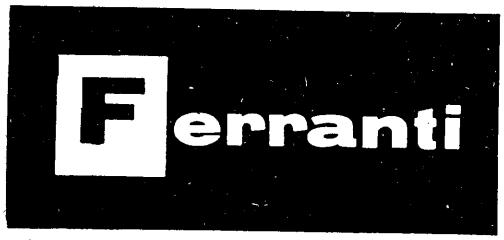

THE ATLAS COMPUTER

FERRANTI ELECTRIC, INC.
ELECTRONICS DIVISION
PLAINVIEW, L.I., N.Y.

W159

BRIEF SPECIFICATION

General Characteristics:

Mode of Operation	:	Binary, parallel, asynchronous.
Word Length	:	48 binary digits (= 8 characters of 6 bits each)
Data Representation	:	fixed point, floating point (octal exponent), 6 bit characters.
Accumulators	:	1 double length.
Index Registers	:	128
Instructions/Word	:	1
Instruction Format	:	

Function	Index	Index	Address (by characters)
10	7	7	24

Storage:

Core Store:	Capacity (basic)	:	16,384 words
	(maximum)	:	see below
	Access time	:	0.75 microseconds
Drum Store:	Speed	:	5,000 r.p.m.
	Size	:	24,576 words/drum
	Capacity (basic)	:	4 drums = 98, 304 words
	(maximum)	:	see below
	Average access time	:	6 msec.*
	Transfer time (512 words)	:	2 msec.*

* Computation and accesses to each drum can all proceed simultaneously.

The maximum capacity is 1,048,576 words divided between cores and drums as required.

Fixed Store:	Capacity (basic)	:	8,192 words
	(maximum)	:	262,144 words
	Access time	:	0.2 microseconds

Operational Speed

Addition, fixed or floating point	:	1.1 microsecond average
Multiplication, fixed or floating point	:	3.5 microsecond average

These figures include access to the operand from the core store. Average times have to be quoted because operations are overlapped for greater speed.

Magnetic Tape:

Characteristics: 1" Ampex FR 300 A Tape.
Speed : 90,000 6 bit characters/second.
Capacity : About 2,875,000 words to a 3,600 ft reel of tape.
Maximum number of mechanisims: 32

Up to 8 tape transfers can be executed in parallel simultaneously with computing and drum transfers.

Time Sharing:

Interruption of the normal sequence of operation, caused either by peripheral equipment or by program,allows time sharing of all input and output operations and between several independent programs.

Peripheral Equipment:

Cards:	Input :	600 cards/minute
	Output :	100 cards/minute
Paper Tape: (5 or 7 hole)	Input :	300 and 1000 characters/second.
	Output :	60 and 300 characters/second.
Printers:		600 and 3000 lines/minute.

Other peripheral devices which can be attached include:

IBM Magnetic Tape (729 MK IV).
Flexowriters
Large Random Access Stores
Graphical Plotters
Data Links
Real Time Clocks
Etc.

Some Points of Interest:

1. The Fixed Store:

In addition to the main immediate access store of ferrite cores, ATLAS has also several thousand words of an entirely novel type of storage, to which access is extremely fast (.2 microseconds). The store consists of a wire mesh with small ferrite plugs inserted in the spaces, the contents of the store being determined by the presence or absence of a plug in each space. The store is fixed to the extent that it cannot be changed by program; to change it requires the physical insertion or removal of the plugs. It is envisaged that the store will be considered as part of the hardware of the machine, and not changed to any great extent after installation.

The existence of this type of storage has had two fundamental effects on the design of ATLAS:

(i) .the more complicated functions required of the arithmetic unit will be performed by "subroutines" in the fixed store, though to the user they appear as individual functions of the order code. This means that is has been possible to keep the basic circuitry in the arithmetic unit simple, making it extremely fast, and yet to provide the computer with an unprecedented range of functions. For example, a large range of division functions, analytical functions such as logarithm, exponential, sine and cosine, complex functions, double length floating point operations, vector operations, mixed radix conversion, and polynomial evaluation, all appear as single functions in the order code.

(ii) Important organisational work can be performed by routines kept permanently in this fast store instead of by complicated and expensive circuitry. For instance, most peripheral equipments communicate with the central computer by means of fixed store programs, and as a result a wide variety of input and output mechanisms can be attached and used efficiently; further, the problems of attaching new peripheral equipment are considerably simplified.

2. Overlapping Operations:

ATLAS is fully asynchronous, and as much overlapping of operations as possible is done. The core store is divided into "stacks" of 4096 words, each with independent access to the computing unit; these stacks are interleaved in pairs so that access to consecutive words of the store is not limited to the core cycle time. Instructions are drawn from the

Overlapping operations (continued)

store in pairs, and the arithmetic unit is so arranged that while one operation is in progress, subsequent operations involving other parts of the computing unit can be proceeding at the same time. For example, while a full length multiplication operation is going on in the accumulator, three or four indexing instructions can be completed. Access to the store and to the various parts of the arithmetic unit are of course arranged so that an instruction dependent on the result of a previous operation will wait for the operation to be completed, (though the computer may go on to execute further instructions as well).

3. Indexing and Modification:

ATLAS has 128 index registers, numbered 0 through 127, of which 0 through 90 are available to the programmer for use in the normal way. The remaining index registers have various special functions: for example, index register 127 is the main control register, and an unconditional jump is done by setting a number in this register. (Index register zero does not strictly exist, it is a dummy which always contains zero).

In an ATLAS instruction fourteen bits are allotted for the specifying of two index registers. In the case of accumulator instructions, the contents of both index registers are added to the address written in the instruction, giving double modification. In the case of indexing instructions, one index register contains the operand and the other is used as a modifier, providing (single) modification of indexing instructions.

The large number of index registers, and the double modification of accumulator operations, are a great help in writing programs for ATLAS. In particular, compilers can take advantage of these features to produce very efficient programs.

4. Autonomous drum and magnetic tape transfers:

Transfers of information to and from drums and magnetic tape units are direct to the core store, in units of 512 words, and once a transfer has been initiated it proceeds autonomously, leaving the computer free for other operations. Each drum is independently connected, and the magnetic tape decks are connected through eight channels, up to four decks per channel, so that eight tape transfers (each of which can be a read or a write) can take place in parallel.

5. Time-sharing and parallel programming:

ATLAS possesses one of the most sophisticated time-sharing systems in existence today. All peripheral equipments are fully time-shared, and several programmes can run independently in the computer at the same time. Such fully integrated time-sharing between programmes makes it possible to make the maximum use of both the central computer and the peripheral devices. While one program has its operation held up because it is waiting for the operation of a peripheral device, work can be continuing on another program in the machine at the same time; also operations which would otherwise have to be performed off-line, on additional equipment, can be done through the central computer even though the computer is doing other work at the time.

The fixed store routines handling the peripherals operate on a time-sharing basis, taking the brief action necessary as and when required by the peripherals and returning control to a main program. This, and the parallel operation of main programs, is handled by an overall fixed store routine known as the Supervisor Program. The fact that this can be done efficiently by program makes it possible for the Supervisor to keep a record of the usage of the whole installation, and continually adjust the priorities of the various tasks to make the most efficient use of all the equipment, including the central computer. As the requirements will be frequently altering as peripherals come in and out of operation and programs finish and new programs start, this continual re-assessment of priorities would be a prohibitive task for a human operator.

Full lock-outs are built in to the hardware and the Supervisor Program to make it absolutely impossible for one program to refer unintentionally to a part of the machine or a peripheral device allotted to another program. In this way it is made possible for programs to be written without any consideration of what other work may be put on the computer at the same time , and development of partially tested programs can be safely done on the machine while important standard programs are running because there is full protection against a mistake in the untested program interfering with the operation of the others.

6. The one-level store concept:

The main store of ATLAS embodies a revolutionary system which enables the user to take full advantage of the whole main store, part cores and part drums, as though it was immediate access throughout. The facilities of a one level store are obtained though a major part of it may consist physically of drum storage. Information is grouped into units of 512 words, known as blocks, and it is these which are addressed by the programs in the machine.

The one-level store concept (continued)

The block addresses do not necessarily correspond to the physical positions of the blocks within the store, but the locating of a block in the core store is done by a parallel comparison which is extremely fast; the time for this is included in the quoted times of instructions.

If a block is on the drum when it is required, a drum transfer is executed under the control of the Supervisor. The Supervisor decides which block at present in the core store should go to the drum to make way for the new block; it does this by means of a learning program which keeps account of the references to the blocks in the core store and determines which is least in use at the time.

With this concept the full advantages of sharing between programs can be realised. Each program can be written independently, and the amount of immediate access storage in use by each program at any instant is arranged by the Supervisor to give the maximum efficiency of use of the computer. Without the "one-level" store arrangement each program would have to be allotted its own fixed part of the core store. This would create a considerable problem of scheduling programs to share the machine, together with the difficulty of allotting to a program enough core store to make it efficient but not so much as to give it an undue share of the central computer. With ATLAS these problems disappear, and the use of the store at any instant is determined by the whole configuration of the current demand on it, and not by the requirements of each program considered as a separate entity.

Drum transfers can also be executed under program control.

7. The Monitor Program:

A part of the Supervisor routine is devoted to the reporting of errors in programs or data. When an error is detected, this part of the Supervisor is entered, and information about the cause of the error is printed out so that the fault can be pinpointed. In this way the machine itself can give considerable help in the checking out of programs; a valuable side effect is that all this information is in a written and therefore permanent form. Examples of faults causing entry to the Monitor section of the Supervisor are a meaningless code, a program grossly overrunning its estimated time, a program referring to a block of information or a peripheral device not allotted to it, and some data being in the wrong format. During the monitoring of one program, the other programs of course proceed undisturbed.

8. The Compiler of Compilers:

With ATLAS comes a new approach to symbolic programming. Doctor R. A. Brooker, of Manchester University, has devised a scheme going a level deeper than existing programming languages, a scheme in which any programming language can itself be defined. In effect, this scheme enables one to "teach" ATLAS any language one chooses, after which the computer can accept programs written in that language; it is a compiler of compilers. This greatly facilitates and speeds up the writing of compilers for ATLAS to accept programs written in other languages, including even the machine languages of other computers. As an example of this, the FORTRAN compiler for ATLAS took one man eight days to write, using Dr. Brooker's scheme. The compiler for FORTRAN, and several other compilers, will be supplied with the computer. The scheme has also the big advantage that a compiler can be readily brought up to date as its language grows and develops.

9. Internal checking:

Every word in the core and drum stores carries an additional binary digit which is used as a parity check on the word. The parity is checked every time the word is referred to, and a failure causes entry to the monitor routine.

Each block on magnetic tape carries a check sum written at the end of the block. Information is recorded on the tape in stripes of 12 binary digits, and there are 2048 in a block. The check sum is two stripes, 24 digits, and consists of the sum of the 2048 12-bit stripes of information. On writing a block of information from the core store to magnetic tape, this checksum is formed and written at the end of the block. While writing on to magnetic tape, a reading head immediately behind the writing head reads back the written information, and a second check-sum formed, which must agree with the check sum formed as the information comes from the cores. Lastly, the check sum written on the tape is also read back and must agree with the other two. If there is any disagreement the tape is moved back to the beginning of the block and the whole writing procedure is repeated. Three successive failures to write correctly cause an entry to the Monitor routine. On reading, the check sum is reformed as the information comes off the tape and checked against the one read from the tape. As on writing, a check failure causes a repeat of the operation and three successive failures cause an entry to the Monitor.