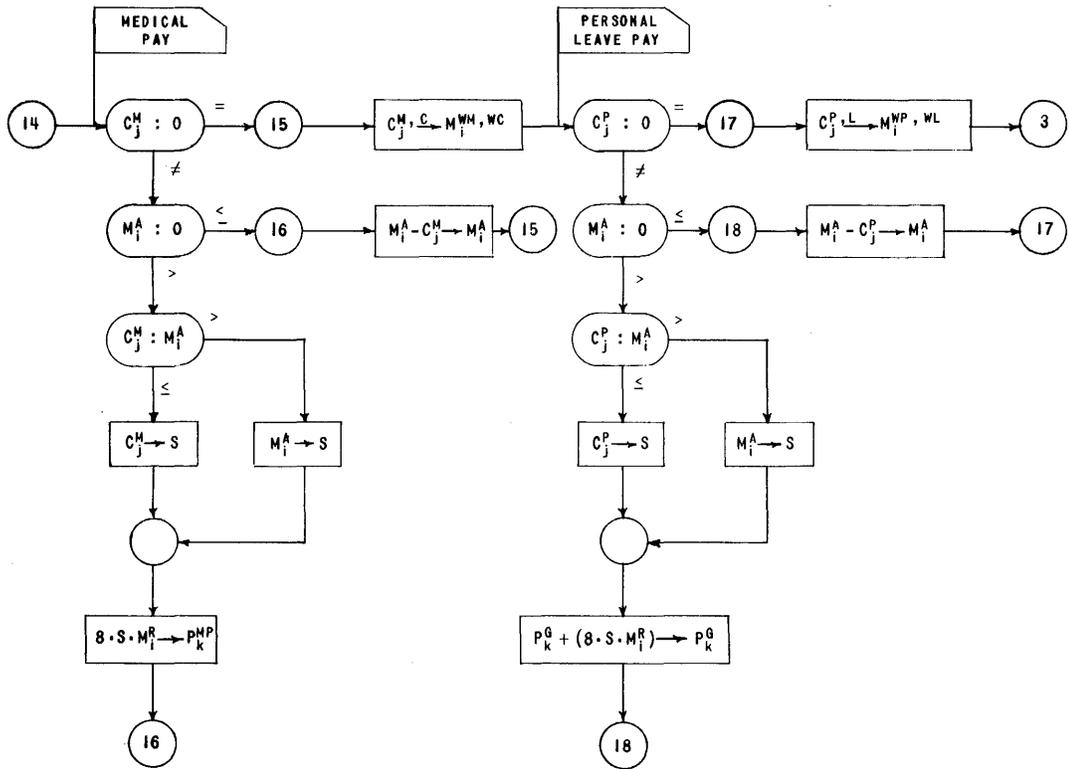
(14) leads to the calculation of medical and personal absences, and summarizes this and the gross pay data in the master file. Before pay is authorized for either absence, a check is made against the amount of absence allowed for the employee. Medical pay is kept separate from gross at this time, since it is not FICA-taxable.
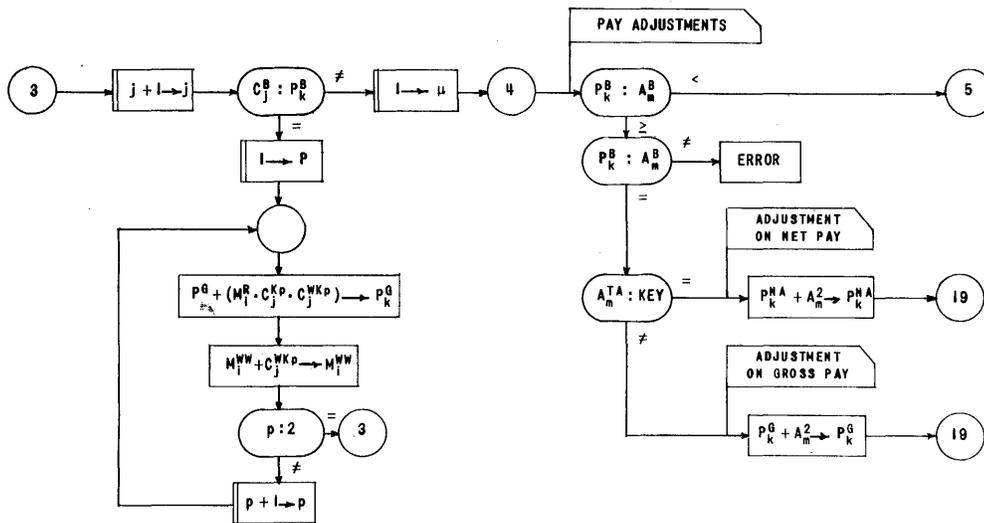
PAY ADJUSTMENTS

(3) to (4) checks whether additional clock-card items pertain to the employee. (4) to (5) determines whether or not an adjustment item is present for this employee, and, if so, makes this adjustment on net or gross as indicated by the type-of-adjustment key.
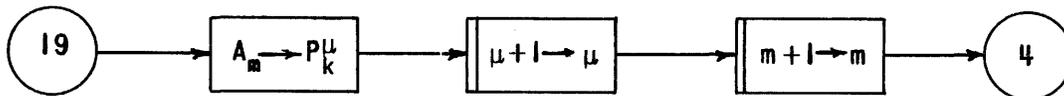
The adjustment information is stored in the payroll item so as to provide the employee with a visible record.
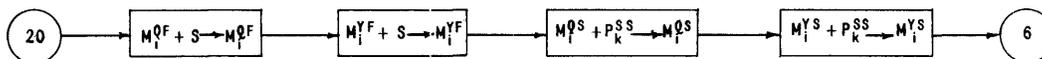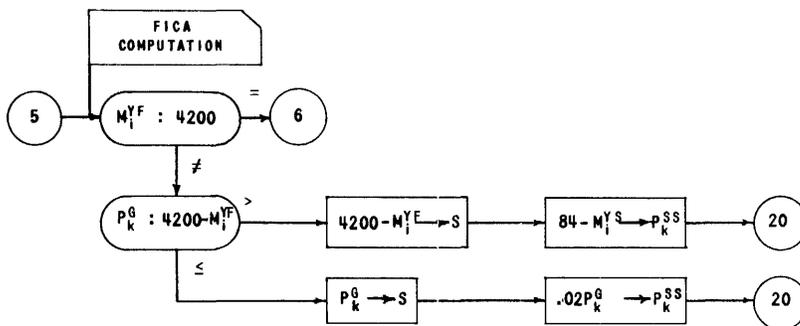
$\textcircled{5}$ to $\textcircled{6}$ determines the necessity for FICA computations. If the year-to-date FICA-taxable earnings are less than \$4200, a FICA tax is computed, and the appropriate quarterly and annual summaries are recorded. The calculation of the tax is designed to tax no more than \$84, irrespective of multiplication roundoffs.
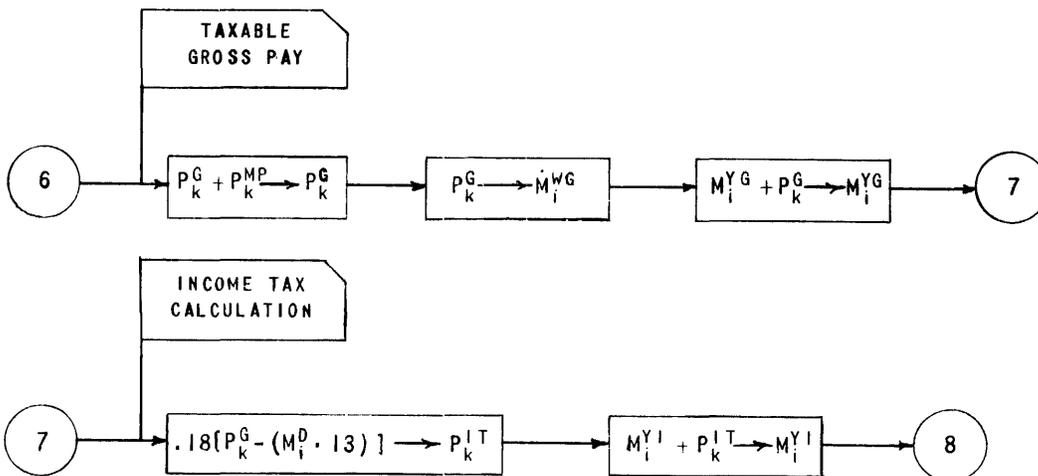
$\textcircled{6}$ to $\textcircled{8}$ adds medical pay if any, to gross pay, determines withholding tax, and records the appropriate summaries.

WEEKLY BOND DEDUCTION

UNION DUES DEDUCTIONS

BLUE CROSS DEDUCTION

$(8) \rightarrow M_i^{YD} : 0 \xrightarrow{=} (9)$

$M_i^{YD} : 0 \xrightarrow{\neq}$

$M_i^{YD} \rightarrow P_k^{YD}$

$M_i^{YA} + P_k^{YD} \rightarrow M_i^{YA}$

DERIVE BOND SIZE E FROM M_i^{YB}

$M_i^{YA} : E \xrightarrow{<}$

$\geq$

$M_i^{YB} \rightarrow P_k^{YB} \rightarrow M_i^Y \rightarrow P_k^Y \rightarrow M_i^{YA} - E \rightarrow M_i^{YA} \rightarrow (9)$

$M_i^U : 0 \xrightarrow{=} (10)$

$M_i^U : 0 \xrightarrow{\neq}$

COMPUTE P_k^U FROM M_i^U

$M_i^X : 0 \xrightarrow{=} (11)$

$M_i^X : 0 \xrightarrow{\neq}$

COMPUTE P_k^X FROM M_i^X
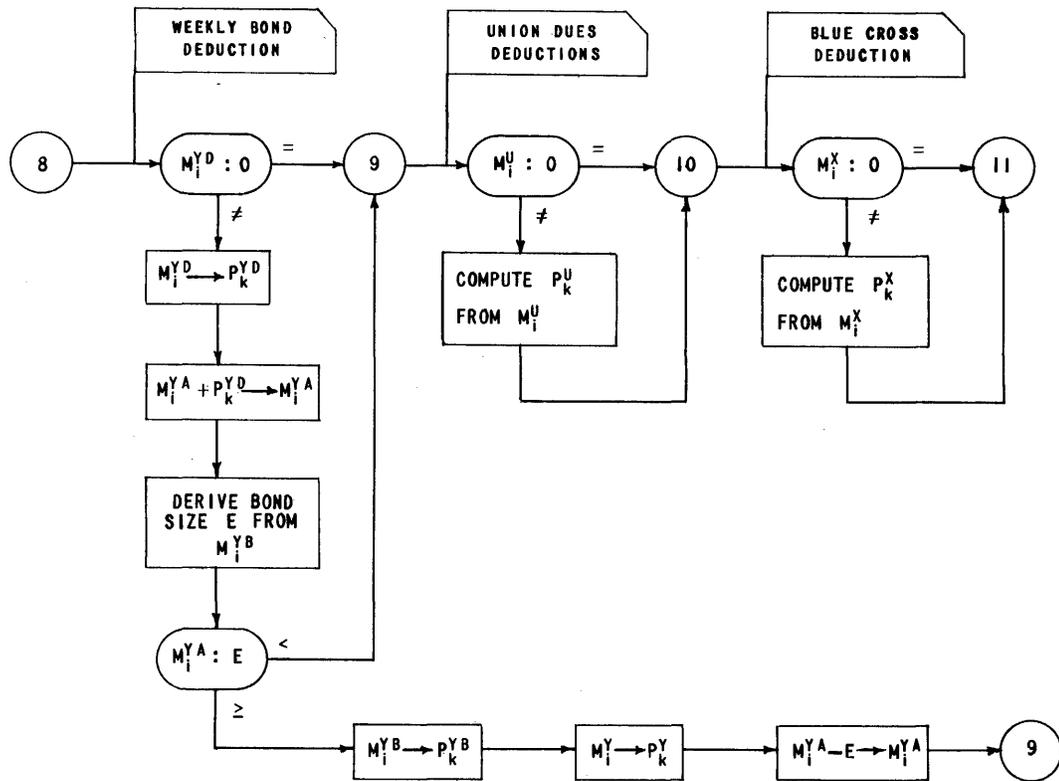
(8) to (11) makes deductions for bonds, union dues, and Blue Cross. If the accumulated bond deductions exceed the bond size, the employee is credited with the purchase of a bond; the bond-size key and account number are entered into the payroll item.

DETERMINATION OF NET PAY

$(11) \rightarrow P_k^G + P_k^{NA} - P_k^{IT} - P_k^{SS} - P_k^U - P_k^X - P_k^{YD} \longrightarrow P_k^{NP} \rightarrow k+1 \rightarrow k \rightarrow (12)$

WRITE ADJUSTED MASTER FILE ITEM

$(12) \rightarrow M_i \rightarrow \bar{M}_i \rightarrow i+1 \rightarrow i \rightarrow (1)$
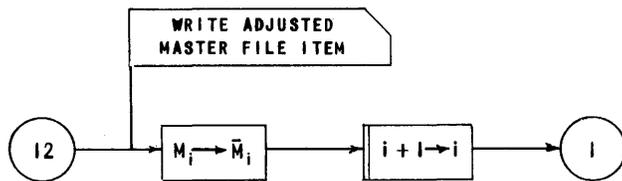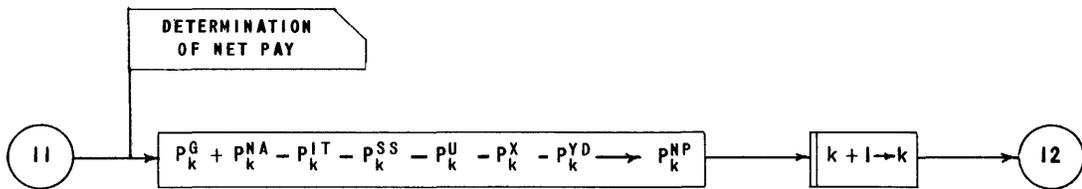
(11) to (12) obtains the net pay by subtracting the various deductions from the gross pay and adding the net pay adjustment, if any.

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┌──────────────┐
‖│  K + I ──► K │
└──────────────┘
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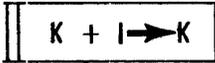
implies that the payroll item just computed is written in the weekly payroll tape. ⑫ to ① writes the complete adjusted file item on the new master file tape, and selects the next master file item.

Run VII uses the weekly payroll tape to prepare four output tapes for printing. Referring to the column labeled "use" in the definition of symbols for the payroll item, (see page 13), those fields marked ① are reproduced in the paycheck and payroll register tapes, those fields marked ② appear in the bond listing tape, and those marked ③ are in the check register tape. Two type-ins are necessary at the start of Run VII: the date and the initial paycheck serial number. The run supplies the date to each paycheck, and generates successive serial numbers to appear on checks and on the check register. If desired, weekly summary reports may be prepared showing totals by department and by shift. Run V may produce time totals and Run VII may produce pay totals.

Equipment time estimates for the weekly cycle are:

	Run IV	Run V	Run VI	Run VII
Unityper:	10 hours	70 hours		
Verifier:	10 hours	70 hours		
Univac:	9 minutes	2½ hours	4 hours	1 2/3 hrs.
High-Speed Printer:				17 hours

(Assumptions: 3,000 payroll adjustments weekly.)

THE QUARTERLY AND ANNUAL CYCLES

The quarterly cycle, illustrated in Fig. 8, is required to prepare the FICA report for the Federal government. One line on this report is devoted to each employee, listing his name, his Social Security number, his quarterly taxable earnings, and the FICA tax withheld. The master file is the sole input for Run VIII, the only run needed for the quarterly cycle. In addition to the FICA report, an earnings record and an attendance record are produced. The earnings record lists for each employee his name, badge number, total hours worked and total wages earned for each of the thirteen weeks in the quarter. The attendance record lists for each employee his name, badge number, total days worked and total time absent (in each of the four categories) for each of the thirteen weeks in the quarter.

Equipment time estimates for the quarterly cycle are:

Univac: 1 2/3 hours
High-Speed Printer: 30 hours
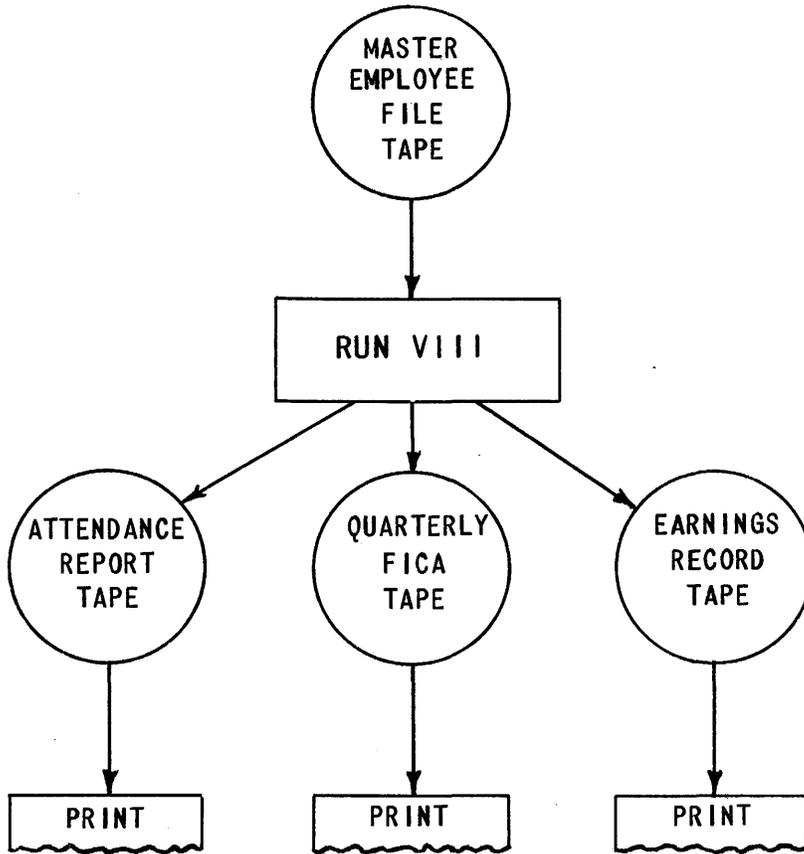
Fig. 7   Operations of the Quarterly Cycle

The annual cycle, shown in Fig. 8, is required to prepare the individual employee's W-2 forms. The only input is the master file from which Run IX derives the employee's name, address, badge number, social security number, exemptions, total gross pay, total FICA earnings, total income tax and FICA tax withheld for the year.

Equipment time estimates for the annual cycle are:

Univac: 1 2/3 hours
High-Speed Printer: 16 hours
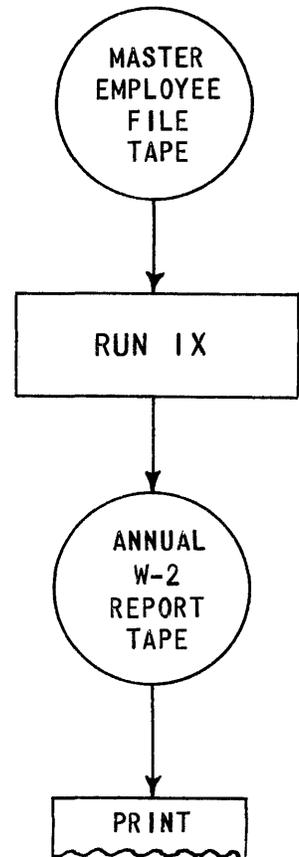
Fig. 8   Operations of the Annual Cycle