CCS-F3X2 Issue 3 16 March 2004

Ferranti Pegasus, Perseus and Sirius

System Architecture

Pegasus

***NOTE**: Most of this material is an edited version of the Case Study file CCSHLFdb1 by Simon Lavington, together with material from the Pagasus Book.*

Pegasus was a medium-price, medium-performance general-purpose computer. Great emphasis was placed on reliability and ease-of-use and, in these respects, Pegasus was ahead of its contemporaries. It was the first production computer to employ a general register-set architecture (ref **D3** 1). It has been said that 'Pegasus opened up a new era in the provision of high-quality programming systems by manufacturers of computers in Britain' (ref. **D3**, 8). Pegasus 1 was primarily intended for scientific and engineering applications. The Pegasus 2 variant, which addressed the business data processing market, made provision for magnetic tape decks and punched card equipment.
An extra unit called a *converter* could also be added to a Pegasus 2 installation. The converter coupled the Pegasus magnetic tape system to punched-card readers and punches, and to high-speed lineprinters.

Figure X2-1. Pegasus 1

A feature of Pegasus is its modular construction, using robust plug-in electronic packages. In the above 1956 photograph an engineer has opened one of the computer's cabinets and is in the process of extracting a package which is the size of a paperback book. Originally called the Ferranti Packaged Computer, the project's name was changed to the similarly sounding 'Ferranti Pegasus Computer' by the company's sales staff. Internally, the Pegasus logical structure embodied an innovative 'general register set' architecture that is still used in many modern computers.

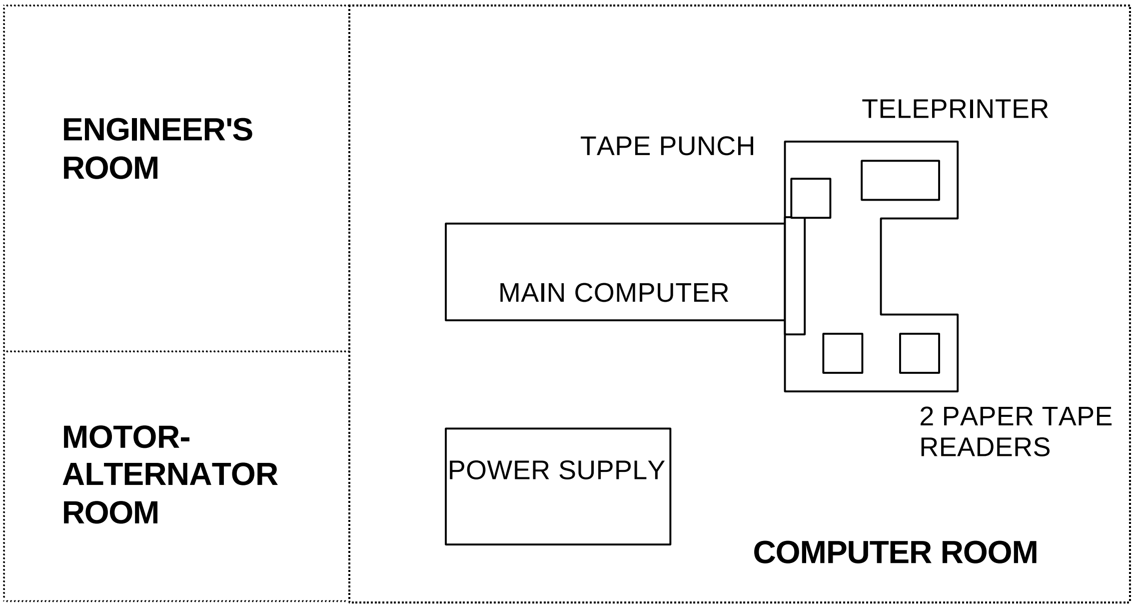
Figure X2-2. Pegasus 2

Figure X2-2 shows a larger, more powerful, four-bay Pegasus 2 computer. Although the provision of magnetic tape decks (seen in the background to the left) and multiple printers (shown to the right) enhanced the appeal of Pegasus to the commercial data processing market, the business community was more interested in systems based on punched card input rather than paper tape input. Accordingly, an extra unit called a Converter could be added to a Pegasus 2 installation. The Converter coupled the Pegasus magnetic tape system to punched card readers and punches, and to high-speed lineprinters.

Pegasus was a serial machine with a word length of 39 bits plus 1 parity check bit plus 2 “gap” bits inaccessible to a programmer. The clock frequency was 333.33 kHz, resulting in a word time of 126 microseconds. It used a technology derived from the Elliott 401 computer. The basic logic elements consisted of germanium diode AND gates followed by either a one clock time delay circuit, or an inverter circuit or else a simple buffer circuit. Most of the circuits used 12AT7 or equivalent double triodes. Rapid access storage was based on steel wire acoustic delay lines mounted on the same kind of plug-in packages as the logic circuits. A Pegasus typically contained about 450 packages, of 20 different types, but with five types predominating. The main internal storage used a magnetic drum holding 5120 words, increased to 9216 words on later machines.

The arrangement of a small Pegasus is shown in Fig X2-3. The installation was provided with 3-phase electrical power via a motor-alternator set which gave a measure of isolation from power disturbances. The motor-alternator was located in a separate room to reduce acoustic noise. An installation might have a resident maintenance engineer, or a part time engineer, and a room was provided for his use with storage for spare parts and a bench and tools for the engineer to diagnose and repair faulty packages.

Fig. X2-3 Layout of a Small Pegasus



Dimensions

Main Computer	8' 0" × 2' 4" × 6' 11" high	(2.44m × 71cm × 2.11m)
Control Desk	8' 3" × 4' 5½ × 2' 6" high	(2.52m × 1.36m × 76cm)
Power Supply Unit	5' 8" × 2' 4" × 6' 10" high	(1.73m × 71cm × 2.08m)
Motor-Alternator Set	6' 7" × 1' 10¼" × 2' 3" high	(2.01m × 57cm × 69cm)

The weight of the main computer with desk and peripherals was 2859 lbs (1298Kg).

Power requirement was approximately 18.5kVA.

A simplified block diagram of the structure of Pegasus is shown in Fig X2-4. The main system storage is the magnetic drum which held program and data. However, programs were actually executed from the Computing Store and efficient block transfers under the control of the programmer brought sections of program from the Main Store into the Computing Store.

Fig. X2-4 Pegasus CPU Block Diagram

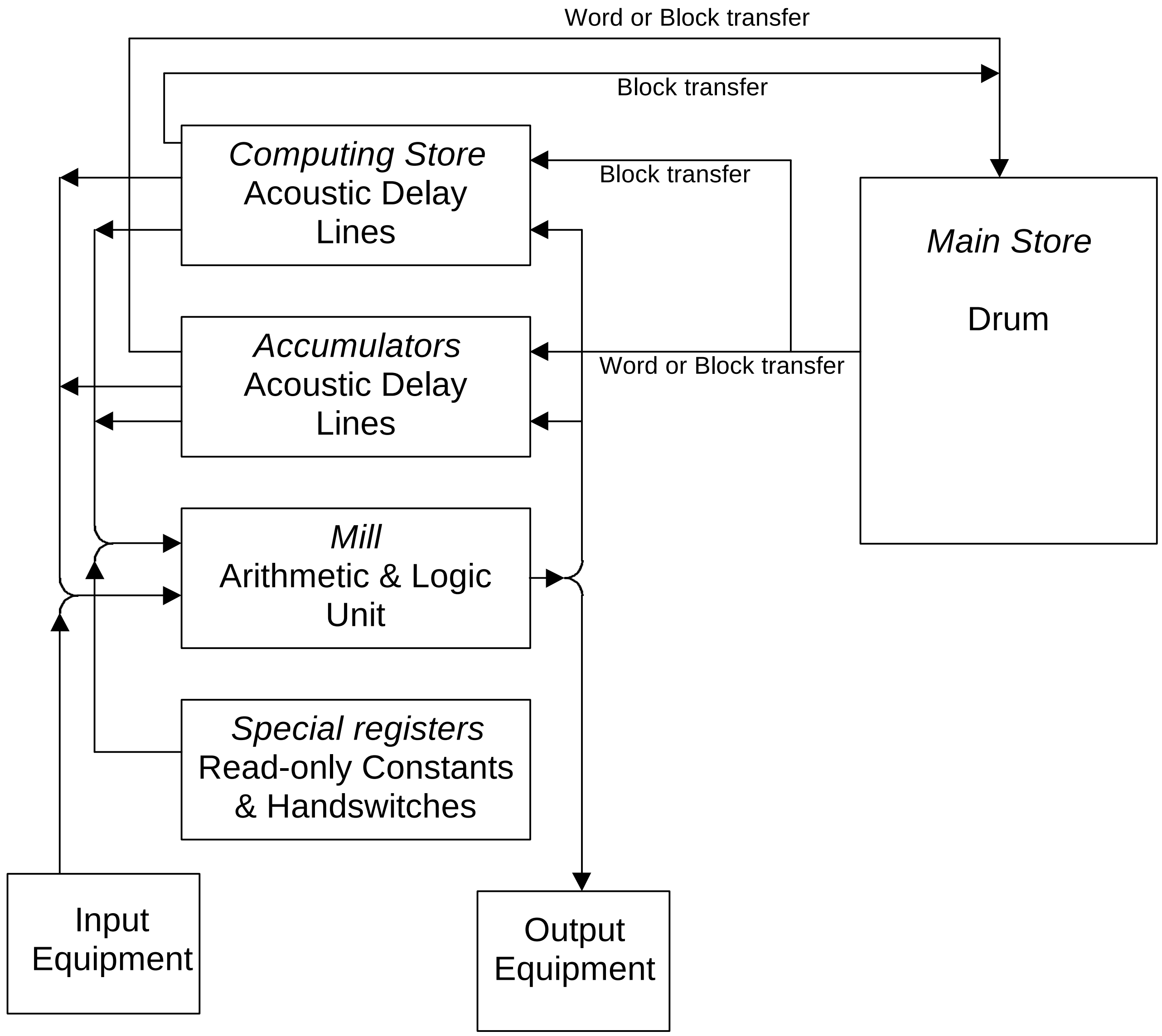


Fig X2-5 on the following page shows the addressing structure for Pegasus. The structure of instructions normally allowed a 7-bit operand address and the 128 possible addresses are allocated according to the table. Note that the programmer need not be concerned that the computing store was the upper half of the addressing range - on input of programs the Initial Orders would translate the programmers' notation (0.0 - 5.7) into the physical addresses.

Fig X2-5 Store Addressing Map

decimal addr.	*program notation*	*description*
0 -> 7	0 -> 7	accumulators, X0 – X7. (X0 is always zero).
8 -> 14	-	(unassigned: always contain zero)
15	15	handswitches (20 bits)
16	16	input/output (5 bits, checked)
17	17	input/output (5 bits, unchecked)
18 -> 31	-	(unassigned: always contain zero)
32	32	constant (-1.0)
33	33	constant (1/2)
34	34	constant (2 ↑-10)
35	35	constant (2 ↑-13)
36 -> 63	-	(unassigned: always contain zero)
64 -> 111	0.0 -> 5.7	48 words for program/data, as six block of 8 words each.
112 -> 127	-	(unassigned: always contain zero).

Computing store addresses 64 to 111 in theTable are identified in the form *Block.Position*, running from 0.0 through to 5.7. The eight accumulators, denoted as X0 – X7, can be used either for computation or for address-modification and loop-counting. X0 is always zero. Accumulators X6 and X7 act as a double-length pair *p,q* during certain multiply, divide, and shift instructions. (See the full Pegasus instruction set given elsewhere).

The Ferranti Perseus Data Processing System

General Description

Perseus was a large-scale data-processing system specifically designed for commercial and administrative work. Two were delivered, starting in 1959, and both systems were used in large insurance companies, typically for policy issue, premium billing, valuations, commission accounting etc.

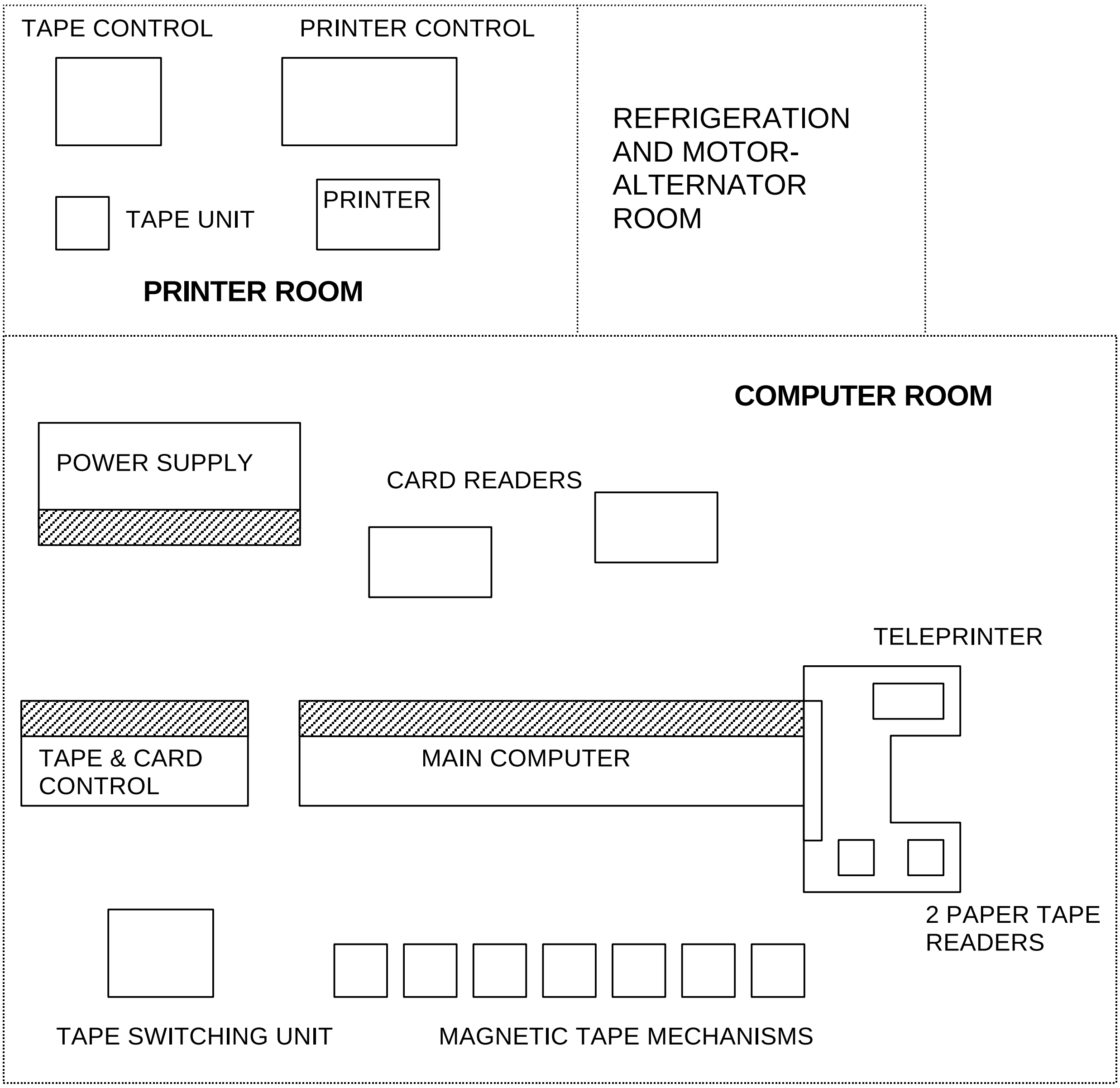
The system used the same electronic technology as Pegasus (see above), and the engineering was similar as can be seen in Figure X2-6, which shows Perseus no. 1 installed at Datacentralen in Stockholm. For the envisaged applications, vast amounts of file data would be involved and 1/2" magnetic tape was the storage medium for that. There was no drum storage as used in Pegasus but a large internal immediate access store using very long acoustic delay lines was provided instead. Large-scale data input was provided by punched card readers, available for both round- and rectangular-hole cards. Data output was to off-line high-speed Samastronic line printers fed from magnetic tape.

Fig. X2-6 Perseus at DataCentralen, Stockholm

The layout of a typical Perseus is shown in Fig X2-7. The main computer has a control desk at one end with two paper tape readers and a teleprinter. A control panel carries control switches and above the control panel is a monitor unit containing two cathode ray tube displays showing information in binary form. A maximum of 16 Electrodata magnetic tape mechanisms could be connected, with up to four simultaneous transfers between tape mechanisms and buffer storage. Power for the system was provided by a stabilised power supply unit which was supplied with regulated three-pase power by motor-alternator sets in a separate room. All the equipment was cooled by closed circuit air chilled by refrigeration plant. Maximum power requirement was 60 kW.

The Samastronic printer, manufactured by Powers-Samas, was controlled by off-line electronics units and supplied with printing data from a magnetic tape mechanism. Typically either one or two printing systems were installed.

Fig. X2-7 Typical Perseus Installation



Perseus Installation Details

Dimensions

Main Computer	20' 7" × 2' 1¼" × 7' 9" high	(6.28m × 62cm × 2.36m)
Control Desk	8' 3" × 4' 5½ × 2' 6" high	(2.52m × 1.36m × 76cm)
Tape and Card Control	9' 11" × 2' 1¼" × 7' 10" high	(3.02m × 62cm × 2.39m)
Magnetic tape Mechanism	1' 7" × 1' 8" × 5' 9½" high	(48cm × 51cm × 1.77m)
Tape Switching Unit	2' 11" × 2' 1" × 5' 0" high	(89cm × 63cm × 1.53m)
Power Supply Unit	16' 0" × 2' 1" × 7' 9" high	(4.88m × 63cm × 2.36m)
Printer	2' 6" × 6' 0" × 5' 6" high	(76cm × 1.83m × 1.68m)
Printer Control	7' 3" × 3' 0" × 6' 0" high	(2.21m × 91cm × 1.83m)
Printer Tape Control	5' 5½" × 2' 1¼" × 6' 10" high	(1.66m × 62cm × 2.08m)

On the Main Computer, The Tape and Card Control, and the Power Supply Unit, there is a platform all along one side 23 inches (59cm) wide and 14 inches (36cm) high, containing air chiller units.

Power Requirements

Approximately 60kVA, depending on what ancillary equipment is provided. The Computer is fully refrigerated and the Tape Mechanisms are air-conditioned. All power for the system is supplied via a Motor-Alternator set, which is housed in a separate room together with the refrigeration equipment.

Perseus System Architecture

Figure X2-8 represents the internal registers and data paths in Perseus. The main store of 1024 78-bit words is addressed as 32 blocks each of 32 words. For example the 106th word in the store is referred to as at Block 3 Position 10, or 3.10 for short. Block 0 contains the accumulators, slow peripherals, arithmetic registers etc, collectively referred to as Special Registers. There are internal data paths among the Special Registers not shown in Fig X2-6, typically for routing data while performing arithmetic.

Because Perseus was a serial machine, it was economical to provide data transfers of a whole block or of a quarter block within the block structure of the store. There was no facility for Direct Memory Access (DMA), all peripheral data transfers being programmed. But because blocks of data could be moved from place to place with a single instruction, absence of DMA was not an arduous limitation. A block could be moved from the computing store to a tape buffer, and then the next instruction could write that buffer to the selected tape mechanism. Any subsequent operations on the buffer or that tape mechanism would be held-up until the operation was completed, although seeks on any of the other tape mecansisms were allowed without holding-up instruction execution.

The machine was aimed at coomercial data-processing as exemplified by the insurance business. The size of a block on tape (and in the computing store) was comfortably enough to hold all the details for one life insurance policy. The order code (to be described in a later section) provided powerful facilities for specifying fields, or contiguous groups of characters within a Perseus word,

Fig X2-8 Perseus Data Paths

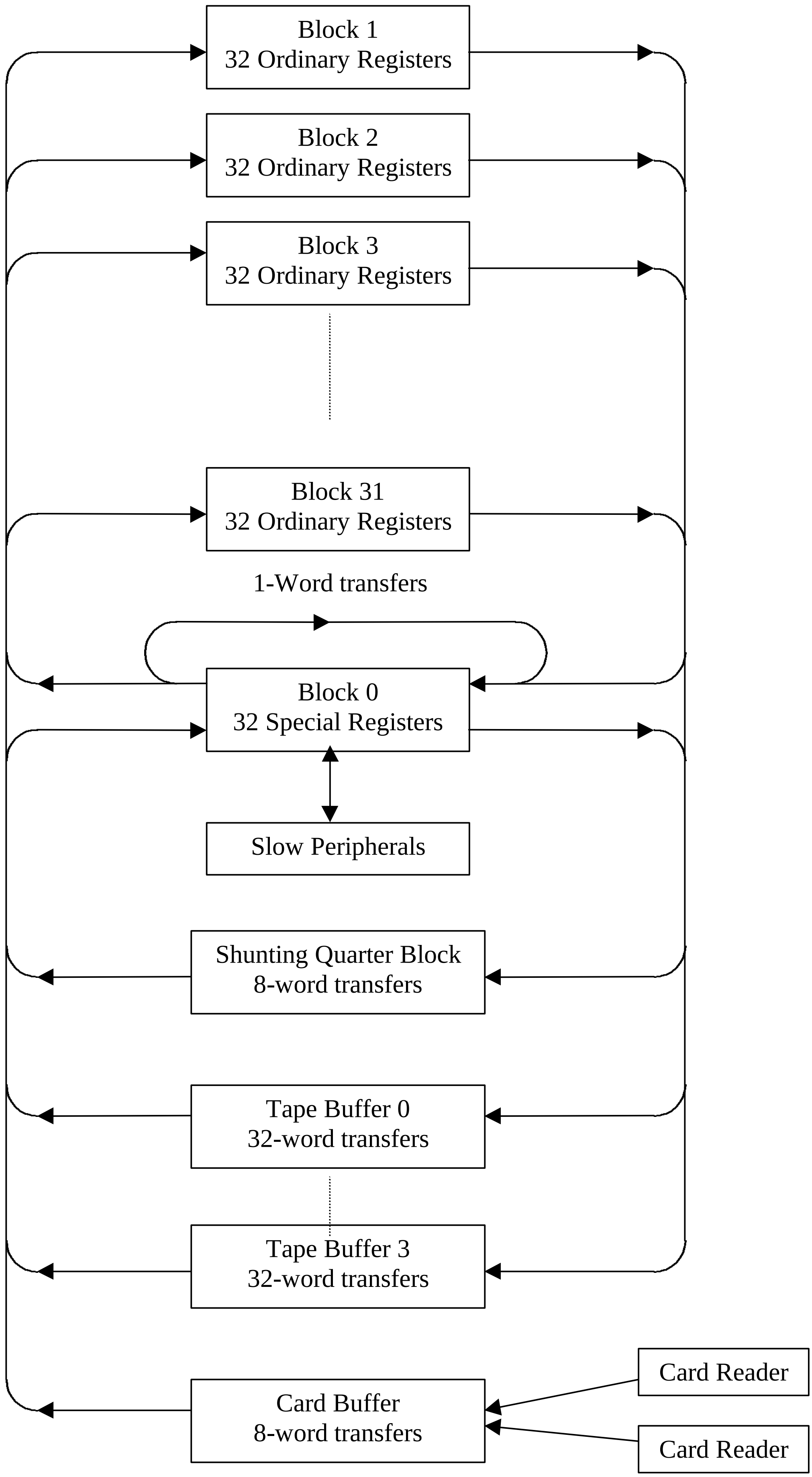
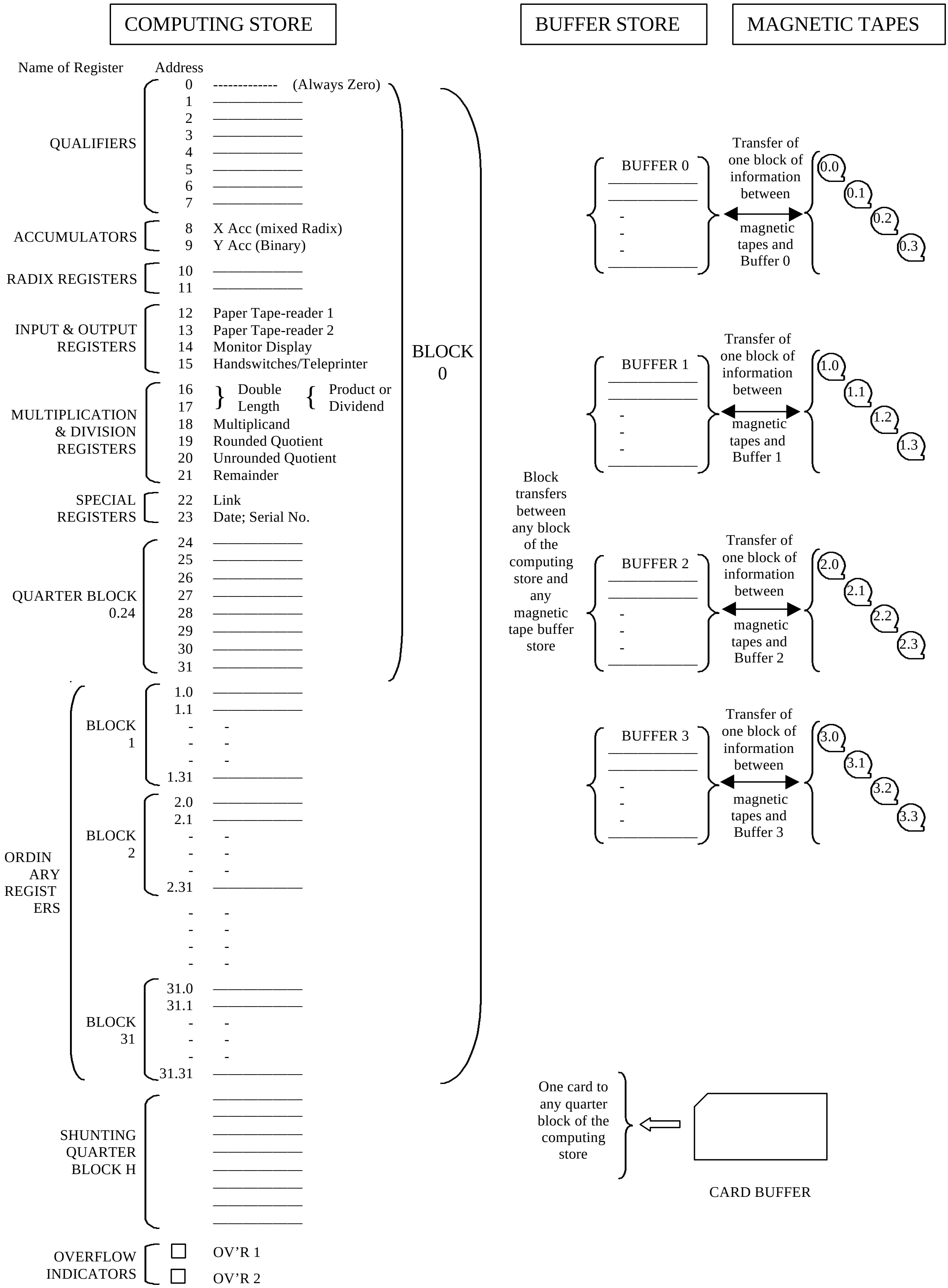


Fig X2-9 Perseus Storage System Layout



and manipulating and performing arithmetic on just that field, leaving the rest of the word unaffected. Such manipulations took place in the X-register, the Mixed Radix Accumulator. A binary accumulator was also provided, the Y-Register, for housekeeping within a program. The accumulators were part of the block of special registers (see Fig X2-9)

Associated with the X-ragister were two Radix Registers (Fig X2-9). Each character position of a radix register held a radix number for that position. For example, the radix numbers for sterling pounds, shillings and pence would be 10,10,……10,10,2,10,12, or for stones, pounds and ounces 10,10,10,……10,14,16. The radix numbers would be set in the appropriate character positions of a Radix Register according to the field position in a word of the relevant data to be manipulated. An example of the effect of these registers would be that a field containing cost per ounce could be multiplied by weight of item to produce the total cost of item

There was no operating system available for Perseus - all system control was carried out by operating personnel seated at the control desk. There was a very powerful set of Initial Orders. This was a permanent set of routines stored in the first 256 blocks of the tape on Tape Mechanism 0. The Initial Orders were entered by operating the "Start" switch on the control desk.

The main purpose of the Initial Orders was to read program s punched on paper tape into the computer having assembled the orders into the internal format of the machine. Many facilities are also available to monitor the operation of a program, to store the assembled program on magnetic tape, to set the date and serial number for program runs and similar operations. Messages to the operator are output on the control desk teleprinter, and input to the Initial Orders is from the tape readers and the control desk handswitches.

Very comprhensive checking facilities were provided in Perseus. All words in the computing store had a parity check digit. All arithmetic operations were checked. Punched cards were automatically read twice and compared before the buffer was released for reading. The paper tape code is self checking. Each magnetic tpae block had a checksum character, and each character in the block had a parity bit. After writing, the block was read back and compared with the buffer. In the case of a magnetic tape error, the operation was automatically repeated several times. If the error persisted, then the computer stopped for manual intervention.

The Ferranti Sirius Computer

Sirius was a small general-purpose digital computer aimed at small-scale applications in industry, commerce, science and technical education. It was Ferranti's first non-military transistor computer, introduced in 1960. In contrast with Ferranti's earlier large-scale valve- technology systems, Sirius was small enough to be sited in conventional office space, with modest maintenance requirements.

The computer was housed in a shallow floor-standing cabinet ranged at the rear of a conventional office desk. The cabinet was 4' 9" high, 6' 9" wide and 10" deep. (145cm x 206cm x 25cm). The cabinet contains the computer circuits and power supplies and bears a decimal digit display panel and time-of-day clock. (A Ferranti electric clock was on the front of all Ferranti computers up to this time). The desk carries two paper tape readers and a paper tape punch, and a moveable control panel.

The technology used was based on the Neuron circuit developed by Scarrott, Johnson and Naylor in about 1955. At the time, transistors were expensive, typically imported from USA, and scarce. The neuron circuit was intended to minimise the use of transistors by providing powerful "ballot box" logic using a multiple-winding transformer followed by timing and amplitude standardisation. The circuits had been proven in a small test-bed computer called NEWT. Although the technology was very reliable in these small systems, it proved to be unsatisfactory in the later very large and complex Orion computer, where it gained a bad reputation.

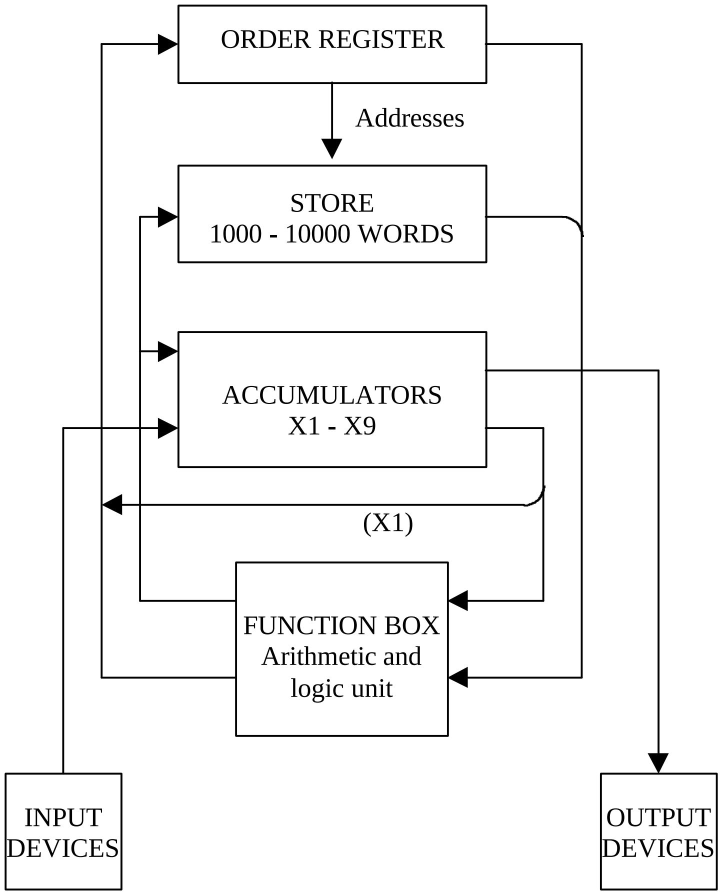
Fig. X2-10 A basic Sirius

Sirius was a serial machine, and used long nickel torsional acoustic delay lines for the main storage. Unlike most other Ferranti computers it was based on binary-coded-decimal (BCD) internal working. The computer operated with strings of ten decimal digits, represented by a 40-bit binary word. The clock frequency of the logic was 500KHz, so one word time was 80 microseconds. The Instruction code was similar to that Pegasus, with multiple accumulators and modified single address instructions.

A basic Sirius had 1000 words of storage comprisng 20 delay lines wach holding 50 words. Standard routines for program and data input, monitoring and output were available, which could be loaded into the first 200 words of storage by a built-in bootstrap process. Optional extension cabinets, each holding 3000 words, could be added to the basic machine to provide a total 10,000 words of storage.

Two input and two output channels were standard. Optional 5-way switch boxes could be added to each channel so that up to ten input and ten output peripherals could be selected under program control. A basic machine was equipped with two Ferranti paper tape readers and one paper tape punch. Customers could also purchase character-by-character magnetic tape drives, graph plotters and punched card equipment. The scale of the machine was also suitable for interfacing to process control equipment, and at least one steel works used one for rolling mill control.

Fig X2-10 Sirius Data Paths (simplified)



The current program address (Order Number) is held in accumulator X1. For simple instructions, execution takes place as follows:

1. X1 to Order Register (OR). Order register addresses store. ON to Function Box (FB) for "1" to be added.

2. Machine waits for appropriate word (of 50 in a delay line) to arrive.
3. Instruction read from store into OR. Modifier address decoded and specified accumulator sent to FB. Operand address of instruction also sent to FB for modification.
4. Modified operand address sent to OR.
5. Machine waits for appropriate word (of 50 in a delay line) to arrive.
6. Operand from store sent to FB. Specified accumulator sent to FB.
7. Answer from FB sent to accumulator.

In normal running, the next instruction can start after step 5 above, i.e there is some instruction overlap. Assuming steps 2 and 5 happen to be zero, most instructions take 3 word times, i.e 240 microseconds. The addressing sequence in the delay lines is arranged to step up in threes, so that often zero wait times were achieved.

The Instruction Code contained 55 different instructions including decimal shifts, multiplication and division.

Hardware checking included a parity bit associated with each word in the Store, and checks that individual decimal digits did not go out of range. The paper tape code used was self-checking.