

The Basic Principles of Computers

Computers for office work are automatic electronic machines which take in information and subject it to a variety of arithmetical and logical processes to produce wanted results. Much of the input information, or data, is numerical; inside the machines numbers are represented by groups of electrical signals, and the machines are called digital computers because a separate signal is used for each digit.

Electronic machines use radio valves, transistors, resistors, capacitors and similar components of the sort that are to be found inside a television set. Electronic computers are fast and accurate; thus, the LEAPS computer can add two 10 - digit numbers together in 1/6000th of a second.

The automatic nature of a computer enables it to undertake, without any human intervention, long sequences of connected operations, by passing the results of earlier operations on to subsequent operations, and by using the intermediate results to select which of alternative sets of operations shall follow.

For their arithmetic most computers use binary numbers as these have only two different digits, 0 and 1, to be represented by electrical signals instead of the ten of decimal numbers. Binary numbers look strange at first, but are built up on a similar plan to decimal numbers thus, 11010 is the binary representation of 26 as, no units, one two, no fours (2×2), one eight($2 \times 2 \times 2$) and one sixteen ($2 \times 2 \times 2 \times 2$). Binary arithmetic is identical with decimal arithmetic, and the computer is arranged to convert automatically between the binary and decimal scales.

The computer performs its arithmetic by combining and selecting the groups of signals that represent the input numbers in ways that produce another group of signals that represent the required answer.

Instructions to LEAPS for
COMMON WEEKLY PAY ITEMS

(See LEAPS MANUAL for all other pay items)

Pay Item	Code and input column pattern
STANDARD PAY	
Annual increment	55 days s d
Effective duty increment	
Late Attendance forfeiture	132 hrs $\frac{1}{4}s$
INTERMITTENT ALLOWANCES	
Motor Driving	5 s d
Cycle Cleaning	
Motor Cycle Driving	405 s d
SUBSTITUTION: Due for payment this week	21 s d
EXTRA DUTY	
Overtime: Current	4 hrs $\frac{1}{4}s$
Belated	100 hrs $\frac{1}{4}s$
Suspended Service	36 hrs $\frac{1}{4}s$
Concession Time	116 hrs $\frac{1}{4}s$
Travelling Time	52 hrs $\frac{1}{4}s$
Extra Duty (all types) IN CASH	117 s d
SUNDAY DUTY	
Normal	20 hrs $\frac{1}{4}s$
IN CASH	181 s d
INCOME TAX	
Change to Normal Cumulative basis	18 code
Change of " " tax code	
Change to Week I Basis	82 code
Change of " " tax code	
NATIONAL INSURANCE	
Benefit (Estains)	7 days s d
No Contribution this week	49

Outline Notes of LEAPS Payroll System

1. Objectives

To minimise the cost of administration and the demands made by the Civil Service on the nation's manpower, the PO Directorate decided in 1955 that computers should be used to process payrolls for all PO staff in London.

2. LEAPS

The London Electronic Agency for Pay and Statistics

London all PO staff in LPR (Inner Area), LTR, HC Regional Headquarters, ETE (Headquarters and C & W), A & PRD, AGD, SupD, Contracts Department, FacD, ED, SBD, and SCD.

Electronic equipment is necessary to achieve economical processing speeds.

2 National/Elliott 405 computers
2 Samastronic printer equipments
Paper Tape punching and verifying equipment.

Agency AGD, Establishments and Accounts Division, LEAPS Branch (AGD/LEAPS), 3rd Floor, Armour House, St. Martin's-le-Grand, E.C.1.
The payclerk - payee relationship will remain undisturbed: the pay clerk will have his calculations and documents prepared for him by the agency.

<u>Pay</u>	Monthly	31,000
Weekly	Postal	34,000
"	LTR (Eng.)	13,000
"	LTR (other)	16,000
"	Other	18,000
	Total	112,000 payees

Statistics ultimately will be compiled in LEAPS from a variety of sources of data.

3. Timing

1955 Directorate's decision
1957 Planning team recruited and trained
January, 1958 Detailed planning began
December, 1958 Delivery of 1st Computer
Mid 1959 NW District Office staff to commence the scheme
1962 Probable completion of ultimate stage.

4. How LEAPS works

Payclerks will receive details affecting payees' pay, complete preprinted documents to show pay data in simple codes and send them by special van to LEAPS where punch and verifying operators will prepare punched paper tape. This tape will be fed to the computer, which, acting on its program of instructions will use the information from the paper tape and from magnetic films to prepare an output film. This film will then be used in the printer equipment to produce pay advices, proof-sheets, postal drafts, pay records etc. which will then be sent to the local office in time for pay day.

5. Implementation

The new arrangements will be introduced by a special task force which will visit each office in turn.

6. Training

Appreciation courses 1st series May-November, 1958
2nd " November, 1958 onwards

Job Instruction has been given to the planning team,
is being " " punch and verifying operators

7. Staff Participation

The Standing Joint LEAPS Committee was set up in December, 1957 so that representatives of all the staff associations concerned could play their part in the planning of the LEAPS project. Accommodation, training, grading and recruitment of staff are examples of topics already tackled by this Committee.

8. Interest

LEAPS is a project of national importance in which all departments and staff of the PO are concerned. Overseas administrations have already begun enquiries.

November, 1958

MBD/COMB

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To be sent to Director and Staff Officer College of the Commonwealth and
overseas Administrations.

Minister of National Development 200.
Director and Staff Officer and Staff Officer 200.
Minister without Portfolio 200.
Minister of Health 200.
Minister of Education 200.
Minister of State without Portfolio 200.
Minister of State without Portfolio 200.

Submitting on behalf of Director and Staff Officer College of the Commonwealth and
overseas Administrations the above figures for consideration and information
and will keep you fully informed of any developments concerning the same.
The undersigned is among others responsible for the preparation of the above figures
and as regards the same I would like to point out that they were prepared on the basis of
existing and existing or likely existing conditions. You will find further information
in the report of the Director and Staff Officer College of the Commonwealth and
overseas Administrations which will be submitted at an early date.

This report was submitted to the Director and Staff Officer College of the Commonwealth and
overseas Administrations on the 20th November 1958.

LEAPS Input procedures and documentation

Manual System

- 1 In the present, manual, system pay documents may be divided into two sets, which are combined to calculate pay each week on paysheets. The two sets are:

PAY RECORDS

One document, for each payee, which lasts one year and is kept in the wages branch. It records standard pay, standard deductions, income tax details, and other items of permanent interest.

(Note: If there are no Weekly Pay Items, basic pay is issued from the Pay Record.)

LEAPS System

- 2 In the LEAPS System the Pay Record will be kept by LEAPS, in the computer "memory", and any Weekly Pay Items that arise will be sent to LEAPS and read into the computer every week. Punched paper tape will be used to read Pay Records into the computer in the first week of payment by LEAPS. Punched paper tape will also be used every week afterwards to read Weekly Pay Items into the computer which will associate them with the Pay Record held in its "memory", and calculate pay.

Punched Tape

- 3 Punched tape is prepared by operators using a machine with a typewriter keyboard and reading from handwritten documents.

Pay Numbers

- 4 To enable the computer to recognize each payee's pay record and weekly items, every payee receives a "pay number" which remains unchanged while he is paid by LEAPS. Payees are not required to remember or quote their numbers, e.g. on their overtime dockets.

Computer Codes

- 5 Also, every item on Pay Records and all Weekly Pay Items must be numbered to enable the computer to identify the item. This number is known as the "computer code", or "code", of the item. Pay numbers are, of course, different for each payee, but the code for any item is always the same e.g. overtime is always code "4", "standard pay" on the Pay Record is "16".

Existing Documents

- 6 Pay numbers and computer codes could be added to existing pay documents, but all existing documents would need to be redesigned to make them suitable for presenting to operators preparing punched tape. Information to be punched into the tape would have to be separated from other figures that should not be punched, and special column spacing necessary for tape punching would have to be provided.

New LEAPS Forms

- 7 LEAPS forms will therefore be introduced which will be completed at local offices from existing pay documents, and which will be sent to LEAPS, where they will be read by operators preparing punched paper tape. The existing pay documents will remain in the local offices.

Form LEAPS 4

- 8 Form LEAPS 4 will be used to start a Pay Record in the first week of payment by LEAPS. Most of the items on Form LEAPS 4 are similar to those on the present, manual record described in para 1. The computer code for most items is printed on the form, e.g. "standard pay" is code "16".

WEEKLY PAY ITEMS

Many documents arise each week outside the wages branch and must be associated with Pay Records e.g. authorities for increments; tax code changes; sick leave reports; overtime and substitution claims; consent forms for deductions from pay.

9 Form LEAPS 1 will be used every week to send weekly pay items to LEAPS; about 2/3 of payees have one or more pay items every week. To save writing so many names and pay numbers, and at the same time prevent errors, LEAPS will have printed each week on forms LEAPS 1 the names and numbers of all payees on the payroll, in alphabetical order. Weekday overtime and Sunday duty are common enough to have special columns on form 1 allocated to them, and as no other items will appear in those columns the computer codes will be printed on the form. If there is no weekly pay item for any payee his line on form 1 is left blank and the computer issues basic pay from the Pay Record held in its memory (para 2).

Form
LEAPS 1

10 Form LEAPS 2 is similar in design to form LEAPS 1, but will not be distributed by LEAPS bearing printed names and numbers. A stock will be held locally and it will be used as a "continuation form" for LEAPS 1. Sometimes form LEAPS 1 will not accommodate all the items for a payee, and when this happens the payee's name and pay number will be copied in manuscript to a continuation form LEAPS 2, and the extra items will then be entered in their appropriate columns.

Form
LEAPS 2

11 Every pay number has a "check digit" (which is a single number, from 0 to 9) printed on the left hand side of form LEAPS 1 at the same time as the name and number. Whenever a pay number is copied from LEAPS 1, e.g. onto form LEAPS 2 as described in para.10, the check digit is copied with it and is read into the computer with the pay number. The computer can check that a pay number has been correctly copied by comparing it with its check digit, as the two bear arithmetical relationship with one another.

Check
Digit

12 Specimen forms LEAPS 4 and LEAPS 1 are attached. The entries on form LEAPS 1 are explained below:

Mr. Hudson has $6\frac{1}{2}$ hours weekday overtime, denoted by code 4 in column 1; and 2 hours of suspended service concession time have to be allowed for, denoted by code 36, in column 3.

Mr. Judd has received an increment of 8s. 6d. denoted by code 55 in column 5. "4 days" signifies that the increment is payable for only 4 days in the week in which it is first signalled. It is paid in full automatically in subsequent weeks.

Mr. Kennedy is commencing his weekly contribution to an insurance society by the entry in column 6. The computer code to do this is 233. The insurance society is denoted by item 45, and the value of the deduction is 6d. He also has a new income tax code number. Code 18 in column 9 denotes a change of tax coding, and 117 is the new tax code number.

Mr. Leary has 4 hours weekday overtime; and $6\frac{1}{2}$ hours Sunday duty, denoted by code 20, in column 2.

Mr. Long is transferring to a new office. Transfer is effected by code 3 in column 10. 97 is LEAPS number for the new paying office and 7 is LEAPS number for the pay point at the new office. He is also due for 16s. 6d. driving allowance denoted by code 5, in column 4.

STORAGE FACILITIES IN LEAPS

1. There are three main types of storage (or "memory") in LEAPS and they meet different requirements. In theory it would be possible to use only one type of storage medium having facilities meeting all requirements, but at present cost would preclude this. In considering the merits of a storage medium, the principal criteria are the time needed for reference to stored information and unit cost. In general, speed of access is costly. Hence, although some types of storage offer immediate access, they are expensive for limited capacity. Other types are cheap and offer unlimited capacity, but impose serious restrictions, usually that access to information must be "sequential" - i.e. all information preceding a wanted piece must be examined and rejected first and "random" access is not practicable.

2. The three types of storage at LEAPS are:

2.1 THE HIGH SPEED WORKING STORE. This corresponds broadly to the human clerk's pad of scrap paper. It holds figures currently being worked on and which are required immediately; the "working store" consists of nickel delay lines, most of which hold 16 computer "words" each of 32 code elements (or 6 decimal digits). The total capacity of LEAPS working store is 512 "words" but it is in no sense a permanent store or file. The average time required to gain access to a piece of information is only about 1.5 milli seconds.

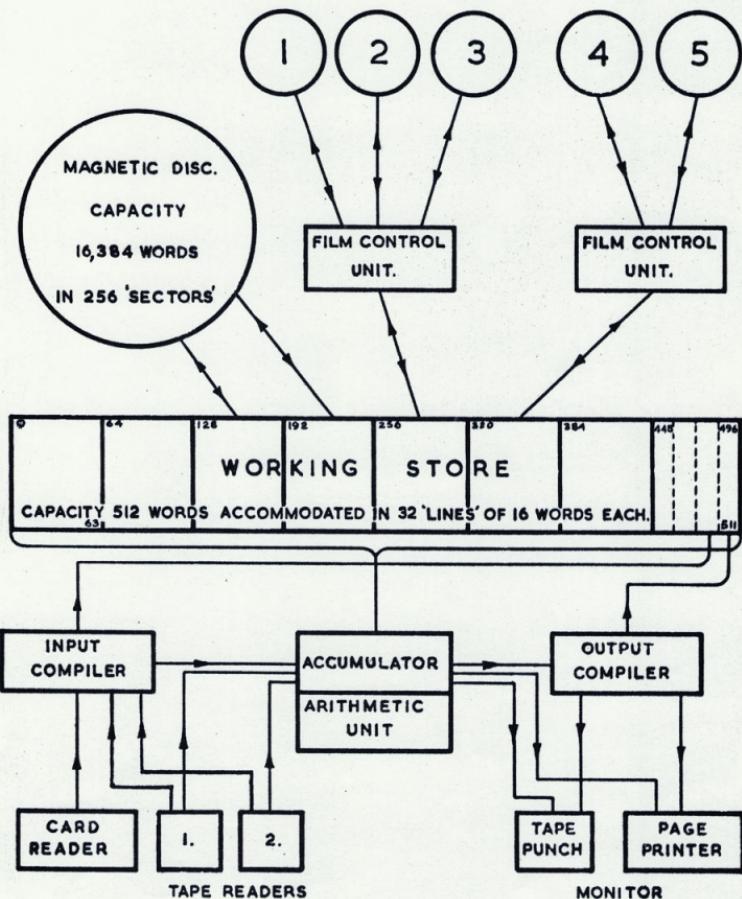
2.2 THE INTERMEDIATE SPEED STORE. It is difficult to find a good analogy. As this store holds the computer's instructions, it is perhaps analogous in part to the clerk's personal copy of the pay manual, but it has other functions including the temporary storage of various accumulations. The intermediate speed store in LEAPS is a magnetic disc on which information in the form of minute magnetic spots is stored in parallel tracks. The disc is $19\frac{1}{2}$ " in diameter and $\frac{1}{2}$ " wide. It is motor driven to revolve at 2,300 revolutions each minute. On average, it takes 32.5 milli-seconds to gain access to a required piece of information. The disc holds 16,384 computer "words" equivalent to somewhat more than 150,000 decimal digits.

2.3 THE HIGH CAPACITY PERMANENT FILE. This corresponds to the reference file of staff cards or the individual pay record headings in a manual system. The high capacity store at LEAPS comprises a separate reel of magnetic 35 mm. film for each pay group, on which information can be permanently kept in the form of invisible and minute magnetic dots. Information for each payee occupies half the width of a film and runs for about 5" along its length. One film can hold information for up to 4,000 payees. A reel of film is 10" in diameter and is 1,000' long. It holds the equivalent of about 3 million decimal digits. Blocks of information must be read by the computer sequentially and, as it takes 13 minutes to read a film under optimum conditions, the average time to "find" a single piece of information is at least $6\frac{1}{2}$ minutes. It is not therefore practicable to refer quickly and at random to a single payee's information. The film normally moves at 30" per second, and complete information for one payee can be read in 200 milli seconds.

NATIONAL/ELLIOTT 405 COMPUTER IN LEAPS.

FUNCTIONAL BLOCK DIAGRAM.

MAGNETIC FILM MECHANISMS.



I COMPUTER WORD = 32 BINARY DIGITS (BITS) = A 9 DECIMAL DIGIT NUMBER OR 5 ALPHABETICAL CHARACTERS.

16 COMPUTER WORDS = 1 'LINE' OF STORAGE.

64 COMPUTER WORDS = 4 LINES = 1 SECTOR ON THE DISC OR 1 BLOCK ON THE FILM.