as I think more consideration must be given to improving the layout of this particular document. However, it will give some idea of the factors to take into account.

With information about each activity consolidated, it is possible to turn again to the resource usage sheet, illustrated in Fig. 3. Now a realistic assessment can be made of how the functions in each activity are distributed between departments, and so of how the costs in each department are allocated between activities. These costs can then be entered and used to show which facets of the organization can most profitably be redesigned, and where the boundaries between the system and the environment will not be too artificial. This has great value in clarifying which applications can most profitably be carried out using a new system with the minimum of repercussions on undeveloped areas of the business, and for indicating short-term improvements which may give better information at reduced cost before any new equipment is introduced.

These systems-study documents that I have described will, it is hoped, facilitate the evaluation of alternative systems and the design of the selected one, and guide the pre-installation work. As systems design proceeds, they must be supplemented by flow-charting, tabular presentation of logic, and extensive reference to check lists. Much thought is being given to codifying the whole process of systems study, and many other procedures and documents have been and are likely to be suggested. All this work tends to formalize the training of systems analysts which too often in the past has been a rather haphazard process. However, we have a long way to go both in the elaboration of techniques and in the accumulation of an extensive body of case studies before we can regard systemology as an established profession in the proper sense of that word. I hope that the British Computer Society and its members will continue to work towards this objective.

Acknowledgement

A paper such as this obviously depends on the work of a great many people, both users of IBM equipment and staff of IBM, and it would be impracticable to acknowledge their contributions individually. I wish, however, to record my particular debt to Mr. Robert C. McHenry, of IBM, Federal Systems Division, for the use I have made of material in his privately circulated paper "An Approach to Systems Analysis Employing Function Descriptions."

References

Fuller particulars of some of the documentation techniques described in this paper will be found in the following IBM manuals:
Study Organization Plan Documentation Techniques Reference Manual (C 20–8075).
Basic System Study Guide (F 20–8150).

Authorization and control of input in the Royal Army Pay Corps Computer Centre application

By Major A. Taylor-Smith, RAPC.*

This paper, read to the British Computer Society in London in November 1963, relates to the Royal Army Pay Corps Computer Centre, which was described by Lt.-Col. D. W. Moore and Major W. S. Caskey in the *Computer Journal*, Vol. 5, No. 4, and should be read in conjunction with those earlier papers.

Introduction

The accounts of all British soldiers stationed in Western Europe are maintained in magnetic-tape form at the Royal Army Pay Corps Computer Centre, Worthy Down. Eventually the accounts of all soldiers, wherever they may be stationed in the world, will be maintained by the Computer Centre.

Input to the Royal Army Pay Corps Computer Centre is by punched cards. The cards are prepared by regimental pay offices in the United Kingdom, from information received from the soldiers' units, dependants and other sources. The information is checked, coded and converted into suitable punched cards for processing by the system.

A diagrammatic layout of the Royal Army Pay Corps computer system is shown at Fig. 1.

The method of control adopted in the Royal Army Pay Corps application is designed to cover the following three aspects:

(*a*) To safeguard the system from unintentional error and to prevent fraud.

(*b*) To control the work flow.

(*c*) To facilitate audit.

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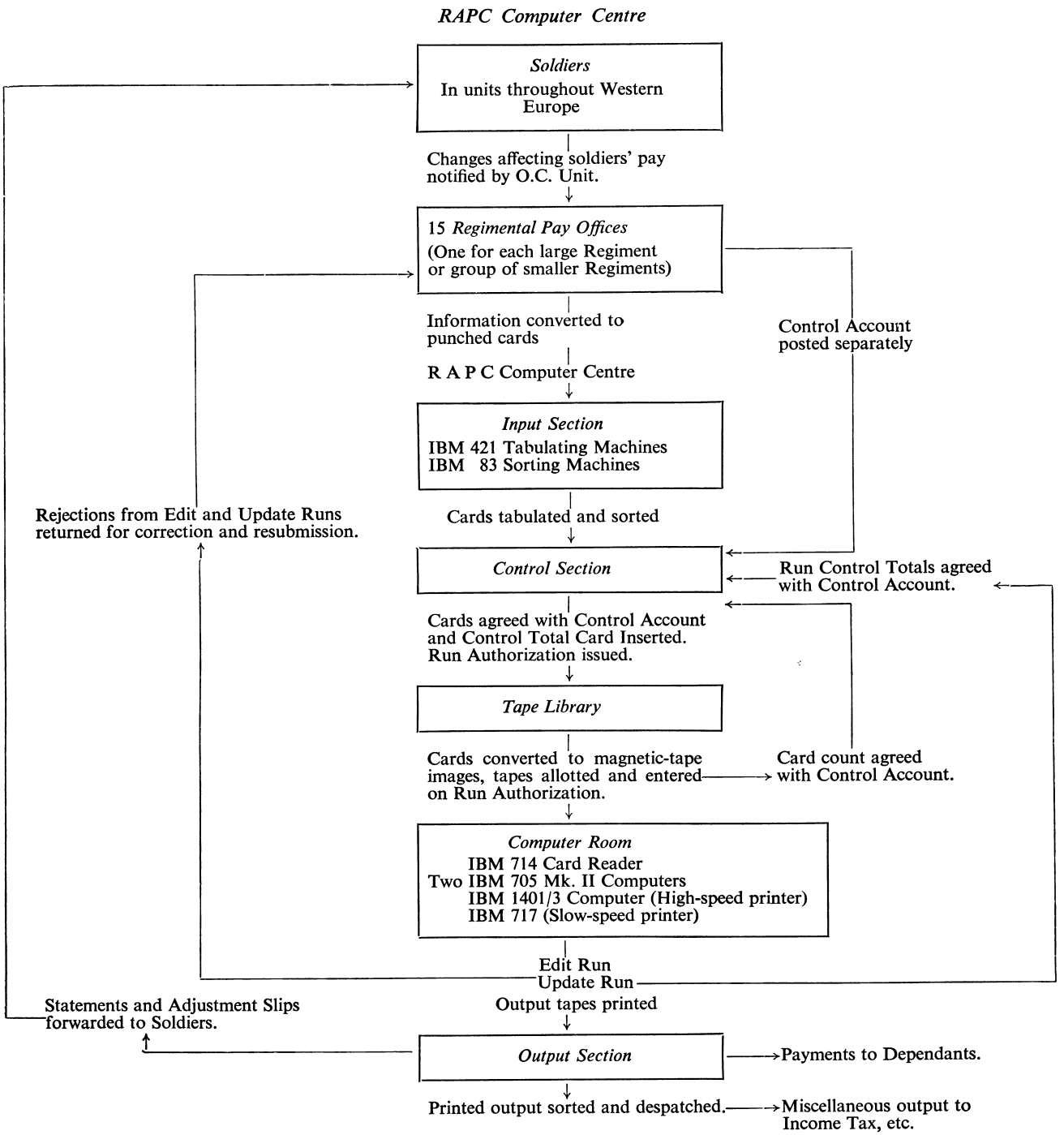

Fig. 1.—Royal Army Pay Corps computer system (diagrammatic layout)

Preparation of the Control Account by the Regimental Pay Office

The punched cards are basically of two types.

Type "A" Those containing a financial amount punched into particular card columns—representing a credit or debit to the soldier's account.

Type "B" Those which contain information in code form in certain card columns to denote a change in the soldier's pay status, promotion or demotion.

Both cards have common information, that is the soldier's army number in card columns 1–8 and the first five digits of the soldier's name in card columns 9–13.

Type A cards are amassed and made up in small sub-batches of 50–100 cards, and the totals of the credit and debit columns are added for each sub-batch. The sub-batch net totals are punched into a control card which

is placed at the end of each sub-batch. With Type B a "hash" total is made by adding the information codes for each sub-batch. The hash grand total is punched into a control card placed at the end of each sub-batch.

In addition a second hash total is made up by adding the last four digits of the serial numbers endorsed on the source documents from which the cards were punched. The hash grand total is also contained in the control card for each sub-batch.

A Control Account is made up from all the sub-batch totals and appears as

(*a*) Grand Total Credit Amounts.
(*b*) Grand Total Debit Amounts.
(*c*) Grand Total "Hash" Information Codes. (Entered by the Computer Centre.)
(*d*) Grand Total "Hash" Serial numbers of source documents.
(*e*) Total Card Count for the batch. (Entered by the Computer Centre.)

See example at Fig. 2.

The Control Account is posted in a Confidential letter to the Officer in Charge of Control Section at the Computer Centre. The punched cards are placed into padlocked boxes, and are sent to the Computer Centre at frequent intervals in accordance with a preplanned schedule. It is emphasized that the Control Account and the cards are dispatched separately to the Computer Centre; the persons processing the cards at the Computer Centre must not have access to the Control Account.

Office: *Edinburgh* Batch Number: 43

Date: 28*th November*, 1963

	CREDIT	DEBIT	HASH TOTAL SERIAL NOS. OF SOURCE DOCUMENTS	HASH TOTAL INFORMATION CODES	TOTAL CARD COUNT
	£ s. d.	£ s. d.			
Sub-batch 1.	71 3 6	30 10 9	16970		
2.			27600	4666	
3.			87888	5972	
4.			39654	0818	
5.			24766	0717	
Total	71 3 6	30 10 9	196878	12173	
Rejected at Edit*	1 3 6	2 10 9	00474	0073	
Accepted at Edit*	70 0 0	28 0 0	96404	2100	
Unposted to accounts at Update*	2 10 6	1 19 9	00301	0099	
Posted to accounts at Update*	67 9 6	26 0 3	96103	2001	

* Inserted by Control Section Computer Centre.

Fig. 2.—Control account (simplified form)

Action at the Computer Centre

Input Section

Tabulation

On receipt of the punched cards they are tabulated on conventional punched-card accounting machines, the machine sub-batch totals are agreed against the sub-batch control cards, and the grand totals agreed against the Control Account. Any disagreement is corrected if possible by telephone, or by returning the disagreed sub-batch to the Regimental Pay Office for correction, and continuing to process only the agreed sub-batches.

Sorting

The punched cards are now sorted into the same sequence as the master tapes containing the soldier's account, namely the first five alpha characters of the surname, and the soldier's army number of eight digits. The cards are counted during the sorting process and the cards agreed with the Control Account. The cards are now passed to Control Section.

Control Section

The officer in charge of the Control Section has already received the Control Account, and it has been proved to his satisfaction that all the cards have arrived. A tape label card to identify that input, and trailer cards containing a summary of the control totals and total card count are added. A Run Authorization for the series of computer runs necessary to process the new information is passed to the Tape Library with the box of punched cards. (See Fig. 3.)

Tape Library

The Tape Librarian issues a magnetic tape, and the sorted cards are converted into magnetic-tape images as an off-line operation by a Card Reader, the cards being counted during the process and the card count agreed with the Control Account again.

The Tape Librarian has meanwhile assembled the tapes necessary to process the information, and entered the tape details in various registers and on the Run Authorization. On completion of the Card/Tape process he signs the Run Authorization and passes the tapes to the Computer Room for processing. (See Fig. 3.)

Computer Room

Edit Run

The first computer operation is the Edit Run which checks the card images on the input tape to ensure that they contain sufficient detail to enable them to be processed. The card images are counted, and the financial and "hash" totals accumulated during the run, and, at End of Job, the totals are compared with the final control card image. In the event of disagreement an error message is produced on the typewriter, and the subsequent runs are not processed until the reason for the disagreement is found.

The output consists of two types of tapes:

(*a*) Card images which passed the Edit test and may go forward as input to the Update stage.

Run: Edit
Part 1 (Completed by Control Section)
Date: 28th November, 1963
Office: Edinburgh
Input Batch Number: 43

Authorized by: R. Shellard

PART 2 (COMPLETED BY TAPE LIBRARIAN)

TAPE UNIT	FUNCTION	TAPE REEL NUMBER	INDEX OF TAPE UNIT USED
1	Read	3002	C
2	Read	4011	A
3	Read	4153	F
4	Write	2563	G
5	Write	2597	B
6	Write	2600	J
7	Write	2570	H
8	Write	2593	K
9	Write	2666	D
10	Program	5001	E

Tape Librarian: T. Atkins

Part 3 (Completed by Console Operator)
* Run successfully completed.
* To be rerun for the following reason:

J. Brown
Console Operator

Fig. 3.—Run authorization

(*b*) Card images which failed the Edit test; these are printed out off-line and returned to the Regimental Pay Office for correction and resubmission.

Update Run

The card images which passed the Edit stage are now processed against the Master Files containing the accounts for that particular Regimental Pay Office. Some of the card images may be rejected at Update stage because they fail to match up with any soldier's account on the Master File (it may be that the account has been transferred to another Regiment's Master File or has been closed). These card images will be rejected to a special error reject tape, printed out at the end of the run, and returned to the Regimental Pay Office in much the same way as the Edit errors.

At End of Job, control totals are again typed out, showing the amounts posted to accounts and those rejected to the Error tape. These are again agreed with the Control Account held by the Officer in charge of Control Section. (See Fig. 2.)

During the course of the run certain credibility checks are carried out, to ensure that the amounts credited to the soldier are likely in accordance with his status. If there is doubt a message is produced on the typewriter, and the output is subject to scrutiny before despatch.

The Update run produces, in addition to the Error reject tape mentioned above:

(*a*) A tape containing adjustment slips to be printed and sent to each soldier, stating the net adjustment to his account.
(*b*) A tape containing details of amounts to be issued to the soldiers' dependants as a result of this run. The Update run allocates the serial number of the postal drafts or allowance order books to be issued, and the address and to whom they are to be sent.
(*c*) A tape containing all miscellaneous forms of output (Income tax, Savings, etc.).

Control of tapes

Tapes are all serially numbered on coloured labels, the colours indicating the purposes for which they may be used, e.g.

Red—Master Files.
Green—Card/Tape (Input Tapes).
Yellow—Print Tapes (Output Tapes).
Blue—Program Tapes.

Registers are kept for all runs, and the Tape Librarian is responsible for keeping these up to date and indicating on the Run Authorization the serial number of each tape to be mounted on each Tape Unit. Removable tape labels are also prepared, using the same colour code, to give brief details of the run for visual recognition of the various tapes.

All tapes have a 41-digit magnetic-tape label record which serves the following purposes:

(*a*) Identifies the Regimental Pay Office Master File to be processed.
(*b*) States the purpose for which the tape is to be used.
(*c*) Gives the reel number if one of a series.
(*d*) Gives the date of processing.
(*e*) In the case of Read tapes, gives the identity of the run on which it was formed.
(*f*) States the number of working days the tape is to be retained before being scrapped. (Purge date.)

Tapes are mounted on the Tape Units by the Tape Handlers in accordance with the Run Authorization. The Console operator checks the serial number of each tape against the Run Authorization. Each Tape Unit has an alpha letter for identification; this letter is endorsed on the Run Authorization during the Console Operator's check. (We have found this useful where a fault has been discovered later—it helps the engineers to diagnose faulty tape units quickly.) (See Fig. 3.)

Control of computer operations

The computer console has a monitor device incorporated which causes a message to be typed on the console typewriter every time the operator depresses a

control instruction key, or manually alters the content of memory in any way.

The programs are written so that at the commencement of any run:

(*a*) the program and Read tape identification labels,
(*b*) the Console Switch settings, and
(*c*) the labels of any Write tapes which have not passed the Purge date are written on the Console typewriter.

The run halts between each of the above messages, and requires positive action by the Console Operator to check the message and press start to continue.

At End of Job the Run Authorization is signed by the Console Operator, and returned to Control Section with a copy of the typewriter log. The tapes are returned to the Tape Librarian, who divides the tapes and controls them through a simple register to ensure that they are printed or carried forward to the successive run.

All typewriter logs are serially numbered and are subject to a 100% check by the Senior Console Operator —usually carried out as soon as the run finishes. The Console Operator keeps a log of all runs, idle time and set-up time. All unscheduled halts due to machine fault or program limitation are noted in a special register. This is of special interest to the engineers and programmers.

Control of output

The computer run produces a control schedule for every office which lists precisely how many types of forms it has generated.

The printer operator prints the control schedule first, so that he will know which and how many forms he will have (and therefore how long the process will take).

The Output Section use a copy of the control schedule to collect all the printed output.

The Regimental Pay Office use a copy of the control schedule to test check receipts.

When printing is completed it is sent to Output Section where the forms are cut up by electric guillotine and counted, the count being agreed with the form control schedule.

Control of negotiable documents

Payments are made by postal drafts or allowance order books which are cashable weekly through the Post Office. These are serially numbered, and the stocks of these documents are held in the Computer Centre. At the beginning of each day, a special Control Data run writes upon the magnetic drum storage the serial numbers of the postal drafts and allowance order books which are available for allocation by the computer that day.

During the course of the various runs the computer issues a postal draft or allowance order book, and at End of Job the computer analyses the total number of drafts and books issued, and over-writes the magnetic drum storage to show the serial numbers next available for issue in the subsequent run. At the end of daily processing the information on the drum storage is copied onto magnetic tape ready to be reinstated at the commencement of business on the next day.

The Control Data also provides the information necessary for tape-label purge date control, and the current date.

Where output is to be printed directly on to preprinted serially numbered negotiable documents, the forms are issued under control and agreed with the Console typewriter control messages.

Book-keeping and control for audit purposes

It is the view of some auditors that they should have their own programs to run on the computer whenever they choose. In the RAPC application the auditors were present when the system was devised, and their requirements were built into the programs as they developed.

The check on the payment credits against the soldier's status is one example.

Every month the auditor nominates a particular account for a particular office. During the monthly Credit of Pay run for that office, the program types out the contents of the working stores just before actioning the nominated account. The following twenty-five accounts are typed out complete with contents of individual working stores. Finally the accumulated book-keeping working-store contents are typed out again, and the run proceeds normally. The typewriter log is sent to the auditor who visits the Regimental Pay Office and fully audits these accounts. It will be appreciated that, by this random selection, a very large portion of the program is checked thoroughly by this manual check by the auditors.

A similar facility is available for the normal processing of Update runs. The important concept is to have the means of producing analyses if required—not necessarily to do it so frequently.

It is important to realize that if the auditors see one account with a particular status with the correct rates of pay, etc., then similar accounts will also be correct; therefore audit should cover as wide a range of status as possible. Such audit is best done from the manual records.

Conclusion

Any computer system of this sort is only as efficient as its controls. The system of control must be designed right from the start with the interests of work flow, control of processing, safeguards and auditing firmly in view. All interested parties should be at hand and their reasonable requests met.

I have endeavoured to outline the principles of control conducted in the Royal Army Pay Corps Computer Centre. The system has been in operation over three years now, and one can best judge its success by the fact that it has produced the highest usage efficiency ratio for all Government Computer systems.