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An Interactive Payroll/Personnel Data Entry System

John Douglas Walker

JOHN DOUGLAS WALKER. An Interactive
Payroll/Personnel Data Entry System
(Under the direction of Stephen F. Weiss.)

ABSTRACT

This thesis describes the development of an interactive data entry system for the University of North Carolina at Chapel Hill Automated Payroll/Personnel System. It includes the analysis of the data processing needs and the existing batch-oriented data entry system as well as the design of the new system. Major emphasis in the design criteria was placed upon providing the Payroll Department with complete control over its data in familiar form. This goal was accomplished through two main techniques. First, the computer terminals were placed in the Payroll offices, for direct use by the staff. Moreover, the information displayed upon the screen is formatted to resemble the original paper documents as closely as possible. The system was implemented and is in use by the Payroll Department. A brief evaluation of its performance and effectiveness is included in the thesis.

AN INTERACTIVE PAYROLL/PERSONNEL DATA ENTRY SYSTEM

by

John Douglas Walker

A thesis submitted to the faculty of the University of North Carolina at Chapel Hill in partial fulfillment of the requirements for the degree of Master of Science in the Dept. of Computer Science

Chapel Hill

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I. INTRODUCTION

OVERVIEW

PROTECS--PayRoll On-line Transaction Entry and Correction System--is an interactive software system designed to enable the University of North Carolina at Chapel Hill (UNC-CH) Payroll Department staff to enter and correct data through CRT computer terminals. The terminals are located in the Payroll Department offices and are linked directly to the Univac 90/80 computer in the Administrative Data Processing Department (ADP). Both of these departments are located in the UNC-CH Business Office Building at 440 West Franklin Street in Chapel Hill. PROTECS serves as a front end subsystem of the University Personnel/Payroll Automated Processing System, an extensive system designed, implemented, and operated by ADP. It has replaced the former data entry system in which the source documents themselves were delivered to ADP to be transcribed into Optical Character Reader (OCR) font for input. This OCR-based system now serves as a back-up to the new system.

This thesis summarizes an analysis of the data entry system which was in existence when this project was undertaken and briefly describes the development of PROTECS, from conception to implementation and subsequent usage by the Payroll Department. It attempts to explain to the reader the idea of Payroll transaction processing, acquainting him with the nature of the data involved and the procedures followed by the Payroll Department. It points out the major drawbacks of the existing data entry system. It describes the gross design of the new system and some of the design alternatives considered and decisions made. Finally, it explores the impact that utilization of PROTECS has had on transaction processing and offers a brief look at the possibilities for expanding the system to increase its usefulness.

Details of the operation of PROTECS from the user's point of view may be found in the USER'S GUIDE TO PROTECS. Details of its structure and operation from the programming point of view may be found in the PROTECS SYSTEM DOCUMENTATION and in the program listings themselves. All of these sources are contained in the Appendix accompanying this thesis.

PAYROLL TRANSACTIONS

The data which the Payroll Department is responsible for entering are used to create and update records in the Personnel/Payroll master file. This file is a computerized data base serving jointly the needs of the Payroll and Personnel departments. It contains a record for every UNC-Chapel Hill employee, with all necessary employment information. The master file is processed to generate the biweekly and monthly payrolls, and to extract data for the SPA (staff) and EPA (academic) Personnel systems.

A payroll transaction is a piece of information about a particular employee to be applied to the master file or directly to the payroll processing. It may originate from the Payroll Department, the Personnel Department, the Registrar's Office, or directly from the department for which the employee works. There is a wide range of purposes for which a transaction may be created, and a single transaction may accomplish one or several of them. For example, a transaction could be processed to adjust an employee's upcoming paycheck to offset a mistake made on his last paycheck. Another transaction could result in the creation of a record for a new employee and could include most of the information to be carried on that record. Another transaction could be entered to set up the deposit of an employee's paycheck directly to his bank account.

Still another one could simultaneously promote an employee to a different classification, increase his salary, change the department for which he works, and change the budget sources from which his salary is paid. In short, a payroll transaction is the means through which any action is taken affecting an employee's personnel record or pay calculation.

NAMING CONVENTIONS

Throughout the thesis certain conventions will be used for frequently referenced names and terms. Among these are ADP (the Administrative Data Processing Department), Data Prep (the Data Preparation Division of ADP, Payroll (the University Payroll Department), Personnel (the University Personnel Department), and OCR (Optical Character Reader). Employees in the Payroll Department--most of whom are officially classified as Accounting Technician I or Accounting Tecnnician II--will usually be referred to as "clerks" for the sake of brevity. Finally, it should be understood that the Payroll Transaction Processing System encompasses the entry and validation of all Payroll and Personnel data except employee time sheets, which are handled by another subsystem.

II. PAYROLL DEPARTMENT ORGANIZATION AND DOCUMENTS

OVERVIEW

This chapter acquaints the reader with the constraints within which the new data entry system was designed. The Payroll Department organization and the input data it processes are both fixed; they are independent of the method of data entry. The converse, however, is not true. The form and nature of the data has a tremendous influence on the design of the entry system. For this reason it is important for the reader to gain a passing understanding of these aspects of the overall problem.

PAYROLL DEPARTMENT ORGANIZATION

The Payroll Department is headed by a director and an assistant director, and is organized into three sections.

Biweekly Section.

This section processes the biweekly payroll chiefly for SPA employees. The staff consists of one Accounting Technician II and two Accounting Technician I's. The two-week pay period is fixed, with the final payroll run always scheduled for the Tuesday before payday Friday.

Monthly Section.

This section processes the monthly payroll for EPA employees. It consists of one Accounting Technician II and two Accounting Technician I's. Although the monthly payroll also has a fixed payday (the first of each month unless that date does not fall on a workday), the final payroll may actually be run anywhere from the twenty-second to the twenty-seventh of the month, depending upon ADP's load and job schedule.

Deduction Section.

This section, consisting of two Accounting Technician I's, processes the voluntary deductions for all employees. Receiving the data from different sources, such as the Employee Benefits Division of Personnel, the Registrar's Office, insurance companies, and the State Employees' Credit Union, these clerks set up or modify the deduction fields in the employee's master file record by filling out a PR-4 form. They may also use a PR-2 (Current Adjustments) form in cases where the deduction was effective before it could be set up on the master file, or for any other purpose requiring a one-time adjustment to a deduction.

INPUT DOCUMENTS

The following sections describe the input documents handled by the Payroll clerks and the types of errors that may be in the data coming into Payroll. Samples of these documents appear at the end of this chapter.

Documents Originating Outside Payroll

These documents originate in other departments within the University, follow appropriate channels, and eventually reach Payroll, where they are manually processed before being sent to ADP.

PD Forms. There are two types of Personnel Action forms: the PD-105 for SPA (subject to the State Personnel Act) employees, and the PD-7 for EPA (exempt from the State Personnel Act) employees. They are the normal channel through which most changes to an employee's master file record are entered into the system. Each field on a PD form is divided (usually horizontally) into a shaded or light gray area and an unshaded area. The shaded area is used for the current values found in the master file record for existing employees (see 2 below). The unshaded area is used to enter the new value of the field to be applied to the master record. PD forms may be used in two ways, and this usage corresponds to their origination.

1) Original Entry: When a new employee is to be put onto the master file, the Personnel Department (for SPA employees) or the hiring department itself (for EPA employees) fills out a blank PD form with the necessary information entered in the unshaded areas.

2) Turnaround: When a PD form is submitted for an employee, it ultimately updates that employee's master file record (or creates a record for a new employee). Then the system generates a corresponding computer-printed PD form containing the updated master file information printed in the shaded portion of each field. This form is sent to the employee's home department where it is kept on file until another change occurs. Then this form is submitted, with the department having to fill in the unshaded portion of only those fields whose values have changed. Within the system, records generated from PD forms are identified as "02" transaction records.

WNC-4 Cards. This is the Employee's Withholding Exemption Certificate, filled out by the employee upon being hired and upon any change in tax-related data. It results in an "05" transaction record.

PR-6. This form is submitted by the Contracts and Grants Department to modify salary sources for an employee. It results in "08" transaction records.

PR-8. This form is filled out by an employee to request and authorize the University to deposit his paycheck directly to his bank account.

PR-9. The employee fills out this form to cancel his authorization of direct paycheck deposits when he no longer wants this service.

Documents Originating Within Payroll

PR-1. Payroll uses this form to handle Releases and Cancellations. For example, it may be necessary to cancel a computer-printed check and pay the employee with a hand-drawn check if some data error caused his pay to be computed incorrectly. Another common use is to change the source from which the employee is paid without affecting the check itself. This is known as a journal entry transaction. A

PR-1 form generates a family of transaction records: "16", "26", "36", "46", "17", "27", "37", and "47".

PR-2. This form is for current adjustments and one-time payments. These transactions do not affect the master file. A common use of this form is to compensate for a change in pay rate which was in effect during the previous pay period but which did not get into the system in time to be included in the paycheck. "08" transaction records are produced from PR-2's.

PR-3. This form is used for miscellaneous changes and corrections. It does cause the master file to be modified. While this is primarily a Payroll form, a PR-3 can also originate in the Personnel Department when Personnel wishes to correct some field on the employee's master record. For example, an incorrect retirement number on a record could be changed by this method. The PR-3 also produces "08" transaction records.

PR-4. This form is used for Payroll deduction data. Voluntary deductions are set up and modified through these forms by two Payroll clerks using the individual forms and cards sent in by the affected companies or organizations. The records created from these forms are identified as "04" transaction records.

Errors on Input Forms

In spite of careful screening by Personnel and departmental secretaries, forms frequently arrive in Payroll filled out incorrectly. The type of error varies widely, and ranges in seriousness from minor typographical errors to cases where an entire form is useless. Some of the most common types of errors observed during the study of the Payroll procedures are listed below.

- Improper effective date of the action (e.g., wrong pay period or improper day during pay period).
- Improper date format (e.g., no leading zeros in month and day or "/" for delimiter instead of "-").
- Use of "$" on money fields.
- Using other than latest PD turnaround form.
- Improper number of characters in a field (e.g., coding leave hours as "16" instead of "016").
- Data coded in improper field (e.g., typing "/S" or "/H" following salary field instead of filling in the "Salaried/Hourly" field).
- Inappropriate action code for situation described.
- Invalid combination of data (e.g., indicating student employee, but also full time temporary; typing "40" in "Hrs/wk" field for full time employee).
- Improper coding of data (e.g., typing "W" or "B" instead of a numerical race code).

- Leaving necessary fields blank.
- Adding unnecessary data.
- Writing or typing data half in shaded area and half in unshaded area.

STAFF PERSONNEL ACTION

FORM PD-105 (Rev. 9-77)

THE UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL

OSP 6020

1 ACTION CODE 0 5 | ACTION DESCRIPTION | DATE PREPARED | DATE ACTION EFFECTIVE

2 SOC SEC NO 3001 | NAME (LAST) | (FIRST) | (MIDDLE) 3002 | UNC 1004 STUDENT | VET 3066

FROM

TO

3 DIVISION | HOME DEPT NO 1039 | HOME DEPARTMENT NAME | ASSD 1059

FROM

TO

4 1025 APPOINTMENT TYPE FULL/PART TIME | 1043 EMP. CLASSIF. PERM TEMP | TITLE CODE 3019 | EMPLOYEE CLASSIFICATION TITLE | GRADE 3020 | STEP 3021 | ANNUAL SALARY HOURLY RATE 3036 | SALARIED HOURLY 1035

FROM

TO

5 1029 POSITION TYPE FULL/PART TIME | 1046 POS. CLASSIF. PERM/TEMP | TITLE CODE 1022 | POSITION CLASSIFICATION TITLE (IF SAME AS ABOVE LEAVE BLANK) | GRADE 3023 | POSITION NO 1027

FROM

TO

6 NO. DAYS WORKED PER WEEK 1024 | 3030 IF TEMPORARY APPOINTMENT DURATION | 1044 DATE TO REMOVE FROM PAYROLL | PART TIME EMPLOYEES HRS PER WEEK 1031 | UNC-EOD 1012 | NEXT INCREMENT DATE 1042 TYPE | SPECIAL PAYMENT 1048

FROM

TO

FOR PAYROLL AND PERSONNEL USE ONLY

7 DATE OF BIRTH 1003 | CITIZENSHIP CODE 1018 | RACE 1006 | SEX 1005 | RETIREMENT NUMBER 1013 | OCCUPATION CATEGORY 1040 | WG-HR 1011 | H 1026 | SUBJECT TO: FED TAX 1014 | STATE TAX 1015 | FICA 1016 | RETIRE 1017

FROM

TO

8 NAME OF EMPLOYEE REPLACED | POSITION NUMBER

9 FROM — SALARY SOURCES (3050) — TO

F/O	S/D	PUR	FUNCT	SUB ACCT	OBJECT	C S	M	SALARY RATE	SOURCE ENDS		F/O	PUR	FUNCT	SUB ACCT	OBJECT	C S	M	SALARY RATE	SOURCE ENDS
										1									
										2									
										3									

NOTICE OF TERMINATION LEAVE WITHOUT PAY

10 3058 TERMINATION LEAVE WITHOUT PAY CODE | REASON | DATE OF LAST WORK DAY OR DEATH | 3055 LAST DATE ON PAYROLL | 1056

1057 TERMINAL PAY: ANNUAL LEAVE HOURS | HOLIDAY HOURS | SICK LEAVE BEING EXHAUSTED: HOURS | FROM | THROUGH | ANNUAL LEAVE BEING EXHAUSTED: HOURS | FROM | THROUGH

11 COMMENTS

AUTHORIZATIONS

12 REQUESTED BY DEPT DIVISION

DATE

BY

DATE

BY

PERSONNEL APPROVAL

DATE IN

DATE OUT

BY

BUDGET APPROVAL

1. DATE BY

2. DATE BY

3. DATE BY

PAYROLL

DATE IN

BY

CHANCELLOR'S OFFICE
PD-7 (REVISED 1978)
(SEE INSTRUCTIONS ON REVERSE SIDE)

THE UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL

EPA PERSONNEL ACTION

SERIAL NUMBER 213786

DATE PREPARED ____________

1 ACTION CODE 0 7	ACTION DESCRIPTION	DATE ACTION EFFECTIVE

2 SOC. SEC. NUMBER 1001 FROM TO	NAME (LAST)	(FIRST)	(MIDDLE) 1002	TAX STATUS	1039 DEPT. NO.	DESTINATION FOR CHECK DEPARTMENT NAME

3 APPT TYPE a 1043 FROM TO	b 1025	DATE OF FIRST EPA APPOINTMENT 1012	DURATION OF APPT. 1028	CONTIN-GENCY 1049	DATE TO REMOVE FROM PAYROLL 1044	ACTION TYPE 1051	1052 DEPT. NO.	APPOINTMENT BASE DEPARTMENT NAME

4 CODE 1041 FROM TO	TITLE RANK CODE and TITLE	LEC EQ 1077	VISITING 1033	JOINT 1053	BASE RATE 1036	NO. PAYMENTS IF NOT ANNUALIZED 1076

5 POSITION NUMBER 1027 FROM TO	RETIREMENT NUMBER 1013	DATE APPOINTED TO CURRENT RANK 1037	FTE 1032 % %	SERVICE PERIOD 1038	SPECIAL PAY 1048	NO. PAYMENTS & ACTUAL PAYMENT

FOR PAYROLL AND REGISTRAR'S USE ONLY

6 UNC-CH STUDENT 1004 FROM TO	BIRTHDATE 1003	CITIZENSHIP CODE 1018	SEX 1005	RACE 1006	WAGE/HOUR CODE 1011	PAY CYCLE 1010	FED. W/H 1014	SUBJECT TO STATE W/H 1015	FICA 1016	RETIRE 1017

7 ON LEAVE OR 1034 OFF-CAMPUS ASSIGN FROM TO	1. □NO PAY 2. □PARTIAL PAY 3. □FULL PAY 1054	PURPOSE, WHERE GOING (LEAVE/OFF-CAMPUS ASSIGNMENT FORM MUST ACCOMPANY PD 7)

SALARY DISTRIBUTION (1050)

	FROM										TO									
8 F D	B D	PUR	FUNCT	SUB ACCT	OBJECT	C/S	M	RATE	SOURCE ENDS		F D	B D	PUR	FUNCT	SUB ACCT	OBJECT	C/S	M	RATE	SOURCE ENDS
										1										
										2										
										3										
										4										

NOTICE OF TERMINATION

9 TERMINATION CODE AND REASON 1058	PAY THROUGH THIS DATE 1056

10 COMMENTS 1 (FOR HONORARIA NON UNIVERSITY EMPLOYEE GIVE ADDRESS TIME PERIOD COVERED REASON FOR PAYMENT WHETHER OR NOT PROSPECTIVE FACULTY MEMBER

2 (FOR SPECIAL PAYMENTS TO UNIVERSITY EMPLOYEES GIVE REASON FOR PAYMENT AND SPECIFY TIME PERIOD COVERED BY PAYMENT)

11 REQUESTED BY

(SIGNATURE) (TITLE)	(SIGNATURE) (TITLE)	(SIGNATURE) (TITLE)
(SIGNATURE) (TITLE)	(SIGNATURE) (TITLE)	(SIGNATURE) (TITLE)

12 PRESIDENT	CHANCELLOR	V-Chanc./Provost	BUDGET	PAYROLL ACCOUNTING
DATE	DATE	DATE	1 DATE BY	DATE IN
			2 DATE BY	DATE PROCESSED
BY	BY	BY	3 DATE BY	BY

CHANCELLOR'S OFFICE

EMPLOYEE'S WITHHOLDING EXEMPTION CERTIFICATE

PRINT NAME AS ON SOCIAL SECURITY CARD → ______ NAME ______ — — SOCIAL SECURITY NUMBER

PRINT PERMANENT ADDRESS HERE ______ STREET ADDRESS

______ CITY OR TOWN AND STATE ______ ZIP CODE

Payroll Office Only

MARK 'X' IF
□Address change only or □Exemption change only

ENTER NUMBER OF FEDERAL EXEMPTIONS AND ALLOWANCES YOU CLAIM IN THIS BOX □

ENTER CHOICE OF FEDERAL TAX SCHEDULE (A–B) IN THIS BOX □

Schedule "A" is for a single person or a married couple both earning a significant income giving consideration to gross salary actual exemptions, and standard deduction

Schedule "B" is for a married person filing jointly whose spouse does not work or does not earn a significant income giving consideration to gross salary actual exemptions and standard deduction

IF CHOICE NOT INDICATED SCHEDULE "A" WILL BE USED

ENTER AMOUNT OF ADDITIONAL FEDERAL WITHHOLDING DESIRED IN THIS BOX $

ENTER DOLLAR AMOUNT OF STATE EXEMPTIONS IN THIS BOX $

ENTER AMOUNT OF ADDITIONAL STATE WITHHOLDING DESIRED IN THIS BOX $

FORM WNC-4
11-74

SIGN HERE → ______ DATE ______
I CERTIFY THAT THE EXEMPTIONS CLAIMED ON THIS CERTIFICATE DO NOT EXCEED THE AMOUNT TO WHICH I AM ENTITLED.

CONTRACTS & GRANTS BUDGET CHANGE FORM

(TO BE USED IN CHANGING SALARY **SOURCE** FROM ONE GRANT OR CONTRACT
TO ANOTHER WHICH IS ADMINISTERED BY **CONTRACTS & GRANTS**)

Mail to **CONTRACTS AND GRANTS**
ROOM 102
440 W FRANKLIN ST. 454A

DATE: ______________________

(To be Completed by Initiating Dept.)

NAME (LAST, FIRST, MIDDLE)			
SOCIAL SECURITY NUMBER (1-9)	HOME DEPT NAME		
HOME DEPT NO.	EFFECTIVE DATE (10-15)		TOTAL ANNUAL SALARY

FROM

TX CODE	FUND	BUD	PURPOSE	FUNCTION	SUBACCOUNT	OBJECT	COST/SHARE	'M' IND	TERM. DATE	AMOUNT	
23-26	27	28	29—31	32—35	36—40	41—44	45 — 49	50	56 — 61	62 — 68	78—80
6050											DØ8
6050											DØ8
6050											DØ8
6050											DØ8
6050											DØ8
6050											DØ8
6050											DØ8
6050											DØ8
TOTAL *											▨

TO

TX CODE	FUND	BUD	PURPOSE	FUNCTION	SUBACCOUNT	OBJECT	COST/SHARE	M IND	TERM. DATE	AMOUNT	
23-26	27	28	29—31	32—35	36—40	41—44	45 — 49	50	56 — 61	62 — 68	78—80
6050											AØ8
6050											AØ8
6050											AØ8
6050											AØ8
6050											AØ8
6050											AØ8
6050											AØ8
6050											AØ8
TOTAL *											▨

*TOTAL OF THE FROMS MUST EQUAL THE TO S

Approval
Principal Investigator ______________________ Dept Chairman ______________________
Contracts and Grants ______________________

PR-6
7-70

PAYROLL COPY

THE UNIVERSITY OF NORTH CAROLINA
AT CHAPEL HILL

DIRECT PAYROLL DEPOSIT AUTHORIZATION

I authorize my employer, The University of North Carolina at Chapel Hill, to deposit my net payroll earnings to my account in the bank named below.

1.	Bank Name	City	State
2.	Employee Name	□ Checking (Mark one)	□ Saving
3.	Employee Social Security Number	Bank Transit/ABA Number	Account Number

4. I am paid on the biweekly payroll □ monthly payroll □.

This authorization will remain in effect until I give written notification to the UNC-CH Payroll Office to cancel it. A minimum of thirty (30) days must be allowed for processing a cancellation or change Termination of employment, however, will cancel this authorization. I understand that (should I terminate University employment) my final paycheck will *not* be deposited to my checking and/or savings account but will be forwarded to my department.

5. *Date* _______________ *Employee Signature* _______________

6 □ New Authorization □ Change in Bank or Account

7.

Attach a copy of your pre-printed deposit slip here.

FOR PAYROLL USE ONLY

Employee Soc. Sec. Nbr.	Effect. Date	Bnk. Trans./ABA Nbr. 6097	6098	Account Nbr. 6099

PR-8 (REV. 1/80)

THE UNIVERSITY OF NORTH CAROLINA
AT CHAPEL HILL

CANCELLATION OF DIRECT PAYROLL DEPOSIT AUTHORIZATION

I hereby cancel my authorization for The University of North Carolina at Chapel Hill to deposit my net payroll earnings directly to my bank effective as soon as possible I understand up to thirty (30) days may be required for processing

1

Employee Name	Employee Soc Sec Nbr

2

Date ______________________ Employee Signature ______________________

3.

FOR PAYROLL USE ONLY

Employee Soc Sec Nbr	Effective Date	6097 **CANCEL**

PR-9

INSTRUCTION FOR COMPLETING THE UNC-CH FORM NO. PR-9: CANCELLATION OF DIRECT PAYROLL DEPOSIT AUTHORIZATION

Prepare only one copy of the cancellation authorization

Line 1 - Enter your name and social security number exactly as it appears on your direct payroll deposit statement and social security card

Line 2 - Enter today's date and sign your name as it appears on the line above

Line 3 - Do NOT complete the block designated 'For Payroll Use Only'.

U N C PAYROLL RELEASES AND CANCELLATIONS

DATE PREPARED ____________
PAYROLL CYCLE ____________
PAYROLL NUMBER ____________

CANCELLATION

SOCIAL SECURITY NUMBER	DATE EFFECTIVE	TAX STAT	CHECK NUMBER	NAME
1 - 9	10 - 15	16	17 - 22	

FUND 23	BUD 24	PURPOSE 25 - 27	FUNCTION 28 - 31	SUB. ACCOUNT 32 - 36	OBJECT 37 - 40	COST/SHARE 41 - 45	M IND 46	GROSS 47 - 53	FICA 54-58	FICA GROSS 59-65	RETIRE. 66-71	RETIREMENT GROSS 72-78	79-80
													16
													16
													16
													16
													16
TOTALS													26

FEDERAL WTH	STATE WTH	MAINTENANCE	NET PAY	REGULAR GROSS	OVERTIME GROSS	REG HRS	OT. HRS.		
									36
23 - 29	30 - 36	37 - 43	44 - 50	51 - 57	58 - 64	65 - 68	69 - 72	73-78	79-80

VOLUNTARY DEDUCTIONS

CODE	AMOUNT	CODE	AMOUNT	CODE	AMOUNT	CODE	AMOUNT	CODE	AMOUNT	CODE	AMOUNT	
												46
23 - 25	26 - 31	32-34	35 - 40	41-43	44 - 49	50-52	53 - 58	59-61	62 - 67	68-70	71 - 76	79-80

RELEASE

SOCIAL SECURITY NUMBER	DATE EFFECTIVE	TAX STAT	CHECK NUMBER	NAME
1 - 9	10 - 15	16	17 - 22	

FUND 23	BUD 24	PURPOSE 25 - 27	FUNCTION 28 31	SUB ACCOUNT 32 - 36	OBJECT 37 - 40	COST/SHARE 41 - 45	M IND 46	GROSS 47 - 53	FICA 54-58	FICA GROSS 59-65	RETIRE 66-71	RETIREMENT GROSS 72-78	79-80
													17
													17
													17
													17
													17
TOTALS													27

FEDERAL WTH	STATE WTH	MAINTENANCE	NET PAY	REGULAR GROSS	OVERTIME GROSS	REG HRS	OT HRS		
									37
23 - 29	30 - 36	37 - 43	44 - 50	51 - 57	58 - 64	65 - 68	69 - 72	73 - 78	79-80

VOLUNTARY DEDUCTIONS

CODE	AMOUNT	CODE	AMOUNT	CODE	AMOUNT	CODE	AMOUNT	CODE	AMOUNT	CODE	AMOUNT	
												47
23 - 25	26 - 31	32-34	35 - 40	41-43	44 - 49	50-52	53 - 58	59-61	62 - 67	68-70	71 - 76	79-80

UNC PAYROLL CURRENT ADJUSTMENTS AND ONE-TIME PAYMENTS

DATE PREPARED ____________

PAYROLL CYCLE ____________

PAYROLL NUMBER ____________

SOCIAL SECURITY NUMBER	DATE EFFECTIVE	TAX STATUS	NAME
1 - 9	10 - 15	16	

PAY PERIOD MONETARY ADJUSTMENTS

CODE	GROSS PAY	CODE	FED/WH	CODE	STATE/WH	CODE			CODE
5250		5254		5255					08
23-26	27 - 34	35-38	39 - 46	47-50	51 - 58	59-62	63 - 70	71-78	79-80

CODE	FICA	CODE	FICA GROSS	CODE	RETIREMENT	CODE	RETIRE GROSS		CODE
5253		5251		5256		5252			08
23-26	27 - 34	35-38	39 - 46	47-50	51 - 58	59-62	63 - 70	71-78	79-80

PAY PERIOD VOLUNTARY DEDUCTION ADJUSTMENTS

CODE	DEDUCTION AMT	CODE	DEDUCTION AMT.	CODE	DEDUCTION AMT	CODE	DEDUCTION AMT		CODE
52		52		52		52			08
23-26	27 - 34	35-38	39 - 46	47-50	51 - 58	59-62	63 - 70	71-78	79-80

PAY PERIOD BUDGET DISTRIBUTION ADJUSTMENTS

	FUND	BUD	PURPOSE	FUNCTION	SUB-ACCOUNT	OBJECT	COST/SHARE	M IND		GROSS AMOUNT	
5050											08
23-26	27	28	29 - 31	32 - 35	36 - 40	41 - 44	45 - 49	50		62 - 68	79-80

UNC PAYROLL - MISCELLANEOUS CHANGES AND CORRECTIONS

DATE PREPARED ____________

PAYROLL CYCLE ____________

PAYROLL NUMBER ____________

SOCIAL SECURITY NUMBER	DATE EFFECTIVE	TAX STATUS	NAME
1 - 9	10 - 15	16	

CODE

6001		SOCIAL SECURITY NUMBER CHANGE	01
6002		NAME CHANGE	08
6013		RETIREMENT NUMBER CHANGE	08
6027		POSITION NUMBER CHANGE	08

BUDGET CHANGES

	FUND	BUD	PURPOSE	FUNCTION	SUB ACCOUNT	OBJECT	COST/SHARE	MIND	SOURCE ENDS	GROSS AMOUNT	A/D	
6050												08
6050												08
6050												08
6050												08
23-26	27	28	29-31	32-35	36-40	41-44	45-49	50	56-61	62-68	78	79-80

	DATA	CODE	DATA	CODE	DATA	CODE	DATA	
6		6		6		6		08
6		6		6		6		08
6		6		6		6		08
6		6		6		6		08
6		6		6		6		08
23-26	27-34	35-38	39-46	47-50	51-58	59-62	63-70	79-80

PR-3
7-70

UNC PAYROLL DEDUCTION DATA

DATE PREPARED ____________

PAYROLL CYCLE ____________

PAYROLL NUMBER ____________

SOCIAL SECURITY NUMBER	DATE EFFECTIVE	NAME
1 · 9	10 · 15	

NON-STATUTORY DEDUCTIONS AND SALARY REDUCTIONS

NAME	CODE	OLD	NEW	NAME	CODE	OLD	NEW	NAME	CODE	OLD	NEW
HOSPITAL INS.	42			TAX ANNUITY	42				42		
LIFE INS.	42			CREDIT UNION	42				42		
ACCIDENT INS.	42			GARNISH-MENT	42				42		
DISABILITY	42			BONDS	42				42		

04
79-80

SAVINGS BONDS

CODE	OWNER	CODE	TOTAL COST	
7260		7264		04
23-26	27 · 56	59-62	63 70	79-80

CODE	CO-OWNER OR BENEFICIARY	
7261 or 7262		04
23-26	27 · 56	79-80

CODE	STREET ADDRESS	CITY STATE ZIP CODE	
7263			04
23-26	27 · 50	51 · 74	79-80

AGENCY TRANSFER GROSS

CODE	RETIREMENT GROSS	CODE	FICA GROSS
1060		1065	

PAY ADVANCE AND BILL BALANCES

CODE	CREDIT UNION ADVANCE	CODE	HOSPITAL BILL
1265		1266	

04
79-80

PR-4
7-70

III. THE EXISTING DATA ENTRY SYSTEM

OVERVIEW

In the existing system the Payroll clerks process all input forms and fill out original PR forms where necessary. At the end of each day, all of these forms are grouped into batches and delivered to the ADP Data Preparation Division. After changing the format of the data to conform to the computer programs that will process it, Data Prep types the data from these documents onto essentially blank paper in Optical Character Reader font. These sheets are then scanned by the OCR, and the information is spooled to a magnetic tape file. The OCR tape file is copied to a sequential disk file on the computer, and this file serves as input to the transaction processing programs.

The first programs validate the batch control totals of the transactions and add sequence numbers to each record, producing an intermediate transaction file. Later programs sort the records, reject transactions with errors, and write the valid transactions to a file which will be used to update the master file at the end of the pay period. Error reports are sent to Payroll the following morning, from which corrections are made and sent to Data Prep along with that day's new transactions. All transactions, good and bad, remain in the intermediate file. Each day's new transactions are merged with existing transactions, and each day's corrections are applied to existing transactions with errors. The file of good transactions is overwritten each day. This process continues throughout most of the pay period until the final payroll is run. Ideally, at this point all transactions in the intermediate file will pass all editing programs and be written to the file of valid transactions to be applied to the master file.

Approximately two days before the final payroll run, there is a preliminary payroll run which includes the master file update and pay calculation procedures. Stopping short of printing pay checks and reports for the pay period, this run produces the master file Change Journal and the Check Register. These documents are checked by Payroll to detect problems and errors in the payroll run, and corrections are made to the related input data. A second preliminary run which stops after the production of the Change Journal (unless another pre-register is requested) affords Payroll a final verification of the accuracy and completeness of data.

PAYROLL DEPARTMENT DATA ENTRY PROCEDURES

Biweekly Section

1. PD-105's are received from the Budget Department and logged in by the Payroll receptionist.
   a. Date received is stamped on each form.
   b. The log number which Personnel has stamped on the form is matched with a pre-stamped number in the Payroll logbook.
   c. Next to the number in the logbook, the receptionist enters employee name, department number, and date received as on the form.
   d. The receptionist then looks up the employee on the Payroll Alphabetic Employee Listing and writes on the input form the home department number, employee status (active/inactive, etc.), and whether biweekly or monthly.
   e. The forms are placed in a basket for one of the clerks to sort by department number and distribute (each clerk processes forms for a particular group of departments).
2. Each clerk "works" forms for his assigned departments as described below. The form is checked for completeness and accuracy. The action effective date is checked to determine its validity and

whether it is for the current pay period. If it is for a previous pay period and affects the employee's pay, it may be necessary to fill out a PR-2 in order to make a one-time payment for the amount which was due to be reflected in the previous paycheck. If the effective date of the action falls in a subsequent pay period, the form is usually held back for entry during the proper period. The fields for Payroll use only are filled out at this time.

3. At the end of the day (3:30-4:00), the processed PD forms, along with any PR-2's PR-3's, and PR-4's prepared that day are grouped into batches. Each batch contains a maximum of 50 forms, sorted alphabetically by employee name. PR-1's are batched separately and sorted by social security number. Within a batch, each form is stamped with a sequential serial number with the format: xyyzzz, where

   x is the day of the pay period (for a biweekly cycle payday Friday is day one, Monday after payday is day two, and so on until the Tuesday of the final payroll run, which is day eight)

   yy is the pay cycle (01-26 for biweekly)

   zzz is a sequential number starting at 001 each day.

   A batch control sheet is prepared for each batch describing the type of forms in the batch, the number of forms in the batch, and the starting and ending serial numbers.

Monthly Section

The Monthly section follows the same basic procedures as the Biweekly section, with some exceptions as noted below.

1. The data comes in on PD-7's rather than PD-105's.
2. The receptionist merely stamps all forms with the date received and places them in the basket.
3. The clerks sort the forms alphabetically by employee name and check each form against the previous Check Register to make sure the employee is on file and to check the accuracy of the social security number.
4. The serial number stamped on the form is of the format xyyzzz where

   x is always 0

   yy is the day of the pay period, beginning the first day forms are processed

   zzz is a sequential number for forms processed that day.

Errors Committed by Payroll

Because of the sheer volume and complexity of the data, the Payroll clerks themselves occasionally introduce errors during the processing of input documents. The errors may range from letting an incorrect PD form slip by to filling out an original PR form incorrectly. Errors of a more abstract type include failing to assess an employee's pay status correctly or taking inappropriate action which fails to achieve the desired result. Listed below are some of the most common types of errors which the Payroll staff make.

- Failure to detect all errors on incoming forms.
- Correcting forms illegibly, improperly, or incompletely.
- Failing to add all appropriate Payroll data (e.g., tax indicators).
- On turnaround PD forms, failing to bring down into unshaded area data which is unchanged but which must be typed by Data Prep and included in the transaction for some types of transactions.
- Calculating amount fields incorrectly on PR-1's.
- Transcribing social security numbers incorrectly or illegibly.
- Counting number of forms in a batch incorrectly.
- Failing to stamp serial number on a form.
- Submitting WNC-4 card for an employee whose PD form has not come through or contained an error causing a

validation program to reject it.

- Allowing a PD turnaround form to go through with a re-employment action code when the employee is already on the active payroll (usually temporary, hourly).

ADP DATA PREPARATION DIVISION PROCEDURES

Overview

The Data Preparation Division of ADP consists of a division supervisor and two shifts of eight typists each, with one of the typists on each shift serving as a shift supervisor. It is the second shift typists who handle the Payroll transaction data. They receive the batches of forms processed by Payroll during the day and the error reports or pages of reports on which corrections have been marked. The work is divided by the supervisor, with each typist alternating between typing and proofreading other typists' work. The typists use IBM Selectric machines with pin-feed carriages and OCR typeballs. The paper is specially designed for OCR applications and is of the continuous type with perforations between pages. The typing is of a free-format design, having no fixed field positions, but relying instead on control characters as field delimiters.

Transaction Typing

Transaction records, to be OCR scanned, are created from the input documents through a rather complex process of mental reformatting and typed control characters. For each kind of input form, the typist must know what fields to pick up, and in what order. The forms are not simply transcribed onto the typing paper; the data is re-organized, and in some cases translated, into a form that can be interpreted by the OCR Scanner and is more compatible with the computer programs.

Headers. Header lines are typed ahead of data to establish fixed information to be inserted into appropriate following records. Each header corresponds to a particular column or range of columns, and the data contained in a header remains stored in the OCR Scanner memory until another header of the same type is encountered. This arrangement saves a typist from having to type fixed data in each record. Each header line consists of the header symbol ("$"), header number, and fixed data to be stored.

Formats. A format control character and format number are typed at the beginning of a record line to identify the type of record that follows. The format number directs the Scanner to the proper program section for processing the record and enables the program to retrieve from memory the data from the applicable headers to be incorporated into the record. Once a format character has been read, all records that follow are assumed to be of the same type until another format control character is encountered. The format control character ("?") is followed directly by the format number, which is followed directly by the record data.

Errors Committed by Data Prep

- Typing improper header for a transaction (e.g., inadvertently identifying "08" records as "02" records to the Scanner program, causing them to be rejected, as the data is not actually in the expected format).
- Omitting data fields.
- Incorrectly transcribing social security number

  1) in the middle of a PD action -- this effectively splits the records into two PD actions, each of which would be invalid because of incompleteness

  2) on all records within a transaction -- this can happen because the first record usually has the social security number typed, while subsequent records simply ditto that field; the transaction is rejected either because it does not match any master file record or, if the incorrect number does happen to match a master file record, because it attempts to update a record which is (hopefully) inconsistent with the data in the transaction.

- Ordinary typographical errors (field code or data incorrectly transcribed).

DATA VALIDATION AND CORRECTION PROCEDURES

Overview

Each day that transactions are processed during the pay period, error reports are produced by the validating programs and are sent to Payroll the following morning. Usually before any new forms are processed, the clerks examine these reports and attempt to correct each error. Corrections may be made by three basic methods, depending on the nature of the error: 1) the input form itself may be changed, 2) the correction may be made directly to the record on the error report, or 3) a PR form may be filled out to generate a transaction to accomplish the desired change. The corrected input forms, the marked error reports, and the PR forms all will be forwarded to ADP along with the new transactions for the day.

Principal Error Reports

Note: in the following descriptions of error reports, the alphanumeric prefix (e.g., "PP040") refers to the name of the transaction processing program which produces the report.

1. PP040 -- Batch Validation Error Report.

   This report shows batches that are out of balance. This condition arises when the number of records processed for a batch does not agree with the control total on the batch sheet. For Releases and Cancellations (PR-1's), it can also result from a discrepancy between the total net pay on the batch card and the total net pay accumulated by the program from the individual records. Either situation is usually caused by Data Prep's failure to type one or more forms in the batch because of some mistake on the form or difficulty in reading some of the information. Correction of these problems is usually achieved by correcting the input document and sending it back to Data Prep with a new serial number in a new batch.

2. PP050 -- Data Validation Error Report.

   This report is produced by the most extensive validation program. Records appear on this report because data in one or more fields was in an incorrect format, was of an unacceptable value, or was inconsistent with other data in the transaction, or there was insufficient data for the intended purpose of the transaction. Records are displayed in essentially the same format in which they are carried throughout the system. Correction of these errors is normally accomplished by marking the report itself and sending it to Data Prep.

3. PP055 -- Account Code Validation Error Report. This report shows transaction records containing salary source account codes which do not appear on the official Chart of Account Codes file. The program does not reject these transactions, but lists them on the report as a warning only. Corrections can usually be made directly on the report.

4. PP075 -- Master File Data Validation Error Report. This report is produced by the second major program in the system, which validates the data against the master file. Records may appear on this report because the transaction was for an existing employee, but there was no corresponding master file record. Otherwise, the error is usually caused by data in the transaction being inconsistent with data in the corresponding master file record. Most of these errors can be corrected directly on the report. In other cases it is necessary for Payroll to enter an additional transaction through another

form to correct the situation.

5. PP076 -- Journal Entries Self-balancing Error Report. This report lists journal entry transactions (Release/Cancellation or credit/debit combinations to change an employee's salary distribution in the accounting system but not to affect any amounts) that were rejected because they were not self-balancing. Errors at this point usually occur because one or more records making up the journal entry contained an error and were therefore rejected earlier in the system. Corrections are normally made to the transaction at the point where the problem originated.

6. PP077 -- Valid Transaction List. This report lists all transactions that have been accepted by the validation programs. While not an error report in the strict sense, it is used by Payroll in the correction process. Frequently transactions which have valid data (they satisfy all requirements for format, completeness, consistency, and reasonableness) nevertheless have incorrect data or achieve the wrong result, either from transcription errors in Data Prep or from improper source data. This list is referenced when warnings on other reports or end results noted in the Change

Journal indicate such a problem. Corrections are often made directly on the list, and that page is torn off and sent to Data Prep.

These are the error reports which are received daily, resulting from the previous day's new transactions and error corrections. Toward the end of the pay period, ideally, there are no new transactions; thus the error reports contain only transactions for which previous attempts at error correction have failed. As these problems are resolved, the reports should diminish to either no messages, or only non-fatal warnings.

Preliminary Payroll Runs and Error Correction

The two preliminary runs touch off a brief flurry of last minute error correction. In addition to the normal error reports, which should be nearly "clean" at this point, Payroll receives a Change Journal from each run and an error report from the pay calculation program from the longer (first) run.

1. The Change Journal functions as an error report in that invalid situations encountered by the master file update program are reflected in the Journal by error messages where normally only the old and new data would be displayed. The most common error appearing in the Change Journal is the failure of

the sum of all salary sources to equal the prescribed base rate. Corrections to errors on the Journal are usually made to the transaction on the PP077 Valid Transaction List or by generating a new transaction through a PR form.

2. The PP100 Exception Report, produced by the pay calculation program, is received by Payroll after the first preliminary run (and second, if requested), as well as after the final run. It lists employees for whom some invalid or unreasonable condition was encountered during pay calculation. One of the most common messages is a warning indicating that an employee's gross pay is unusually high (current values: greater than $700 for biweekly employees subject to the Fair Labor Standards Act, $1500 for biweekly employees exempt from the FLSA, and $3000 for monthly employees). Another common message indicates that after pay calculation there was a net pay credit -- i.e., total statutory and voluntary deductions exceeded the computed gross pay. Corrections are made at the most appropriate point after the transaction has been traced back through the system to determine the source of the error.

Typing of Corrections by Data Prep

Corrections to existing transaction records as marked on error reports can be typed in two different ways. For radical changes to the record, the typist may simply delete the existing record and re-type it with the correct data. To delete the record she types "?0" (format "0"), the social security number, and the sequence number which has been added by one of the transaction processing programs. She then types the corrected record just as if it were new data; the only difference is that she includes the sequence number from the original record. This allows the transaction processing programs to replace the original record with the corrected one.

For simple changes to a record, the typist may specify only the field or fields to be changed and the corrected data. First she must determine in which column of the record the erroneous field begins. Then she types "?5", social security number, sequence number, column in which to begin change, corrected data, and "&" to denote end of change.

IV. INADEQUACIES OF THE EXISTING SYSTEM

OVERVIEW

The existing Payroll Transaction Processing System is a batch processing system based on applying OCR technology to a punched card-oriented data entry procedure. Although it is a vast improvement over the card system from a data entry operational viewpoint, it is no longer adequate to meet the needs of the Payroll Department. The number and transiency of University employees has continued to grow; so has the amount and complexity of the associated data that must be processed. Specific problems and an overall lack of efficiency have been increasing the workload and frustrations of the Payroll staff. This inconveniences employees in the pay process, and adds to the load and scheduling problems of ADP's personnel and resources.

Most of the shortcomings of the existing system result from the indirectness and multiple data transcriptions inherent in the design philosophy and technology used. The

Payroll staff has no direct control over the data after it has been coded onto the forms. Their only control is an "after the fact" examination of error reports and, later, a Change Journal to determine what went into the system incorrectly. Significant data degradation occurs during the transcription process between data coding and data input to the processing programs. To appreciate fully the underlying weakness of the current system, one must examine the interplay of the factors which characterize it.

OUTSIDE PARTY TRANSCRIPTION

One of the primary contributors to the weakness of the system is the simple fact that Payroll is dependent upon an "outside" party to prepare data for entry into the processing programs. While Data Prep personnel are to be commended for the speed and accuracy of their work under the constraints of the established transcription method, they are not trained in Payroll procedures. They can type only exactly what is on a form (actually, the more experienced typists do a considerable amount of editing and correcting in an effort to reduce the error rate, even though they are instructed to type only what they see). The complexity of the data and the likelihood of errors on the forms make data entry by an outside party an inappropriate concept.

The PD-105 and PD-7, which constitute the highest volume of forms, are the most complicated forms. They can contain an enormous amount of data which is entered through a rather elaborate set of codes for conciseness. In addition the PD forms are usually initiated by the various departmental secretaries throughout the University, most of whom have limited experience in filling them out. Thus the rate of errors already on the forms when Payroll receives them is quite high. Although the Payroll clerks attempt to check each form for accuracy, the volume of forms and pressures of time preclude extreme vigilance. Moreover, the clerks themselves may make mistakes in completing the forms, leaving out a necessary field or coding one incorrectly. Consequently, much of the data reaching Data Prep is not "clean". Since the process of transcribing data from the form into a machine-readable format provides the best opportunity for all fields to be scrutinized, it is here that most of the obvious errors could be caught by trained personnel. Unfortunately, it is impossible for Data Prep personnel to handle that operation.

COMPLEX TRANSCRIPTION PROCESS

The second basic weakness of the existing system is the method of transcribing data from forms into OCR format. This technique is quite involved, requiring months of training before a new typist is reasonably comfortable with it. The use of headers and format control characters complicates the process, although it does reduce the amount of typing. The fact that data fields are not picked up in exactly the same order and format in which they appear on the form further increases the complexity. Adding in the normal typographical errors, one is almost surprised that the transcription processs introduces no more errors than it does.

Not only is the typing process complicated, but the OCR technology itself can cause problems. In the first place there is one more piece of equipment in addition to the computer which must be depended upon. The OCR Scanner in ADP is the only one on the entire campus. Thus not only is competition for it keen, but a breakdown leaves Payroll temporarily stalled, as there is no back-up machine. While there have been few incapacitating failures, minor Scanner problems have introduced errors into transactions in the past.

Finally, one is forced to consider the philosophy behind OCR technology. It was designed to reduce data transcription by being able to read human-readable forms that have already been prepared. The idea of preparing human-readable forms and then typing them into OCR format solely to get them into a computer system seems foreign indeed to OCR philosophy.

SLOW DATA TURNAROUND

The third detrimental factor in the existing system is the long delay between coding a transaction and confirming that it was entered into the system correctly. This delay is directly related to the first two factors. Having an outside party handle data transcription mandates batching and scheduling to promote efficiency. Secondly, the OCR technology used further tightens the batch-oriented nature of the transaction processing. Both the typing and the scanning of transactions are independent off-line functions and require the accumulation and contiguous processing of large amounts of data.

There is currently a minimum of a twenty-four hour turnaround for a transaction coded one morning to be confirmed as correct in the system via the error reports and valid transaction list. If there were an error and a subsequent correction, there would be another twenty-four hour delay before the effect of the correction could be determined. Furthermore, the correction would be subject to practically the same types of errors as the original transaction. Indeed, it is not uncommon to see the Payroll staff spend several days trying to get a particular transaction into the system properly because of a combination of an original error, inappropriate correction technique, and errors in transcribing the correction. When this situation occurs late in the pay period, the transaction may not get corrected in time for the final payroll run, necessitating a manual payment and an adjustment during the next pay period.

INEFFECTIVE ERROR CORRECTION PROCESS

The fourth detrimental factor in the existing system, closely linked with the first three, is the method of error reporting and correcting. The multiple error reports, although logically separated according to the type of validation program and hence the broad type of errror, can cause the staff some problems of coordination in determining the source of an error and making the correction. For instance, it is possible for an error on two different reports to result from the same flaw in a transaction. If corrections are made independently from each report, the result may be undesirable. Another possibility is that a correction made from one report one day may itself have an error (or have one introduced during transcription) which causes the transaction to appear on a different report the next day. When the apparent error is then corrected, the transaction may be back in its original erroneous state. Both of these situations can occur more readily when the current practice of not having all the reports handled by the same clerk is followed. In addition to the reports being separate, the use of the Change Journal as an error report is not only wasteful in terms of paper and processing time, but it means that invariably there are corrections to be made on the last two days before the final payroll is run. Another weakness of the error reports is that the transactions they display are in a format which resembles the record format used for the processing programs, rather than one which resembles the original form.

The method of making the corrections is a more damaging source of inefectiveness than even the reporting technique itself. When marking the error reports, it is often difficult for the clerks to specify clearly and exactly how Data Prep should type the correction. Moreover, even when the correction to be made is clear, the cumbersome method of typing corrections causes trouble. Trying to determine which column a field begins in is difficult for the Data Prep staff when working only with the error report, because the same field may begin in different columns, depending upon the format under which it was typed. Similarly, adding a line is tricky in that it may or may not require a header to precede it, depending upon the previous line added (and there may be several lines of replacement corrections in between, making it difficult to locate the last addition). Mistakes resulting from these difficulties are frequent during the transcription process.

Finally, the correction process is hindered by the delay between data coding and error reporting. A minor effect is that the original documents must be located and examined before the Payroll staff can determine the problem and make the necessary changes. While becoming reacquainted with the transaction causes but little inconvenience, there is a more important aspect of this delay. There are many errors which occur during the processing for which no one obvious solution exists. In these cases even the more experienced clerks are unsure of the best way to achieve the desired result. The approach taken seems to be one of experimentation, where a technique is decided upon with the assumption that if it produces the wrong result, something will show up on an error report or on the Change Journal. The drawback is that by the time the result -- especially success -- is noted, details of the circumstances and correction technique employed are hazy; and there is always that possibility that the correction attempt may be shattered by a transcription error, further removing effect from action. Consequently, there is little positive reinforcement of successful correction techniques or negative reinforcement of inappropriate techniques, because there is no immediate feedback of results.

SUMMARY

The basic weakness of the existing system, then, can be reduced to four closely-linked elements: 1) Payroll's dependence upon an "untrained" outside group to transcribe complex, unclean data which often requires judgemental interpretation; 2) the use of a rather complicated transcription process and constraining technology; 3) an excessive time lag between data coding and error reporting; and 4) a somewhat cumbersome and imprecise error correction process. The combined effect of these extremely interdependent factors greatly diminishes the efficiency of the system.

Yet this very interdependence makes it difficult to improve efficiency by eliminating any single factor. The solution is to eliminate or reduce as far as possible all of these factors by adopting a design philosophy and a technology that give Payroll the direct control of data from receipt to computer processing and reduce the number and complexity of transcriptions. An added benefit of such a solution would be the enhancement of privacy and security of data, an issue of increasing importance today.

V. PROTECS -- THE NEW DATA ENTRY SYSTEM

OVERVIEW

Philosophy and Technology

The analysis of the Payroll Transaction Processing System led to the conclusion that the appropriate design philosophy for an upgraded data entry system would be to let the user input his own data directly into the computer system. Furthermore, the data should appear in the same basic format throughout all contact with the user, insofar as possible. Finally, the system should have the capacity for interactive data entry, validation, and correction. Thus it was apparent that the logical technology for implementation would employ CRT computer terminals located in the user department.

Such a design philosophy and technology would have much in its favor and would circumvent the major shortcomings of the existing system. It would provide Payroll with more direct control over transactions, sharply reduce the amount and complexity of data transcriptions, and greatly simplify the correction process. Consequently, the error rate should be reduced substantially. The instances of manual payment and retroactive adjustments caused by missed data entry deadlines and failure of the correction process should decline. The number of paper forms originating in Payroll should be cut to a fraction of its present level, as most transactions could be created at the terminal from existing documents. Finally, a subtle benefit of the increased directness and simplicity would be faster data turnaround and more immediate feedback from staff actions. This improvement should tend to discourage ineffective techniques, reinforce good techniques, and increase understanding of the pay process.

Overall Data Entry Process

Under the new data entry system, the Payroll clerks are responsible not only for processing input forms and originating transactions within Payroll, but also for entering all data into the transaction processing system through the terminals. PROTECS writes the transactions to an Indexed Sequential Access Method (ISAM) file on disk. This file remains extant throughout the current pay period, being constantly updated with new transactions and corrections when PROTECS is in use.

Each time the validation procedure is invoked, a copy of this file is made to serve as input to the validating programs. As under the old system, transactions with errors are printed on error reports, but stay in the file for subsequent correction. Transactions that have passed all programs are written to the valid transaction file and listed on a report. Payroll clerks check the error reports, retrieve the invalid transactions from the file for display on the terminal, and change them appropriately. The corrected records are written back to the file. By the end of the pay period, all transactions in the file should pass all validating programs and be able to update the master file.

SYSTEM DESCRIPTION

Software

PROTECS consists of three major program modules written in COBOL and several small assembly language programs. The main driver module calls the other two modules and all the assembly language programs as subroutines. The assembly language routines are used to accomplish specific narrow purposes, often involving an interface with the VS/9 System Macro Processor. For example, one subroutine issues a macro to activate a certain ENTER file (a background task file containing JCL). This file in turn executes a procedure that validates the transactions. Some of the assembly language routines are utilities provided by the ADP Systems Programming staff that extract information from the VS/9 environment.

The main program module is itself under the control of CAM (VS/9 Communication Access Method) through which it communicates with the terminals. To access PROTECS, a user types the CONNECT command. This command attaches his terminal to CAM in a manner similar to that in which the LOGON command attaches his terminal to the normal VS/9 interactive operation. If the name "PROTECS" is supplied as an operand of the CONNECT command, CAM calls PROTECS and performs the task of passing messages back and forth between it and the terminals.

Because CAM can detect and specify which terminal it is serving in either direction, PROTECS is designed to be re-entrant. As the driver module finishes servicing a terminal's request, it stores that terminal's line number as a key. With the key it stores a pointer to the next program section expected to be executed and the current values of information associated with that terminal. Then when the same terminal is ready to be serviced again, processing for it can begin at the appropriate point in the program. The advantage of this re-entrant scheme is that all five terminals can be connected simultaneously. Yet each terminal operates independently, as if it were the only one attached.

Hardware

The hardware configuration for PROTECS currently comprises five Hazeltine 1510 buffered display terminals. Because the Payroll Department is located in the same building as ADP, it was possible to wire these terminals directly to the computer, avoiding the expense of modems and telephone lines for transmission. The 1510 terminals have no built-in intelligence, so they operate at all times under the control of the PROTECS programs running on the mainframe.

These terminals are equipped with some display enhancements and editing features, including reverse video, half and full intensity (protected and unprotected fields), cursor addressing, line insertion and deletion, and page transmission. Most of these features can be remotely controlled by the programs. Consequently, the terminals are capable of displaying form facsimiles and providing for fill-in-the-blank data entry. They also have a special FUNCTION key, which is used in conjuction with a regular alphanumeric key. This special key causes the terminal to transmit a unique two-character sequence reflecting the particular alphanumeric key used, without the SEND key (data transmission key) being struck and regardless of the current display.

General Operation

The operation of PROTECS from the user's point of view is designed to be as simple as possible, requiring a minimum of information to be entered and a minimum of keystroking to control the operation. The entire entry process is one of filling in the blanks. Required fields for which values can be anticipated but may occasionally vary (such as date and serial number) are pre-filled in with the expected value. They can be passed over by the operator unless an exceptional transaction is to be entered. Fixed data to be included in a transaction record are generated by the programs after the information on the screen has been transmitted. For example, if the blank associated with a particular field has been filled in by the operator, a field code will be generated to accompany the field value in the transaction record created. Dollar signs, decimal points, hyphens, etc. are automatically displayed on the screen. Thus only the bare essentials of the input data need to be supplied by the operator.

The control of the operation is accomplished mostly through built-in functions. These are activated by the operator's striking only the FUNCTION key and one alphanumeric key. They cause the terminal to transmit immediately a unique bit pattern which is interpreted by PROTECS as a command to take a particular action.

The two major modes of operation are new data entry and data correction. After the preliminaries of signing on have been accomplished, the operator may add new transactions to the file or correct existing ones, and he may change modes freely. To accomplish new data entry, he uses a built-in function to cause PROTECS to display a blank mock-up of the desired input form. He then fills in the proper blanks, checks the screen for mistakes, and strikes the SEND key to transmit the data to the computer. PROTECS generates transaction records, translating the data into the internal format required by the transaction processing programs, and writes these records out to the transaction file. It notifies the operator of the number of records created and their sequence numbers, clears the displayed fields of data, fills in the date, and increments the serial number. The operator can begin keying in the next form immediately. If he wishes to use a different type of form next, he uses the appropriate function to obtain the needed blank mock-up.

To correct an existing transaction, the operator supplies the serial number of the original form or the sequence number assigned to the first record generated from the form. PROTECS reads the transaction file, obtains all the records that were generated from the original form, translates them into the display format, and displays them on the screen as a facsimile of the original input form with the fields filled in. The operator then changes, adds, or deletes fields and hits the SEND key. The transmitted information is once more broken down into transaction records and written out to the file.

DESIGN ALTERNATIVES AND DECISIONS

Overview

Throughout the development of PROTECS, alternatives for various aspects of the system had to be considered and decided upon. Among the most important were the following: 1) for whom should the system be designed, Payroll or Data Prep? 2) for what type of hardware configuration should the system be designed? 3) should the system be designed, programmed, and implemented as a completed unit, or in stages?

The Choice of User

While the whole concept of the system was still being pondered, the basic question arose as to whether it should be used by Payroll or by Data Prep. The question had to be settled before the design could progress, as it was germane to the approach to data entry that the system would take.

The Data Prep typists are experienced in data entry from many types of documents. Undoubtedly, they could be trained to enter documents through terminals faster than many Payroll clerks. However, of the four major factors responsible for the weakness of the existing system, only the problem of a complex data transcription process would be eliminated if the system were designed for the Data Prep staff. The basic disadvantage of having the data input operation performed by a party outside Payroll would remain. The data turnaround rate would likewise remain unchanged. Finally, corrections would continue to be handled in the same ineffective manner.

Moreover, on-line validation of transactions as they are entered would clearly be desirable to incorporate into the system eventually. Yet its implementation and effective use would depend upon having a Payroll clerk make corrections to transactions as they are entered. This would mandate that the data entry operation be assumed by Payroll at the time on-line validation were implemented. It seemed only reasonable in this light to have Payroll enter data from the beginning.

For all the reason cited above, it was decided that PROTECS should be designed for use by the Payroll staff.

Hardware Alternatives

Another question which had to be settled fairly early in the development was the type of terminal hardware to be used. The system could be designed for dumb terminals; for intelligent, programmable terminals capable of independent, off-line data entry, validation, and storage; or for a terminal configuration somewhere in between.

1. Buffered Display (Dumb) Terminals.
   These terminals would possess no microprocessors and only sufficient memory to store one page or screen, to allow transmission of a full screen of data at one time. Under this hardware constraint all processing and all display control would be handled by the programs running on the computer. The cost for five of these terminals would be approximately $6000.
2. Semi-intelligent Terminals with Storage Devices.
   This type of terminal would be capable of supporting a mass storage device, such as a tape cassette or a floppy disk unit. It would also be able to store and retrive screen formats for display, and it would provide some programmable function keys to control its operation. Therefore it would be possible to design a system which would allow for some crude data entry operation in an off-line mode. The transactions would be captured by the mass storage

device for future transmission to the computer. This would be a valuable capability at times when the computer was down or overloaded. Moreover, having some of the control of the operation handled by the terminal would both speed response time and reduce the load on the mainframe. The cost for this configuration would be in the range of $20,000-$25,000.

3. Intelligent, Programmable Terminals.

These are highly sophisticated terminals with the processing power of the minicomputer of a few years ago. They are fully programmable in an abbreviated assembly language, and some can even be programmed directly in a high level language. Most types are equipped with fairly large memories (32K is not uncommon), and all can support mass storage devices. Some of these terminals even have a small Disk Operating System (DOS) and can support ISAM files.

With these capabilities, it would be possible to program most of the sytem within the terminals, providing for totally independent, off-line data entry and storage operation. Furthermore, the majority of data validation could be done by the terminals on an individual transaction basis. Normal response would be very fast, and almost no processing and input/output load would be placed on the mainframe. The cost of this type of hardware configuration would be around $30,000.

The $30,000 configuration is clearly the most desirable. It would provide the easiest and fastest data entry techniques. Its operation would be virtually unchanged, whether the computer were up or down. Finally, it would place the least strain on ADP's processing power.

As is often the case in the real world of budgeting, the deciding factor in this case was cost. It was simply impossible for Payroll to secure funding for a $30,000 terminal system. This is a goal still being pursued actively for the future.

The dumb terminal configuration was selected, primarily because of the financial constraints. There were other factors which made this a very practical choice for the present. One of the most important of these was the fact that ADP's new Univac 90/80 computer was to be installed before PROTECS would go into operation. The resulting temendous boost in ADP's data processing power would make it feasible to add another large interactive application totally dependent upon the mainframe. This additional strain could not have been accomodated under the old Univac 70/7 computer system.

Another factor which made the dumb terminal system practical is the high reliability of ADP's operating systems. In spite of being greatly overtaxed, the old system using the 70/7 experienced relatively little down time. Since this computer was being retained, it was anticipated that the 90/80 could be installed and stabilized to be equally reliable before applications were transferred to it. Happily, after an inititial period of hardware problems, the 90/80 has proved to be very reliable, and Payroll has experienced little inconvenience resulting from computer down time.

It is interesting to note that the middle alternative, often the most practical, was not very desirable in this situation. The main advantage of the $20,000-25,000 hardware over the $6000 configuration is that it would be capable of supporting a crude off-line data entry operation. In view of the reliability of the computer and the added complexity from the user's viewpoint, this alternative did not seem to be practical from a cost/benefit standpoint. It would cost over two-thirds as much as the most expensive alternative without providing nearly the capabilities.

Development and Implementation Scheduling Alternatives

As the design of PROTECS continued, it became clear that implementation could be scheduled in many different ways. Since it was a one-man project, the designing and programming was expected to stretch over a significant length of time. Furthermore, no analyst or programmer in the Payroll/Personnel staff had had any experience with interactive systems under the VS/9 operating system. Therefore, while it would be possible to develop, program, test, and deliver PROTECS as a completed system, there were two obvious disadvantages to such an approach. First, implementation would certainly be delayed. Since the dissatisfaction with the existing system had been growing rapidly, it was desirable to begin providing some relief as early as practical. Secondly, it was important to have a system that worked efficiently, was easy to use by personnel having no experience with terminals, and met the user's needs as completely as possible.

It seemed advisable, then, to develop and implement the system in stages. This scheme would permit part of the system to be ready to use at a much earlier date. It would allow the Payroll clerks to be exposed to it gradually and be fully trained before they had to assume operation of the total system. Furthermore, it would make it easier for Payroll to take over the data entry process from Data Prep gradually, rather than all at once. Perhaps most importantly, feedback from the implemented portion could guide the development of the rest, and changes to the working sections would be sufficiently narrow in scope to provide minimum disruption to Payroll's learning process.

The initial thought was to develop and implement a rather low-powered system to provide on-line correction by Payroll of transactions entered by Data Prep. The second stage would encompass new data entry by Payroll. Finally, the correction system would be upgraded to provide the same comprehensive functions and flexibility as the data entry portion. In addition to the general advantages of modular development, this approach would provide the earliest relief for the greatest source of problems and dissatisfaction in the existing system.

As the design progressed, however, it became clear that with little added effort the correction portion and new data entry portion could be developed simultaneously at the desired level of sophistication. Many of the same basic programming structures could be used for both. From the user's viewpoint, of course, it would be far better to have the basic operation of the system remain constant from its earliest introduction. Thus the idea of a "quick-and-dirty" correction system was dropped.

The type of implementation segmentation ultimately chosen was based on the input documents that could be processed. Much of the coding in the programs apparently would consist of the data structures and algorithms necessary to display and translate the many different formats of the input documents. The basic control structures of the system should be the same for all types of input. Consequently, the system could be developed and implemented around one type of input form initially, and then gradually expanded to handle the rest. Feedback from the operation with each additional form could be used to fine tune the entire system.

The form chosen for the initial development was the PD-105. This form is one of the highest in volume and one of the largest and most complex of any used. At the same time, transaction records generated from this form have more in common with all the other types of records than those from any other form. There probably have been more errors generated from this form than any other. Finally, the PD-105 is used only for employees paid biweekly. For this reason any problem in the creation of these records would be detected within a week, the time between the first day of data entry and the preliminary payroll run.

PROTECS went into partial operation with the PD-105. The first use of the system was to run parallel data entry with Data Prep. PD-105's were entered into a dummy transaction file through PROTECS by the Payroll clerks, and then they were sent to Data Prep for entry into the official transaction file. Both files were validated and the error reports and valid transaction lists from each were compared. At the same time, PROTECS was being expanded to handle the next type or types of forms. One by one, the capability of handling each form was developed, tested, exposed to parallel runs, and finally put into production.

CHANGES IN PAYROLL PROCEDURES

Under the new system the Payroll clerks do not prepare data for input by Data Prep, but instead enter the data directly. While the department is organized and operates the same as it did under the old system, there have been many changes to the procedures followed.

Forms are now worked and entered all day long, rather than being stockpiled for batching at the end of the day. The serial number is stamped on each document at the time the information is entered through the terminal. This practice enables the serial number to be used as an indication that the form has been entered. The first digit of the serial number is now used to identify the clerk who entered the transaction, rather than which day it was sent to Data Prep for entry.

One of the most significant changes in procedures is the way in which transactions originating within Payroll are handled. Paper PR-4 forms (for voluntary deductions) are almost never filled out now. Instead, the deduction information is keyed into a PR-4 mock-up on the screen directly from the original source documents, such as the cards from insurance companies, Credit Union deduction authorization, etc. A similar practice is followed when PR-2's or PR-3's are needed to make adjustments or to correct fields. If a PD form for the employee already exists, a notation is made on it, and the transaction is keyed in with no corresponding paper document.

Another simplification concerns the submission of a PR-3 from Personnel to correct one or more fields on a PD-105 submitted earlier in the pay period. This action is initiated because Personnel has noticed on its Change Journal that these fields, while valid, are incorrect, either through an error in filling out the document or in its entry by Payroll. Now Payroll can usually retrieve the PD-105 through PROTECS and correct the fields on it, rather than keying in the additional PR-3. This procedure reduces the number of transactions and the likelihood of introducing more errors.

CHANGES IN DATA VALIDATION AND CORRECTION PROCEDURES

Most of the validation programs are unchanged under the new system. There are significant differences in the validation procedure, however, and even greater changes in the correction process. While all the problems have not been solved, the new procedures are considerably simpler and more effective.

First, except on the rare occasions when some transactions have been entered by Data Prep, there is no longer any batch validation performed. There is also no merging of new transactions with existing ones, no application of corrections to existing transactions, and no addition of sequence numbers to new records. Thus the execution of several programs and manipulation of corresponding files is bypassed during routine execution of the validation procedure. This change also eliminates the PP040 Batch Validation Error Report. To provide a new means of detecting forms that have been accidentally overlooked and not keyed in, a new and simple validation program has been added. PP047 detects breaks in consecutive serial numbers in the input transactions. It produces an error report showing the numbers before and after each break. Since each clerk uses consecutive numbers, all cases of missing serial numbers are investigated to determine the cause.

Error reports are still produced individually by each program. The nature of the programs and difficulty of designing a sorting scheme for a print file make it impossible to combine these reports without extensive modification of all programs. In view of the desire for on-line validation of individual transactions, expending the required effort cannot be justified.

There are three factors, however, that greatly improve the effectiveness of these reports. First, the Payroll clerks can initiate the validation procedure as often as they wish, rather than having it run by ADP only at night. This fact, coupled with the lower rate of error generation and the vastly improved correction techniques, tends to keep the number of invalid transactions in the system at any time fairly small. Thus the reports are greatly reduced in bulk. Secondly, each clerk now examines all reports, a procedural change facilitated by producing duplicate copies of major reports. This practice makes it more likely that the true nature of errors is discovered (see the earlier discussion of the old correction process). Finally, with the use of the serial number to link transactions with the clerk who entered or corrected them, each clerk can quickly spot his own transactions on the error reports.

Another change is that most of the error detecting formerly done by the master file updating program has been taken over by PP075, the program which validates transactions against the master file. This change means that errors which used to appear in the Change Journal now appear on the PP075 error report. There are two main benefits from this difference. First, errors are detected and corrected much earlier, as the PP075 report is produced from the very first day of data entry. The Change Journal is produced only very late in the pay period. Secondly, the Change Journal is now regarded less as an error report than as a means of following a transaction to see that it had the proper effect on the master file record.

The most sweeping change, of course, is in the actual method used to correct transactions. Under the old system the clerks marked the error reports and sent them to Data Prep, where correction records would be typed from them. Under the new system the clerks themselves correct the transactions directly on the screen in the format of the original input document. Each clerk corrects his own forms and usually does not need to mark the reports at all.

VI. EVALUATION OF PROTECS

OVERVIEW

PROTECS went into operation in June, 1978. The ensuing months have afforded an opportunity to observe and weigh its effectiveness in meeting the needs of the Payroll Department. The users have had time enough to become familiar with their new procedures and to demonstrate their satisfaction. As expected, the system has constantly been improved in capabilities and ease of use, as experience has provided feedback. Future extensions have been explored, and plans are being made for the eventual implementaion of some of them.

SYSTEM PERFORMANCE AND IMPACT

Performance

Generally speaking, the performance of PROTECS has been gratifying. There have been no major software problems, and minor problems have been corrected immediately upon discovery, so that Payroll has been inconvenienced very little by the software. The system has been improved steadily as time and experience have permitted. Together with the Payroll staff's increasing data entry skills, these improvements have caused the transaction input rate to be much higher and the error rate much lower than when the system first went into operation.

There have been a few hardware problems and some occasional trouble with the CAM interface. The hardware problems have been varied in nature. Some of the terminals have broken and have had to be repaired. A faulty building ground in an electrical circuit and a freak thunderstorm combined one evening to burn out all the terminals. Finally, an intermittent problem with some of the terminal transmission lines has plagued the operation. However, except for the thunderstorm (all terminals are now unplugged at the end of each day), none of these problems has caused the system to be unusable for more than an hour or so at a time. Moreover, the occurrences have been few and widely spaced.

Impact

PROTECS has had a considerable and beneficial impact on transaction processing. From the standpoint of ADP's operation, it has simplified scheduling of resources. It is no longer necessary to schedule Data Prep time to type source documents. There is no longer any need for OCR processing, which requires the OCR scanner and an operator to be scheduled and dedicated. Furthermore, the routine validation of transactions is now accomplished automatically, through a procedure initiated by Payroll through PROTECS. Formerly, ADP personnel had to set up and submit a job each evening to accomplish this task.

More importantly, PROTECS has had quite an impact on the quality of data and on the sense of responsibility for and control of data that the Payroll staff feels. The new system has greatly reduced the data degradation that was such a problem under the old system. The error rate in transactions is a fraction of what it was. Of course, the speed and accuracy with which data is keyed in varies widely among the staff. More than once, however, the faster clerks have been observed to enter over 150 forms in a session (generating a total of about 450 records or 1800 data fields) with only one field on one form containing an error. Such accuracy would be nearly impossible under the old system. Because of it the number of retroactive corrections made each pay period has dropped.

The fact that the transactions are handled only by Payroll has enhanced the staff's sense of responsibility for and control of data. The relationship of cause and effect is more clearly seen. The clerks realize that if they have processed a transaction appropriately or calculated a field correctly, it will go into the system correctly, as long as they make no mistake in the entry process. Conversely, if a transaction has an error or produces the wrong result, they know there is no one else to blame. This sense of directness, together with the capability of providing validation and error reports quickly (sometimes within twenty minutes of the last entry), appears to be improving both their attitudes and performance. They seem more willing to try new techniques and to think about what they are doing and why. It is rewarding to believe that PROTECS has been instrumental in improving job comprehension, enthusiasm, and satisfaction for a few employees.

CUSTOMER ACCEPTANCE

On the whole, the reaction of the Payroll Department to the new system has been quite favorable. The staff members experienced some concerns and mixed feelings during the design and early stages of implementation. Over the past few months, however, their satisfaction and enthusiasm has continued to grow with their experience. Some natural factors existed to generate an atmosphere of acceptance. Other influences were deliberately created through establishing a good working relationship with the staff, carefully presenting new ideas, and subtly encouraging optimism about new methods.

One of the chief elements that helped set the stage for a receptive outlook was the growing frustration with the existing system. The feeling of futility in trying to get data into the processing system accurately and the irritation of repeatedly correcting the same errors made the idea of a system offering more direct control over data quite attractive. The promise of a simplified and effective correction process was even more appealing.

Other factors reinforced the appeal of the system. The thought that the rate of errors would be lower was encouraging in its own right, even without regard for the correction process. The possibility of increasing the flexibility of scheduling and reducing deadline pressures was also encouraging. Finally, the whole concept of using computer terminals was new and exciting. It offerred a change in the consistent and sometimes boring office routines.

While I made no direct effort to sell the system, I did try to create and foster the atmosphere of acceptance. I spent a considerable amount of time in the Payroll Department assessing the data entry needs and becoming familiar with the problems and frustrations of the staff. Lending a sympathetic ear and making an effort to understand their problems helped convey the feeling that any changes would be made directly for their benefit. I also openly solicited ideas from the staff and tried to plant seeds from which they could originate ideas. Making sure that each clerk had input into some aspect of the system, I frequently asked for advice and evaluation of ideas from everyone. This process of involving the staff in the design continued throughout the development and later improvement of the system.

The concept of implementing in stages made it easier for the staff to begin using the system with a minimum of pressure. When the first phase was ready to go into operation, I spent approximately an hour on the terminal with each clerk, guiding him through the basic operations. As the ability to handle each form was added to the system, I demonstrated it and was present in Payroll during its initial use. I also made certain that the Assistant Payroll Director was thoroughly versed in the operation of each new phase and, later, of each improvement added. This tactic insured that the clerks could consult a knowledgeable individual in Payroll on operational questions. They would be much more likely to do this than to call me. Along with the training, I tried to be diligent in supplying revisions or supplements to the user's guide whenever changes were made to the system.

The most serious doubts expressed by the clerks concerned the increased workload. They could see only that they were expected to do their old jobs and Data Prep's job as well. To allay these fears, I reassured them of several facts. First, Data Prep would serve as a back-up to handle their overflow as long as necessary. Secondly, the implementation would be in stages, making it easier to adjust to the changes. Further, there would be changes in the procedures and scheduling to save time and to smooth out the peaks in the workload. The expected lower error rate would also save them time. Finally, they were assured that if it proved absolutely necessary, additional personnel would be hired.

Other negative attitudes concerned a reluctance to change old procedures. This attitude was found only in a few long-term employees. Patience and the clerk's own experience with the system were all that was necessary to begin improving this outlook. It became obvious that the work would be easier, more efficient, and more fun if procedures were changed to take advantage of the system. The continued solicitation of new ideas also stimulated the development of an open-minded attitude, as old habits were examined for their underlying motives. Ultimately, some of the employees most unwilling to drop old methods have become the most eager to advance suggestions for change.

COSTS AND SAVINGS

Costs

It is almost impossible to assess with any accuracy the costs and savings associated with the development and implementation of PROTECS. One of the chief difficulties of cost assessment is in categorizing and estimating the time spent on the project. A substantial amount of the total time was spent on investigating and learning things of general importance. While this learning experience was motivated by the need to develop PROTECS, the application of the knowledge is universal; indeed, the experience and knowledge are already being applied to other projects. PROTECS happened to be the first one to need this kind of knowledge and experience. Many techniques and facts were investigated and learned that were not applied to PROTECS but have proven or will prove to be useful in future situations.

Within these constraints, a very rough estimate of the time spent on the research and development of PROTECS would be as follows:

- nine man-weeks on the analysis of the Payroll Transaction Processing System and the existing data entry system
- twenty man-weeks on the design, programming and implementation of a fully operational version of PROTECS.

Even if these time estimates were accurate, it would be difficult to attach a cost to them. ADP is allocated a fixed portion of its budget to provide data processing services to the Payroll Department. While all necessary maintenance and new programming continued, this project had priority over some less urgently needed projects that otherwise might have been started during this period. The way in which management handles this project can influence the assessment and interpretation of its costs.

Even the hardware costs are not rigid. Some terminals are borrowed, some bought. If ownership were ignored, and the planned (but not installed) fifth terminal were included, then the hardware costs could be estimated as follows:

- 5 terminals at $1200 = $6000 (one-time cost)
- installation of cables: $180 (one-time cost)
- terminal maintenance : $1020 (annual cost).

It should be noted that the cost of terminals is not truly a one-time expense in the very long run. Even though the continuing cost of the maintenance contract conceivably could keep the terminals operating indefinitely, eventually they should be replaced to keep pace with technology. In reality, however, an entirely different system would likely replace the current one before the terminals would have to be changed.

The Payroll Depatment is taking steps to fill a vacant position on its staff to absorb the increased workload. This position has not been needed during the last few months that PROTECS has been in operation, because the volume of transactions during October, November, and December is fairly low. It would be very advantageous, however, to have an additional employee trained and able to share the load during the more active times of the year. Although this position was allocated before PROTECS was even conceived, it may be appropriate to consider it in the overall cost.

Savings

Savings stemming from the implementation of PROTECS are also difficult to pin down. The major savings result from the fact that normally the Data Prep staff is no longer needed for typing Payroll transaction data. This change frees approximately two Data Prep positions, which can be used elsewhere. The fact that the OCR scanner is no longer needed is probably offset by the increased use of other computer resources. There is, however, a small savings in the number of paper Payroll forms being used.

Overall, the savings seem to outweigh the costs, especially in the long run of continuing costs. This ratio is somewhat remarkable in view of the benefits provided by the system. It is indeed a bargain when a system can be built to offer better service, reduce employee frustration, and improve the quality of data, not only without incurring additional expenses, but with a net savings.

FUTURE EXTENSIONS

Overview

There are many enhancements which could be added to PROTECS in the future. Some of these are small functions which would simply add flexibility or usefulness within the current scope of the system. Others are sweeping changes that would extend the system to encompass areas outside its original purpose. Some are sorely needed and will surely be developed as soon as time and programmming resources permit. Others are non-essential and may be implemented along with something else, if time and interests allow it. Discussed below are a few of the more important possibilities.

On-line Validation

This extension is one of the most highly desirable. Providing the operator with the knowledge of whether or not a transaction is valid without making him wait for a printed report is a very important capability. The most effective scheme would be the individual validation of each transaction as it was entered. Then the operator would be able to correct mistakes immediately while the input form was still in front of him. He would know that when a transaction was accepted upon entry, it should never have to be handled again. This type of validation could certainly be implemented if intelligent, programmable terminals were used. For the present system based on dumb terminals, however, this scheme might degrade response time too severely or increase memory paging excessively, because the validation requirements and programs are enormously complex. Some experimentation could probably resolve this question fairly easily.

The second best scheme would have all transactions validated in batch mode, but make it possible to retrieve the form mock-up with errors indicated on the screen. A list of serial numbers of the erroneous forms could be accessed through PROTECS to aid in the selection of forms for correction. As is now possible, data entry could continue during the several minutes required for validation processing.

Time Record Data Entry Subsystem

PROTECS was designed for the entry of all Personnel/Payroll data except employee time records. Time records for SPA employees are now processed by Payroll, OCR-typed by Data Prep, and computer processed by another subsystem of the Personnel/Payroll Automated Processing System. Time sheets constitute a significant portion of

Payroll's workload, as the Biweekly staff handles approximately 2700 each pay period. Many of the same problems are plaguing their entry that were causing transactions processing to be so ineffecient.

It would be very desirable to add to PROTECS in the near future the capacity for entry of time records. This project would be extensive, but only a fraction as large or complicated as the original PROTECS project. Time records are in one fixed, relatively simple format, as opposed to the wide variety of complex transaction formats. Furthermore, the existing control structures of PROTECS could be adapted to accommodate the additional communication and input/output requirements. The most difficult part of the project would be designing and programming the operation to be as effective as possible, minimizing the amount of information needed to be entered. Perhaps a file of employees who normally submit time sheets could be maintained, sorted in the order in which time sheets are processed by the clerks. Each record would appear on the screen with all fixed data filled in, leaving only the required totals to be filled in by the clerk. Upon transmission, the next record would appear automatically.

Master File Inquiry Routine

This extension is a non-essential project which should be considered nevertheless, as the effort required would be rather small, the cost would be negligible, and the service provided would be useful. The master file currently is printed on paper and microfiche after being updated during the final payroll run of each pay period. One paper copy is furnished to Payroll, and each clerk is given a microfiche copy for the viewer on his desk. These printouts are used frequently for reference when it is necessary to know the current status of some employee's record. Since this situation arises most often when forms are being worked and entered, it would be very convenient to be able to retrieve the master file record and display it on the terminal. Retrieval would be faster and easier, since the file covers several fiche cards. In addition, this capability would avoid the problem of not having fiche copies available before the clerks begin working forms for the next period.

Implementation would be simple, as all the necessary parts for the system exist already. The master file has already been changed from tape to disk for other reasons, and the terminals and communication software have already been set up. The most difficult task would be to design and program the screen format and translating routines to display the large and highly complex master file record. Implementation would also require the master file to be converted from sequential (SAM) to ISAM organization. But this conversion would be simple and would have an important secondary effect. Currently, the program which validates transactions against the master file must read the entire master file sequentially. Early in the pay period, this technique is very inefficient, since there are very few transactions in the file. Because the social security numbers, which serve as the key upon which a match is determined, are widely spaced, the program must check and compare many master records for each transaction record read. This sequential processing of the huge master file (containing as many as 18,000 records at times) is primarily responsible for the slow execution of the validation procedure. With an ISAM organization, record matching--and consequently the entire validation procedure--would be much faster. Therefore, in the overall analysis the benefits of this non-essential extension seem worthy of the effort required for implementation.

USER'S GUIDE TO PROTECS

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USER'S GUIDE TO PROTECS

I. INTRODUCTION

PROTECS -- PayRoll On-line Transaction Entry and Correction System -- is a computer system designed to enable the University of North Carolina at Chapel Hill Payroll Department staff to enter and correct data through TV-type computer terminals. These terminals are located in the Payroll Department offices and are linked to the computer in the Administrative Data Processing Department (ADP). The information entered through the terminals is processed by the University Payroll Automated Processing System, designed, implemented, and operated by ADP. The processed transactions are used to update the Personnel/Payroll Master File and to produce the payroll for University employees.

II. THE TERMINAL

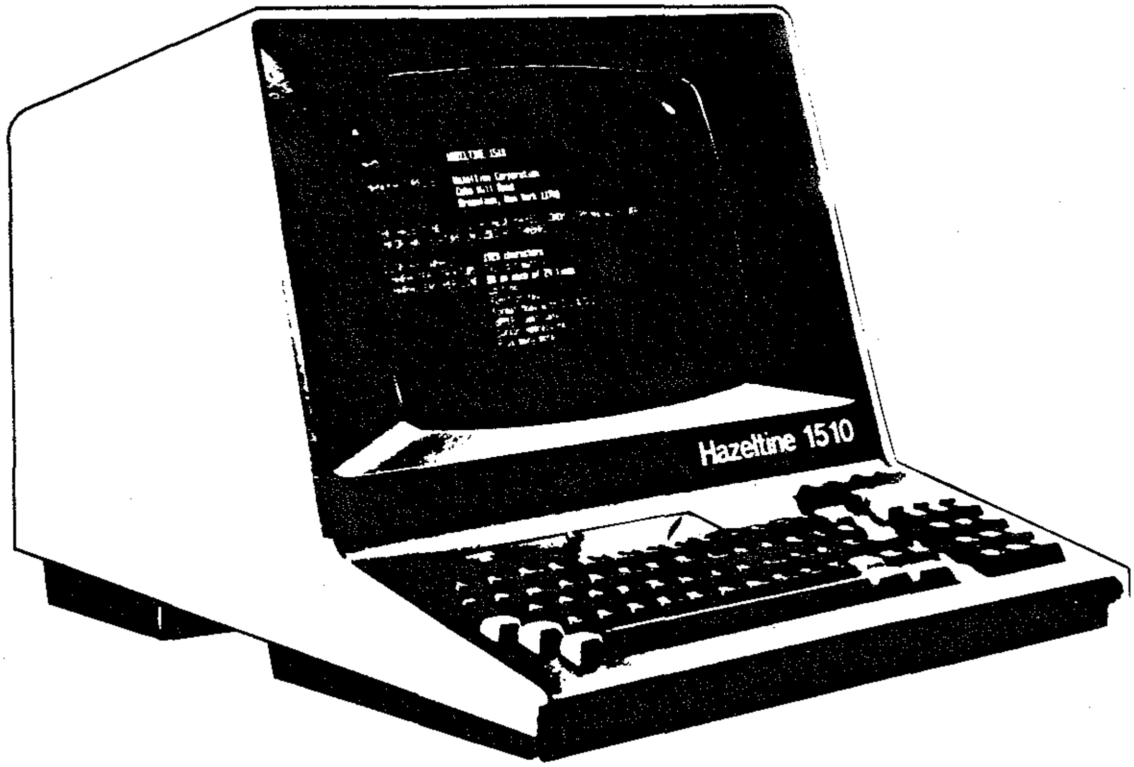

Figure 1. Hazeltine 1510 Display Terminal

PROTECS currently uses Hazeltine 1510 buffered display terminals, consisting of a video display and a typewriter-like keyboard. Details of the terminal's operation may be found in the Hazeltine 1510 Reference Manual. All switches will already be set up for operation under PROTECS and should not need to be changed. The only switch you will use is the ON/OFF switch, located on the back of the terminal on the lower right side.

The keyboard operates much like that of an electric typewriter, with the exception of a few special keys described below and a numeric pad -- as on an adding machine -- for entering numeric data. All characters are displayed on the video screen, whether entered from the keyboard or originating from the computer. The current position on the screen, the place where the next character typed will appear, is marked by a pointer called the cursor.

Under PROTECS the terminal is used in reverse video display mode, with black characters on a lighter background. Under program control this background can be either gray (half intensity) or white (full intensity). All gray areas of the screen are called "protected" and will not accept characters entered from the keyboard. Thus you may type only in the light "unprotected" areas. PROTECS uses this feature to create prompting instruction displays and form facsimile displays, providing unprotected "blanks" that you will fill in with the appropriate reply or data.

SPECIAL KEYS

NOTE: Refer to the keyboard diagram found at the end of this section (Figure 2).

SEND KEY: A large gray key located in the upper half of the keyboard on the extreme right, this key is used to transmit whatever is displayed on the screen to the computer.

TAB KEY: A large gray key in the lower right-hand corner of the keyboard, the TAB key advances the cursor to the next position on the screen where data can be entered from the terminal keyboard. These positions will normally appear as light "blanks" against the darker background of the display. Holding down the shift key before depressing the TAB key produces a BACK TAB action, where the cursor jumps back to the previous blank. Holding the TAB key down causes the cursor to advance (or back up) rapidly from blank to blank until the key is released.

FUNCTION KEY: This key is located just to the left of the TAB key (which sometimes causes it to be hit accidentally). It is used in conjunction with certain alphanumeric keys to cause PROTECS to take a particular action. Its use will be covered in detail later, but the basic operation is to depress and release the FUNCTION key and then depress the desired alphanumeric key. A list of the alphanumeric keys which may be paired with the FUNCTION key is contained in the Appendix. If the FUNCTION key is accidentally depressed (which causes the FORMAT light to blink), simply depressing it again cancels its action.

ARROW KEYS: To the left of the SEND key, in the upper right-hand corner, are four keys, each marked with an arrow. These keys move the cursor one position in the direction of the arrow -- left, right, up, or down -- without disturbing the display. Most frequently used is the left arrow key, which enables you to position the cursor over a character just typed incorrectly and to strike over it with the intended character.

HOME, CLEAR, RESET Keys: These three keys, located in the extreme upper right-hand corner, are not normally needed except for communicating with the computer outside of PROTECS. This situation occurs when loading or connecting to the system as described later. The HOME key moves the cursor to the upper left-hand corner (the "home" position) of the screen. The CLEAR key blanks out the entire display. The RESET key returns the terminal to its normal mode of operation after it is no longer under the control of PROTECS. These keys should always be used in the sequence "HOME, CLEAR, RESET".

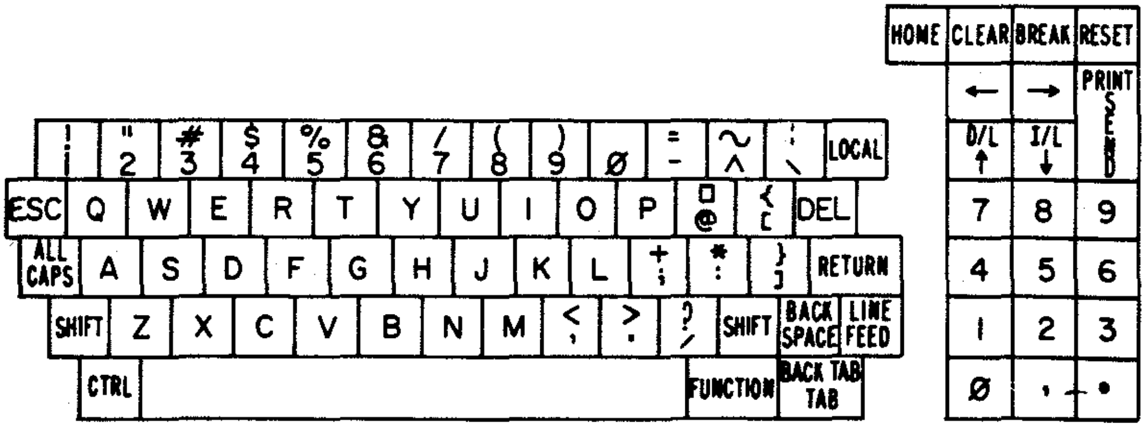

Figure 2. Hazeltine 1510 Keyboard Diagram

III. CONNECTING TO PROTECS

NOTE: Throughout this manual, when you are instructed to type something, the command or message to be typed will be enclosed in quotation marks. You should type everything between the quotation marks, but not the quotation marks themselves.

To connect your terminal to PROTECS, you must initiate communication with the computer. Making sure that the terminal is turned on (POWER ON light is lit), depress the HOME, CLEAR, and RESET keys in that order. This step is unnecessary if you have just powered up the terminal. Next, move the cursor out of the home position, either by striking a character or the space bar, or by using one of the arrow keys. This action is needed because the terminal will not transmit immediately from the home position. Now depress the SEND key to notify the computer that you are ready to use it. It will respond with

```
/PLEASE LOGON
```

You should now type "CONNECT MPROTECS" for the Monthly Payroll version, or "CONNECT BPROTECS" for the Biweekly Payroll version, and depress the SEND key. PROTECS will respond:

```
MPROTECS
:
```

or

```
BPROTECS
:
```

When you receive this response, depress SEND once more. PROTECS will now request your ID, and display a blank in which you may type it. Strike the TAB key to move the cursor to the blank and type your ID. Depress SEND. If you have not typed your ID correctly, you will be prompted to enter it again.

When your ID is correct, PROTECS will welcome you by name and prompt you to depress SEND. When you do so PROTECS will display the message:

```
    NEW DATA                           CORRECTIONS
----------------              ----------------------------

USE FUNCTION KEY              ENTER SEQUENCE NUMBER: _____

 FOR BLANK FORM                   OR SERIAL NUMBER: ______
```

This is the message you will receive from this point on whenever PROTECS is ready for you to enter more data or make a correction. It will be referred to from here on as the _request message_.

IV. ENTERING NEW DATA

Data entry through PROTECS is quite simple, requiring you only to fill in the blanks in the displayed form. To request a particular blank form, depress the FUNCTION key followed by the alphanumeric key corresponding to the desired form (see Appendix). For example, to obtain a blank PD-7, depress and release the FUNCTION key and then depress the "7" key. PROTECS will display a facsimile of the paper form with data fields blank.

The action-effective date will be filled in for you already, set to the last day in the pay period. If this date is inappropriate, simply type the desired date in place of it. The serial number also will be filled in with a number which is one greater than the serial number of the last form you entered. You may also override this field if you wish. PROTECS will use whatever value comes in from the serial number field to determine the number pre-filled on the next blank form. In the case of PR-1's the check number field will contain zeroes, which you must always override with the desired check number. WNC-4's, of course, will have no serial number displayed.

You may now fill in the rest of the form, using the TAB and arrow keys to position the cursor and typing in the appropriate fields. The terminal will let you type only in the blanks, and as each field is completed, the cursor will automatically jump to the beginning of the next one. Thus once you become familiar with the displayed form, you can fill it in almost without taking your eyes off the original paper form.

When the entire form has been completed and checked over, depress SEND. PROTECS will create transaction records from the form, assign them sequence numbers, and add them to the file. A message will be displayed at the bottom of the screen informing you of the number of records generated from the form and the first and last sequence numbers. PROTECS will then blank out the data in the fields, but it will leave the blank form on the screen with the date and next serial number filled in. Thus you can immediately begin filling out the next form if it is the same type as the one on the screen. To obtain a different type of form, or the request message, use the appropriate FUNCTION-alphanumeric combination.

V. CORRECTING EXISTING TRANSACTIONS

Corrections are made through PROTECS in a manner analagous to having the original input form in a typewriter and being able merely to type over erroneous fields to change them. Existing transactions are accessed through the request message. If this message is not on the screen now, obtain it by depressing the FUNCTION-0 combination.

Transactions may be retrieved from the file either by serial number or by sequence number. The serial number may be obtained from the paper form or from the error report. The sequence number to use, if desired, is the one associated with the first record in the erroneous transaction group printed on the error report. Type one of these numbers in the appropriate blank of the request message (strike the TAB key to position the cursor) and depress SEND. PROTECS will construct a facsimile of the original form on the screen with the data fields containing the information which was entered from the paper form.

You may now correct the form directly on the screen, referring to the original form when necessary. Using the TAB and arrow keys, position the cursor and type over the incorrect characters in erroneous fields. You may add any fields which were left out or delete (using the space bar) any fields which should not have been filled out. When you are satisfied with the corrected form, depress SEND to cause PROTECS to rewrite the corrected records to the transaction file. You will now receive the request message.

If you wish to delete the entire transaction from the file, as if the form had never been submitted for data entry, simply type "Y" in the delete block at the top of the form and depress SEND. All records associated with that form will be erased from the file and PROTECS will display a message confirming the deletion.

VI. STOPPING PROTECS

When you have finished making corrections and entering new data for this terminal session, you are ready to disconnect from PROTECS. You do this through the request message, by typing the command, "@STOP", in the sequence number blank and depressing the SEND key. PROTECS will respond with a message stating that this session is terminated and asking if you would like to have the transaction file validated at this point. Protecs will tell you what time the last validation was initiated, if one was, so that you may judge whether or not sufficient work has been done to justify another validation at this point. You may reply with either a "Y" or "N" in the blank provided.

A "yes" reply activates a procedure on the computer to run the updated transaction file through the validating programs to detect errors. The familiar error reports will be produced from the procedure along with a list of valid transactions. You may retrieve these reports from Output Box 68 in the Operations area of ADP. If you do not pick them up yourself, the ADP Payroll Expediter will deliver them to you when they are retrieved along with other output. Thus you can usually check your work within the hour. Keep in mind, however, that the entire file will be validated. If anyone else has made corrections or entered data either before you or at the same time, their transactions will also be included in the reports. Furthermore, if another staff member continues to use PROTECS after you have initiated the validation procedure, the error reports will not reflect the current status of the transaction file, but will show it as it was when you stopped. For this reason it may be advisable to wait until everyone has finished before validating. The last person to stop can reply "yes" to the validation query.

Whether you reply "Y" or "N", PROTECS will inform you that the terminal is disconnected. You should depress SEND to complete the disengagement from PROTECS. When you are ready to do more work on the terminal, just follow the earlier instructions for connecting.

VII. SPECIAL FUNCTIONS

PROTECS has been designed with some built-in functions to make data entry easier and more flexible. Two of these functions have already been described. The FUNCTION-form combination obtains blank form facsimiles. The FUNCTION-0 combination causes PROTECS to display the request messge. It is helpful to remember that these functions are quite flexible in their use. Blank forms may be swapped about freely, even if you have begun filling in fields. Either a blank form or the request message may be procured at any time except when an existing transaction is being displayed on the screen. In addition to these functions, there are other special functions to help provide you with necessary or useful information during the entry and correction of data.

One of these additional functions will display the beginning sequence number of the last new transaction you entered during the current session and the beginning sequence number of the last transaction you examined. This is very helpful for those cases in which you discover that the last transaction that you added to the file was incomplete or incorrect, and you failed to note the sequence numbers generated for it. The FUNCTION-S combination causes PROTECS to display the sequence number for you, even if existing transactions have been examined or modified in the interim.

The ability to discover the beginning sequence number of the last transaction examined is very useful in retrieving a journal entry transaction which you entered earlier and for which you did not note the sequence number. The Cancellation and Release use the same serial number, even though they are displayed as two separate forms. Therefore you can retrieve only the first one entered (usually the Cancellation) by using the serial number. However, once you have displayed this form and returned it to the file, you can use the FUNCTION-S combination to obtain the sequence number associated with it. Then you can estimate the first sequence number of the corresponding Release form by adding to this sequence number a value of 5 for each data line on the Cancellation form. Depressing FUNCTION-0 now enables you to type in the estimated sequence number through the request message to retrieve the desired Release form.

Another function furnishes you with statistics concerning the number of forms entered and corrected. The FUNCTION-T combination causes PROTECS to display a screen with the following information:

1) the time of day at which you connected for the current session
2) the number of forms you have added during this session
3) the number of forms you have corrected or examined

during this session

4) the time of day of the last PROTECS startup

5) the total number of forms added since the last startup

6) the total number of forms corrected or examined since the last startup

7) the total number of records processed since the last startup.

VIII. POTENTIAL PITFALLS AND RECOVERY TECHNIQUES

While PROTECS is fairly flexible and forgiving of operator fumbles, the interface between the terminal and the PROTECS programs can occasionally cause some problems. These potential problems are outlined here, along with some suggestions for recovering from them.

When the terminal interface system displays a message from PROTECS, it finishes by returning the cursor to the left of the screen and displaying a colon (:). It does this in preparation for receiving a transmission from the terminal when you hit the SEND or FUNCTION key. Unfortunately, there is often a significant time lag between the completion of the displayed message and the placing of the colon on the screen. It is possible for you to move the cursor before this action has been completed. Doing so usually affects the display in some manner (most frequently deleting part of a blank or unprotected field) such that it will produce unpredictable results when transmitted from the terminal.

The best solution, of course, is to MAKE SURE THE COLON HAS BEEN DISPLAYED BEFORE YOU DO ANYTHING. Occasionally, it will catch you off guard, however, no matter how vigilant you are. The recovery technique which should be used is to cause PROTECS to reproduce the display. In the case of blank forms, this is accomplished by depressing the FUNCTION-alphanumeric key combination to generate the appropriate form again. The request message can be generated similarly, by depressing FUNCTION-0. If the screen is disturbed while displaying an existing transaction, depressing the FUNCTION key followed by any alphanumeric key results in the regeneration of the form with the original data.

These techniques can be used in other situations as well. If you discover in the middle of making a correction that you have not been changing the fields appropriately, a FUNCTION-alphanumeric combination lets you start over with the existing data. If you start to add a new transaction and suddenly wish to see some existing transaction first, FUNCTION-0 will display the request message and let you type in the sequence or serial number of the desired transaction. Similarly, if you have already transmitted the "@STOP" command and have received the termination message and validation query when you realize that you have not yet completed your data entry or corrections, you may use the FUNCTION-0 or FUNCTION-form code to get the request message or a blank form.

A more serious problem can occur if you hit SEND or some FUNCTION combination before the colon is displayed. Depending upon the exact timing, there may be no ill effects or PROTECS may abort. The same possibility exists if you hit SEND a second time before PROTECS has responded to your transmission. If you are in doubt as to whether or not you really depressed the SEND key, look at the position of the cursor on the screen. If it is in the lower left hand corner, this means that you have already hit SEND and the terminal is transmitting the data on the screen to PROTECS. DO NOT HIT SEND AGAIN!

Either from these causes or some cause beyond your control, occasionally PROTECS may quit responding or you may suddenly get a "PLEASE LOGON" message. In this case, inform your supervisor, and he or she can probably reload PROTECS. If the computer itself has gone down, you will have to wait until it is brought back up before PROTECS will operate. When these situations occur, it is inconvenient, but there is usually no damage done to the transaction file UNLESS YOU WERE IN THE MIDDLE OF A CORRECTION WHEN THE SYSTEM WENT DOWN. In this case, PROTECS may have lost the transaction that you had on the screen. When you are able to get back on the system, you should check to see if that transaction is still in the file. If it is not, you should type it in again, just as if it were new data.

In spite of these potential problems, you should not feel that if you make one wrong move you may destroy the entire transaction file that you and your co-workers have been laboring to build. Relax! There is virtually no way you could accidentally destroy or even damage the file. Even if somehow you caused PROTECS to crash, the most serious damage that could occur would be the loss of the single transaction any operator might happen to be displaying at the time. The explanations and cautions in this section are here only to inform you of the type of problems that could occur and to try to save you the inconvenience of a delay which you might avoid with the possession of this knowledge. Think of PROTECS as another office tool to help you perform your job more accurately and completely, just as an adding machine or typewriter does. Become familiar with it and use it with confidence!

APPENDIX

I. Stopping a PROTECS Session

Type "@STOP" in the sequence number blank in the request message.

II. Alphanumeric Keys Used with the FUNCTION Key

A. Functions to Display Blank Forms.

Key	Form
2	PR-2
3	PR-3
4	PR-4
5	PD-105
7	PD-7
8	PR-8
9	PR-9
C	PR-1 CANCELLATION
R	PR-1 RELEASE
W	WNC-4

B. FUNCTION-0 displays the request message.

C. FUNCTION-S displays the beginning sequence number of the last new transaction form you added to the file, and the number of the last form you displayed.

D. FUNCTION-T displays the number of forms you have added and the number you have examined or corrected since you connected. It also displays the totals for the entire system since the last startup.

E. FUNCTION-anything causes an existing transaction being examined or corrected to be regenerated on the screen as it was before it was changed.

PROTECS SYSTEM DOCUMENTATION

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Administrative Data Processing

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February 29, 1980

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PART ONE--SYSTEM OPERATION

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I. INTRODUCTION

PROTECS -- PayRoll On-line Transaction Entry and Correction System -- is an interactive, terminal-based data entry system which operates as a front-end subsystem of the University Payroll/Personnel System. Using CRT display terminals located in their offices, the Payroll staff enter all data via mockups of their paper forms displayed on the terminals. Transactions are validated in batch mode, and error reports are printed. Using these reports the Payroll staff make corrections through PROTECS by retrieving the original transactions from the file and correcting the reassembled forms displayed. The former OCR-based system serves as backup to PROTECS and handles any overflow transactions during peak periods of the year.

PROTECS consists of a main program written in COBOL and several subroutines written in both COBOL and assembler language, including some ADP Systems Utilities. The main program is itself called by CAM (that is, it contains the entry points for CAM), which communicates with the terminals.

PROTECS normally operates without programmer or expediter attention, being started up and shut down by the user department at its own convenience. Back-up copies of the transaction file to another disc pack are made automatically every time a predetermined number of records have been added or modified, and again at shutdown time. The validating procedures which execute all the validating programs can be initiated by the user through PROTECS. The only time ADP intervention is routinely required is at the end of each pay cycle. At this time all PROTECS data files must be erased and then set up for the next cycle. Even this function is accomplished through PROC.PP.CLEAN, which must be run at the end of each cycle anyway in order to erase other files used during the payroll processing.

Currently there are two nearly identical versions of PROTECS in production. BPROTECS accesses only Biweekly data files, and MPROTECS accesses only Monthly data files. Each version also activates a different validating task and a different back-up task in order to keep Biweekly and Monthly payroll processing separate and unmixable.

II. SYSTEM FILES

ENTER Files

1. E.PP.PROTECS.LOAD-BPROTECS

   This file, which is activated by PROC.PP.PROTECS.LOAD-BPROTECS, initiates the background task from which BPROTECS is to be run. It executes PROC.PP.PROTECS.RUN, passing it a parameter for BPROTECS.

2. E.PP.PROTECS.LOAD-MPROTECS

   This file operates in the MPROTECS version exactly as the above file does for BPROTECS.

3. E.PP.PROTECS.VALIDATE.BIWEEKLY

   This file, activated by a subroutine in BPROTECS, initiates the batch validation of the Biweekly transaction file. It contains commands to execute PROC.PP.PROTECS.TX-VALIDATE, passing it parameters for Biweekly processing.

4. E.PP.PROTECS.VALIDATE.MONTHLY

   This file does the same for Monthly processing as the above file does for Biweekly.

5. E.PP.PROTECS.BACKUP.BIWEEKLY

   This file, activated by a subroutine in BPROTECS, contains the Command Language statements to copy the BPROTECS ISAM transaction file to a SAM file on VGFIN2 for back-up. If VGFIN2 cannot be mounted, a temporary back-up file is created on VGPAY1.

6. E.PP.PROTECS.BACKUP.MONTHLY
   This file is the same as above, but for Monthly processing.

7. E.PP.PROTECS.BIWEEKLY.LOG-UPDATE
   This file, activated by E.PP.PROTECS.LOAD-BPROTECS, executes PROC.PP.PROTECS.LOG-UPDATE and passes it the CYCLETYPE=BIWEEKLY parameter. Its purpose is to cause the BIWEEKLY PROTECS log file to be updated by the temporary daily log file (TEMP.PP.PROTECS.BIWEEKLY.SYSLST), immediately after this file is written out when E.PP.PROTECS.LOAD-BPROTECS logs off.

8. E.PP.PROTECS.MONTHLY.LOG-UPDATE
   This file operates for the Monthly side of the system in the same manner as the above Biweekly file does.

PROCEDURE (DO) Files

1. PROC.PP.PROTECS.LOAD-BPROTECS
   This file, executed directly by the user, begins the startup process for BPROTECS. It activates

E.PP.PROTECS.LOAD-BPROTECS and then returns to the user, allowing him to LOGOFF in order to use his terminal to CONNECT to PROTECS. This file is protected by a read password which must be entered by the user before he can execute the procedure.

2. PROC.PP.PROTECS.LOAD-MPROTECS

   This file is the same as described above, but for MPROTECS.

3. PROC.PP.PROTECS.RUN

   This file is executed by the background task initiated by either E.PP.PROTECS.LOAD-BPROTECS or E.PP.PROTECS.LOAD-MPROTECS. It issues appropriate file commands and executes either P.BPROTECS or P.MPROTECS, depending upon the parameters passed to it from the ENTER file.

4. PROC.PP.PROTECS.TX-VALIDATE

   This file is executed by the background task initiated by either E.PP.PROTECS.VALIDATE.BIWEEKLY or E.PP.PROTECS.VALIDATE.MONTHLY. It uses EDT to plug the current master file name into PROC.PP.PROTECS.VALIDATE-TXS and executes this procedure, passing to it the parameters for Biweekly or Monthly processing, depending upon the ENTER file from which PROC.PP.PROTECS.TX-VALIDATE itself was executed.

5. PROC.PP.PROTECS.VALIDATE-TXS

   This file is executed by PROC.PP.PROTECS.TX-VALIDATE. It receives the parameters for biweekly or monthly processing from that procedure and accomplishes the validation of the appropriate PROTECS transaction file. It operates almost identically to PROC.PP.TRANSACTIONS, from PP047 on, except that the output file of valid transactions from PP077 is dummied. It operates on a copy of the transaction file, and thus can run concurrently with PROTECS.

6. PROC.PP.PROTECS.LOG-UPDATE

   This file may be executed by E.PP.PROTECS.BIWEEKLY.LOG-UPDATE, E.PP.PROTECS.MONTHLY.LOG-UPDATE, or PROC.PP.PROTECS.RUN. Its purpose is to update the Biweekly or Monthly PROTECS Log file (DATA.PP.PROTECS.BIWEEKLY.LOG or DATA.PP.PROTECS.MONTHLY.LOG) by adding to the end of it the contents of the daily log file written from SYSLST during the execution of BPROTECS or MPROTECS.

DATA Files (Note: &CYCLETYPE = BIWEEKLY or MONTHLY)

1. DATA.PP.PROTECS.ISAM.TXS.&CYCLETYPE

This file is the major PROTECS file. It contains all transactions for either Biweekly or Monthly processing and is updated continuously while PROTECS is running. The records are 86 bytes in a fixed length format and are keyed on the sequence number, found in bytes 10-14. The last byte contains a character identifying the operator who entered the transaction or who last examined or modified it. There is a header record containing the pay cycle and the associated beginning, ending, and check release dates. The key field of the header record contains zeroes.

2. DATA.PP.PROTECS.ISAM.SERIAL.&CYCLETYPE

   This file exists to allow the user to retrieve transactions from the transaction file by serial number instead of sequence number. It contains 12 byte fixed length records which are keyed on the serial number contained in bytes 2-7. Each record contains the sequence number of the first transaction record associated with the key serial number.

3. DATA.PP.PROTECS.SAM.TXS.&CYCLETYPE.BACKUP

   This SAM file serves as the back-up copy of the ISAM transaction file. It is located on VGFIN2 and contains the full 86 byte records.

4. DATA.PP.PROTECS.SAM.TXS.&CYCLETYPE.BACKUP2

This file is identical to the above file and is created on VGPAY1 only in the event that VGFIN2 could not be mounted for the back-up procedure.

5. DATA.PP.PROTECS.ISAM.ID-FILE

This file contains the valid passwords for all authorized users of PROTECS. It also contains other information:

a) the terminal line numbers through which each user is permitted to CONNECT to PROTECS

b) the name of the operator associated with each password

c) a one-byte identifying character for each operator.

The records are 65 bytes in length and are keyed on the password located in bytes 1-6.

6. DATA.PP.PROTECS.&CYCLETYPE.LOG

This file contains the accumulated log entries from the daily operation of BPROTECS and MPROTECS. It is updated by a UTLCOPY with OPEN=EXTEND each time PROTECS is halted, the INFILE being the SYSLST disc file containing all log entries for a particular execution of PROTECS.

III. STARTUP PROCEDURE

Either or both versions of PROTECS can be loaded by the Payroll staff whenever desired. Instructions for doing so have been given only to the assistant director and the section supervisors. While the startup procedure is very simple and straightforward from the user's point of view, the actual process invoked is a rather indirect series of steps. This added complexity is due to the restrictions imposed by the nature of the task under which PROTECS is executed, coupled with the file structures necessary to provide security.

The PROTECS load module is executed by a procedure or DO file containing all necessary JCL or system commands. In order for it to be accessible from any Payroll terminal at any time during the day, however, it must run as a batch task and remain on the type 2 queue. For this reason the procedure file must be executed by an ENTER file which, when activated, is assigned the TSN under which PROTECS operates.

For reasons of security it is desirable to prevent access to the startup procedure file unless the proper file password has been issued directly by the potential user. Unfortunately, it is not possible to password-protect an ENTER file. Primarily for this reason, another DO file is provided which activates the ENTER file. This DO file is password protected and is executed directly by the user.

The startup procedure followed by the user is as follows:

1) LOGON to VS/9 using the assigned account code and password
2) issue the PASSWORD command using the current password for BPROTECS or MPROTECS
3) issue the DO command for the appropriate one of PROC.PP.PROTECS.LOAD-BPROTECS or PROC.PP.PROTECS.LOAD-MPROTECS
4) receive the TSN from the activation of the ENTER file and a confirmation message stating that initialization is in progress
5) issue the LOGOFF command.

This action results in the following sequence of events:

1) the outer DO file is executed and issues the ENTER command
2) the ENTER file is activated to initiate the background task
3) the task begins running (usually immediately) on the type 2 queue
4) the background task executes the inner DO file, passing the parameters for BPROTECS or MPROTECS
5) the DO file loads and executes the appropriate version of PROTECS.

IV. EXECUTION (PROCESSING)

Introduction

Once PROTECS has been loaded and executed, it may be connected to at any time by any terminal or combination of terminals in the Payroll department. The user accomplishes this by typing "CONNECT BPROTECS" or "CONNECT MPROTECS" instead of the LOGON statement. His terminal will then be communicating with CAM rather than directly with VS/9. The CAM modules provide the interface between the terminals and PROTECS, calling PROTECS as a subroutine and passing messages to it from the terminals and from it back to the terminals. Details of the PROTECS modules' actions can be found in the program documentation, but the following paragraphs will provide a very general summary of the operation of the system.

ID Checking

Each time a terminal is connected, PROTECS requests an identifying password which is unique to each user. It checks this password against a file containing user ID's and some associated information. The user is given four chances to enter his ID correctly, after which the terminal is disconnected. If he enters a valid ID, his terminal line number is then checked to determine whether he is authorized to access PROTECS from that line. If he is not, the line is disconnected.

Transaction Processing

The heart of the operation of PROTECS, of course, is adding new transactions and correcting existing transactions. The transaction file and the serial number file are both read from and written to during transaction processing.

Corrections. In order for the user to correct an existing transaction, PROTECS must retrieve all constituent records from the transaction file. If the user supplies the sequence number of one of these records, PROTECS retrieves that record and then searches backwards and forwards from that point to find all related records making up that transaction. If the user supplies the transaction's serial number instead, PROTECS takes the additional step of first reading the serial number file to obtain the sequence number of the first record of the transaction.

When all records are retrieved, PROTECS translates them into a facsimile of the original document, and displays this on the screen. The user makes his changes and transmits the data on the screen to PROTECS. The system then translates the data back into transaction records and writes them back out to the file.

New Transactions. When a new transaction is to be added to the file, PROTECS receives from the terminal a code specifying the type of form on which it is to be entered. This code is generated from a FUNCTION-alphanumeric key combination. A subroutine creates a blank form facsimile, which is transmitted to the terminal for display. The user fills in the desired fields and transmits the data. PROTECS builds transaction records, gives them sequence numbers and writes them out, adding them to the end of the transaction file. It also writes a record to the serial number file, associating with the serial number key the sequence number of the first record in the new transaction group.

Automatic Back-up Processing

Each time PROTECS writes a new record or a corrected record to the transaction file, it increments a counter. When this counter reaches a predetermined level, a subroutine is called which issues an ENTER macro. The ENTER file thus activated contains the necessary commands to copy the entire transaction file to a SAM file on a different disc pack. Since PROC.PP.PROTECS.RUN uses shared updating for the transaction file, this file can be read simultaneously by the back-up task. By using an ENTER file, processing is uninterrupted, and the entire back-up procedure is transparent to the user. At system shutdown time, the file is again copied to the back-up file to provide a completely up-to-date copy. The Command Language statements for this final back-up are contained in PROC.PP.PROTECS.RUN, following statements that deallocate excessive space. This arrangement avoids a conflict which could occur if the back-up task attempted to access the file while space was being backed off.

Validation of Transactions

PROTECS currently makes no provision for on-line validation of transactions entered. However, it does allow the user to initiate immediate batch validation of the entire transaction file at any time he wishes. When PROTECS receives a command from the user to disconnect his terminal, it asks him if he wishes to request validation. If the user replies affirmatively, PROTECS calls a subroutine which issues an ENTER macro. The activated ENTER file executes a procedure which runs a copy of the transaction file through all the validating programs, producing error reports. To avoid inadvertent unnecessary validation, the disconnecting user is informed of what time the last validation was initiated, if a validation request was made previously.

V. SHUTDOWN PROCEDURE

PROTECS is shut down by the user at his convenience in an even simpler manner than that used to accomplish system startup. When PROTECS receives the command "@@HALT" from the user, it begins this termination process:

1) checks to make sure no other terminal is still connected and issues a warning message if any is
2) displays on the terminal that transmitted the "@@HALT" command the accumulated statistics for the system since the last startup
3) writes statistics and shutdown information to the SYSLST file
4) closes all files
5) notifies CAM to stop processing
6) turns system switch 15 off
7) returns control to CAM.

CAM, having been notified to stop processing, terminates and returns control to the executing procedure. After backing off space for the transaction file and serial file, the procedure copies the transaction file to the back-up file and then returns control to the background task initiated from the ENTER file. This task activates another ENTER file for updating the PROTECS cycle log file and then immediately issues the LOGOFF command, causing the SYSLST file to be written to a temporary PROTECS disc file. It is this file that is used to update update the cycle log file.

VI. INFORMATION PROVIDED

PROTECS provides some valuable management information to provide audit trails, to aid in diagnosing problems, and to evaluate system and personnel performance. This information is recorded on the SYSLST disc file, which is produced each time the system is shut down. Through careful scrutiny of this data, it is possible to obtain a fairly clear tracing of everything that went on during the time PROTECS was loaded.

Each time a record is read from or written to the transaction file, PROTECS writes it to the SYSLST file as well. In the event that a problem should occur, then, it is a fairly simple matter to trace the action that led to the problem. One can see which Payroll clerk entered or corrected the data in question, what it looked like before and after the correction, whether or not a detectable hardware or line error occurred, what sequence numbers were assigned to the records, etc.

If an unauthorized user tries to access the system, PROTECS writes to the SYSLST file an informative message which includes the last invalid password entered and the line number through which the attempt was made. Similarly, if access is attempted from an unauthorized terminal, PROTECS writes out the line number and the valid password used.

When an operator finishes his session at the terminal and his terminal is disconnected, the following statistics are written to the SYSLST file in the form of a terminal session log:

1) the physical line number
2) the time of day the line was connected
3) the time of day the line was disconnected
4) the name of the terminal operator
5) the number of new transaction forms entered
6) the number of existing forms examined or modified
7) the total number of records added, examined, or modified by this operator during this session
8) the reply given to the query to initiate validation
9) the number of hardware errors that occurred, if any.

When PROTECS is shut down, information concerning the entire system is written to SYSLST including the following:

1) the name of the terminal operator who issued the "@@HALT" command
2) the line number of the terminal from which this command was issued
3) the time of day at which this terminal was connected
4) the number of records processed from this line before the "@@HALT" command was given, the number of forms added, and the number of forms examined or modified

5) the time of day at which the system was started up

6) the time of day at which the system was shut down

7) the time of day at which the last validation was initiated, if any was, and the operator who requested it

8) the total number of new transaction forms entered

9) the total number of transaction forms examined or modified

10) the total number of records processed

11) the total number of hardware errors that occurred, if any.

After each shutdown of PROTECS, this temporary SYSLST log file is added to the permanent log file for the current payroll cycle. This entire file will be printed out at the end of the biweekly or monthly cycle by PROC.PP.CLEAN. It may also be printed completely or in part at any time, or it may be examined through a terminal.

VII. SECURITY

While PROTECS is not designed with impregnable defenses against unauthorized users, there are several levels of security built in to discourage casual attempts to gain access. The preceding sections have mentioned most of these measures, but a consolidated treatment may be useful.

First, every file in the system is non-sharable. Thus access is automatically denied to anyone who does not LOGON to the 90/80 with a valid account code and password for a PR user ID.

Then, to start up PROTECS, the current file password for the procedure file must be issued. This password is made known only to the assistant director of Payroll, the section supervisors directly under her, and the few ADP analysts and programmers who maintain the Payroll/Personnel system.

Once PROTECS is loaded, access to it is denied without proper identification. Each Payroll employee authorized to use the system is issued a unique, confidential password. PROTECS requests and checks this password before it allows the user to do anything. If the user cannot supply a valid identifying password within four attempts, he is disconnected. PROTECS records the invalid ID used and the line number to aid in tracking down cases of misuse. A valid ID enables PROTECS to associate an operator with the transactions he enters and corrects, and to keep statistics on that operator and terminal for the current session.

Even with a valid ID or password, a user may connect to PROTECS through only certain authorized terminal lines. The lines which may be used are variable for each ID. Typically, Payroll employees may use only the terminals in their own department, while the PROTECS maintenance programmmer may use these and his own terminal as well. No other terminals in the building nor any dial-up lines may be used. PROTECS records any attempt to gain access through an unauthorized line.