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ABSTRACT

The Mini-Computer is compared with the general purpose computer. On a performance basis the Mini-Computer shows several interesting comparisons with the System 360 computer. The Mini-Computer core cycle, instruction execution speeds, and disc operating speeds are quite similar to the much larger 360-30 and 40 while its magnetic tape speeds are somewhat slower. The most serious comparison discrepancy is the much reduced quantity of magnetic core in the Mini-Computer System. In a cost comparison, the Mini-Computer Processor is notably lower in hardware cost. Comparisons of computer costs and performance capability show that the Mini-Computer System performs every basic computer operation at a substantially lower cost. What is needed is a recognition of real application potential by users and producers and a core efficient software system such as the "Pyramid Interpreter System" in which a compiler is used to generate a "macro" code rather than a machine code. Summarizing the results, not only can a Mini-Computer System perform comparably with present-day business computers, but it can do it at only 10% to 25% of the cost. A tabular comparison is shown which accounts for the core enhancing and speed reducing affects of the Pyramid Interpreter System. (Author/NH)

"MINI-COMPUTER SYSTEMS - A NEW CLASS OF GENERAL PURPOSE COMPUTER"

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MINI-COMPUTER SYSTEMS--
A NEW CLASS OF GENERAL PURPOSE COMPUTER

WHEN DID IT ALL START?

In the beginning there was Man and after Man came Business. And Business begat Data. And Data embarrassed Man. So he invented Processing to embarrass Data. And so Data Processing grew to inhabit the Earth.

Millenia later, as ancient legend foretold, a Computer appeared and in his brilliance convinced everyone that he, once the son of Data Processing, was really the father. And the Computer waxed strong, always growing, always expanding, becoming ever more fatherly.

Then, one day, a very tiny Computer appeared that didn't grow, that didn't speak COBOL, that could only on special occasion lisp pidgeon FORTRAN. Laughingly it became known as "Mini" (perhaps because the name "Dumbo" was already taken). Could Mini really be a computer, this retarded midget violating sacred law? But if not, what was he? What could Mini possibly be good for?

WHAT IS A MINI-COMPUTER?

Can a computer by any other name be something else? Is Mini-Computer really different than big brother G.P. Computer? A wise man once mused, "If it blows your program, it must be a computer."

My experience indicates that a Mini-Computer is just like any other computer; it blinks lights, drops parity, prints garbage, and says illegal operation every chance it can. But somehow it is being proposed as something different, not really useful for the same things. For example, it is marketed mainly as a programmable component so that you can build your own--, whatever it is. Today you can buy or rent a G.P. Computer that is guaranteed to already know how to do something--presumably Data Processing; a full-fledged system complete with instructions on how to lose data and insult customers. If you want a mini-computer, you get a rack chassis, a list of several dozen machine code instructions, an erroneous wire list, and a warm handshake.

In other words, the mini-computer is really a component, a tool for someone else's special purpose project, while a G.P. Computer is a System designed for Data Processing. But suppose someone short on sense but long on faith added all the things needed to make a mini-computer a system, would Dumbo the flop-eared computer fly?

WHAT DOES A GOOD COMPUTER DO?

Good computers solve problems, bad computers don't. Better computers are good computers that solve problems for less money. But, alas, sometimes the brilliant gleam of a new computer spoils this thought.

What does a computer do when it's doing what it's doing? While we think it is computing, in reality, down inside, it is playing solitaire; a game of "hot potato," happily moving data back-and-forth between its various memory media: core to register, register to register, disc to core, tape to register, card to core, etc., etc., sometimes clevely crossing wires so that by Boolean magic data is transformed on the fly into answers.

Whatever problem a computer is assigned to perform, the task can be summarized by the number of individual memory data transfers performed. For every problem certain of these transfer operations predominate to pace the execution speed of the problem. Because execution time relates to dollars, that's where your money goes.

If your problems are scientific, you add an ounce of data from an I/O device to a ton of core-register data transfers, seemingly without end. If your problems are business oriented you enter a record from an I/O device, perform a thimble-full of arithmetic (like add one or two fields, multiply another, compare a third) and then transfer the record out to another I/O device--over and over again. In the scientific problem, execution time is inevitably controlled by core access; for business problems the I/O data access dominates.

Historically, the scientific problem gave the initial boost to computer design. The end result was the General Purpose Scientific Computer. However, a strange malady has befallen the G.P. Scientific Computer where the word "Scientific" has become so misspelled that is has become the word "Business." Unfortunately, this malady has affected only the word and has not reached deeper causing any real adjustment to the pacing I/O limitation of business computation.

Of course, everyone knows this. We have all talked about it along with the weather for years. But have we ever included the Mini-Computer in the conversation?

HOW WELL DOES A COMPUTER DO WHAT IT DOES?

Because it is everywhere, the System 360 computer series is probably the truest present-day standard of computer performance. For comparison, a suitable representative of a full Mini-Computer System is more difficult to select; however, drawing from personal experience, the DATAPLEX™ 383 Processor, made by Data Instruments Company, seems a reasonable choice.

Everyone is familiar with System 360 computers so no effort need be made to describe them; however, the DATAPLEX 383 Processor is not so familiar. Therefore, we will take a short time out to describe the 383 Processor.

In reality, the 383 Processor is one of a series of Processors; Figure 1 illustrates the general DATAPLEX Processor System. As Figure 1 indicates, a Mini-Computer is the Central Processing Unit surrounded by I/O satellites. As standard, the

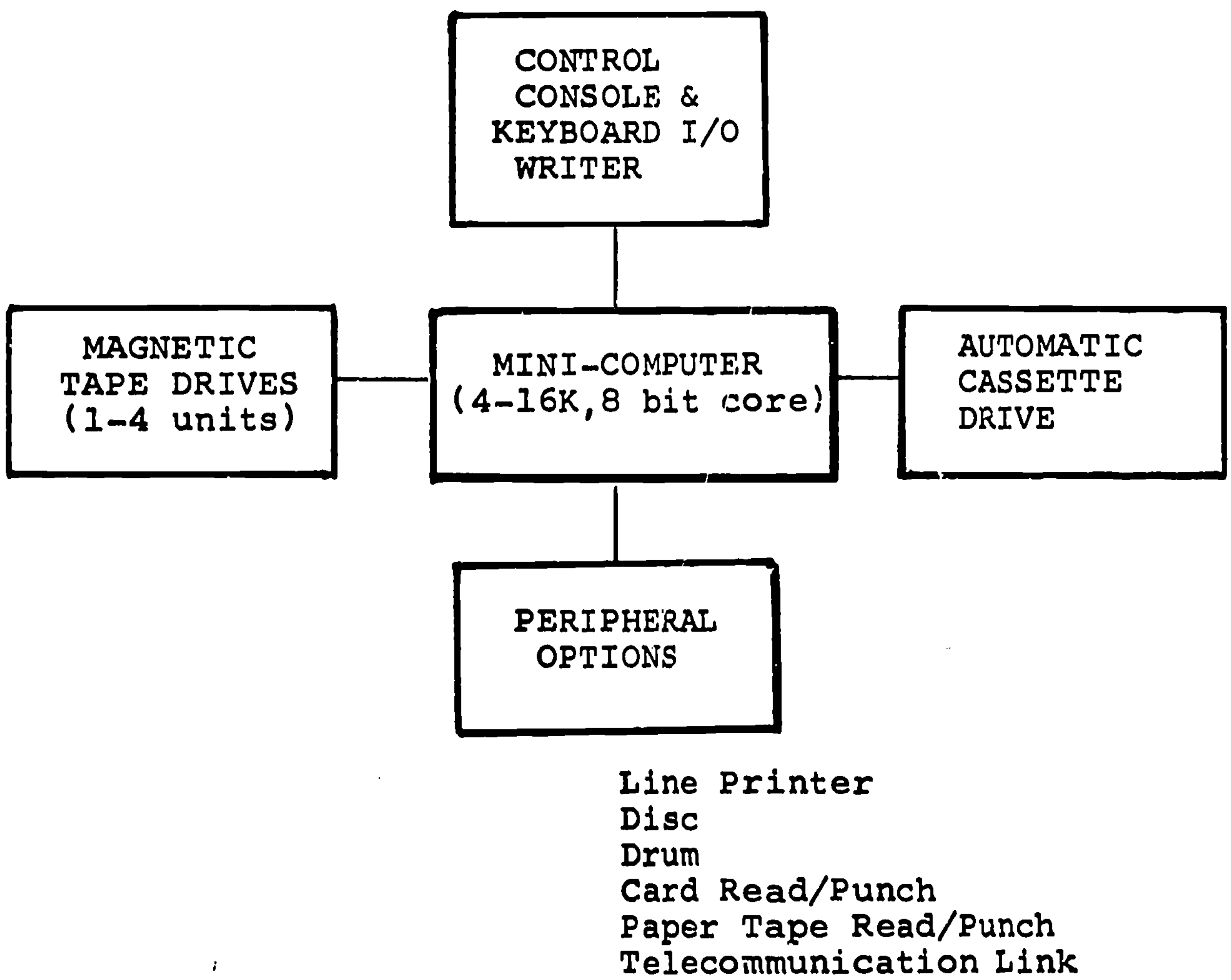

FIGURE 1 - <u>DATAPLEX™ PROCESSOR SYSTEM</u>

Processor functions with one or more magnetic tape drives, an automatic cassette drive, a control console, and a keyboard I/O writer. A full complement of peripheral options allow customized tailoring to individual applications. The 383 Processor, which is the direct subject of our interest, has three tape drives, a 2311 compatible magnetic disc, a line printer, a card reader, and a telecommunication link.

On a performance basis the Mini-Computer System shows several interesting comparisons with the System 360 computers. Figure 2 tabularly lists several of these. Referring to Figure 2, the Mini-Computer core cycle, instruction execution speeds, and disc operating speeds are quite similar to the much larger 360-30 and 40 while its magnetic tape speeds are somewhat slower. The most serious comparison discrepancy is the much reduced quantity of magnetic core in the Mini-Computer System. However, it is not in the speeds of operation or the lack of core that the real story lies. It is in equipment cost.

Equipment and operating costs are listed in Figure 3. The cost comparison is notably different than the performance comparison. The Mini-Computer Processor is notably lower in hardware cost.

Combining computer costs and performance capability leads to the comparisons in Figure 4. The results are remarkable since in all cases the Mini-Computer System performs every basic computer operation at a substantially lower cost. This implies that the Mini-Computer System is better.

If all this is really true, why isn't everybody using Mini-Computer Systems? Well, someday maybe they will! But it is not that easy, first several important things need to be accomplished.

WHAT DO MINI-COMPUTERS NEED?

Not much--depending on who you ask. Mostly what is needed is a recognition of real application potential by users

OPERATION \ COMPUTER	360-30	360-40	360-50	360-65	360-75	Mini-Computer System
Core Memory Cycle (usec)	1.5	2.5	2.0	0.75	0.75	2.5
Core Capacity (K words)	65	256	512	756	1048	16
Typical Instruction Execution-ADD (usec)	30	12	4	1.3	0.80	10
Disc Random Positioning Time (msec)	75	75	75	75	75	75
Disc Half-Latency Time (msec)	13	13	13	13	13	13
Total Disc Access (msec)	88	88	88	88	88	88
Magnetic Tape Speed (ips)	150	150	150	150	150	37.5
Magnetic Tape Density (ch/in)	800	800	800	800	800	800
Magnetic Tape Peak Data Rate (Kch/sec)	120	120	120	120	120	30
Magnetic Tape Start/ Stop Time (msec)	3	3	3	3	3	10
Magnetic Tape Record Rate (msec)	5	5	5	5	5	20
Total Tape Record Access (msec)	11	11	11	11	11	40
Card Read Speed (cards/min)	1000	1000	1000	1000	1000	300

FIGURE 2 - COMPUTER PERFORMANCE FACTORS

COMPUTER / COSTS		360-30	360-40	360-50	360-65	360-75	Mini-Computer System
Computer plus Peripherals	(K$/mo)	10.0	19.5	33.0	65.0	85.0	2.35
Operating Costs	(K$/mo)	5.0	9.8	16.5	32.5	42.5	0.6*
Total Computer Costs	(K$/mo)	15.0	29.3	49.5	97.5	127.5	2.95
	(¢/sec)	2.4	4.6	7.8	15.4	20.1	0.46

* Lowered operating costs are caused by dedicated computer operation to single application tasks permitting more automatic operation.

FIGURE 3 - COMPUTER OPERATING COSTS

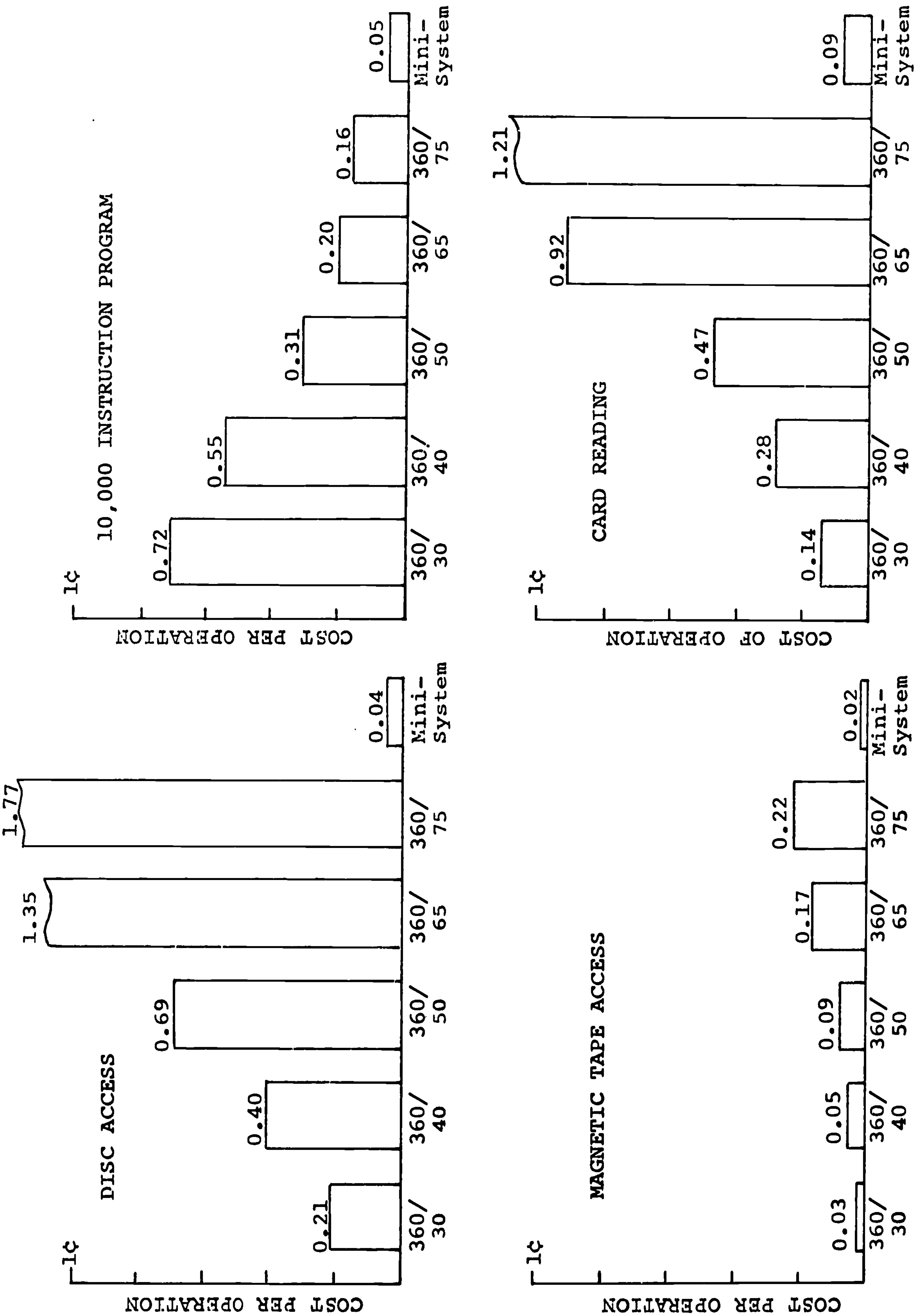

FIGURE 4 - <u>FUNCTION COST COMPARISON</u>

as well as producers. If you want a system which is more than a warm handshake, then you need a working hardware implementation (including essential peripherals) and a software architecture that makes a little magnetic core look like a lot. If you look real hard you may find a few reasonable hardware implementations, but what you will find difficult to locate is a core enhancing software system.

This lack of core efficient software systems exists because of an industry preoccupation with execution speed, or equivalently, with compiler concepts that produce machine coded object programs. Everyone knows what a compiler is; it's a neat technique that uses the computer to program itself. The result is a two step programming and execution sequence that provides machine object code whose qualifications are ranked by its speed of execution. A sort of "Damn the Core, Full Speed Ahead" concept.

But there are other methods, one in particular which the author lovingly calls the "Pyramid Interpreter System." This concept is an advanced system of some sophistication which integrates the concepts of compiler, interpreter, and language into one entity. However, for our present purposes let us consider it as a new compiler concept where the object code is not machine code, but another code whose qualifications are ranked by its degree of core conservation. In this case, a compiler is used to generate a "macro" code rather than a machine code. The result is a stored program that the machine cannot directly execute but requires an interpreter system (implemented as either hardware, software, or firmware) to translate it into executable machine code.

How do programs in machine code versus macro code compare? For a real life comparison, consider the FORMOL™ III system (FORMat Oriented Language) used in the DATAPLEX Processor. This system performs as follows:

1. Contains 25 basic macro operations which are sufficient to program all known data processing operations. It is a variable length, string processing language oriented to character, field, record, and file manipulation.

2. Averages approximately 5.5 bytes (8 bits each) of core memory for each macro operation.
3. Operates with a core-stored software interpreter of 4000 bytes (8 bits).
4. Has an execution overhead for interpretation averaging 50% for all macro operations.

These performance numbers validate the following conclusions:

1. Each macro operation is equivalent to an average of 160 bytes of machine coded programming (including buffering and parameter storage).
2. One byte of memory in macro code is equivalent to about 30 bytes of machine code.
3. A 16,000 byte mini-computer, with 12,000 bytes available for macro code memory, can store 2180 macro operations in core. This is equivalent to 350,000 bytes of machine coded programming.
4. A macro coded program runs at about half the speed of the best equivalent machine coded program.

As a result, a 30:1 improvement in effective memory capacity is gained at a cost of a 2:1 decrease in execution speed.

Looking further, the 2:1 decrease in execution speed really only bears directly on internal processing speed which is typically a small part of business Data Processing. The main Data Processing effort (80 to 90%) is input/output in nature, that is, disc, tape, card access, etc. Therefore, for data processing a 2:1 speed change in internal processing speed bears only on 10 to 20% of total operation. The consequence is a net execution speed decrease of only 10 to 20% for 30 to 1 gain in core effectiveness.

Summarizing the results, not only can a Mini-Computer System perform comparably with present-day business computers, but it can do it at only 10% to 25% of the cost. To see this clearly, a tabular comparison is developed in Figure 5 which accounts for the core enhancing and speed reducing affects of the Pyramid Interpreter System.

HOW IMPORTANT IS THE RESULT?

Very important! The Mini-Computer System changes the

COMPUTER / FUNCTION	360/30	360/40	Mini-System
Effective Core Capacity	65K	256K	350K
Effective Machine Code Execution Time	30usec	12usec	20usec
Disc Capacity	7.5Mbyte	7.5Mbyte	7.5Mbyte
Disc Access Time	88msec	88msec	88msec
Tape Data Rate	120KC	120KC	30KC
Tape Access Time	11msec	11msec	40msec
Card Read Speed	1000c/s	1000c/s	300c/s
System Monthly Rental	$10K	$20K	$2.3K

FIGURE 5 - COMPUTER COMPARISON

entire application potential of computers to Business Data Processing. For example, consider the following ramifications:

- The Mini-Computer System rebalances I/O-to-Computing power to more properly match Business Data Processing. It eliminates the need for the business use of relabeled scientific computers and their attendant waste of unusable central processing capacity. On a cost and performance basis, Mini-Computer Systems have the inherent nature to be ideal Data Processing Computers.
- The substantially lowered cost of Mini-Computer Systems makes it possible to commit computers to single dedicated applications rather than requiring several different applications to cost justify the system. A dedicated computing system for $50,000 to $100,000 total value can be economically effective for such diverse applications as Stock Certificate Transfer, Text Preparation, File Maintenance, Data Base Development, Portfolio Management, Order Input, Inventory Control, Payroll Preparation, and Forms Processing for Financial Institutions, Universities, Insurance Companies, Libraries, Publishers, Manufacturers, Governments, Wholesalers, and Service Companies.
- The Mini-Computer System fills a performance/cost gap in the need for distributed computer systems that provide local processing capabilities prior to eventual centralized Data Processing. Particular needs exist in Source Data Acquisition, Branch Business Operations, and red flag transaction handling.
- Computing System costs reduced to 10 to 25% of present-day systems extend the usability of computer systems downward to lower gross volume business activities. Small Business operations and departmental Large Business Operations of a few million dollar annual volume will be able to justify their own Data Processing capability.
- Mini-Computer mobility, lack of special air conditioning and housing requirements, as well as dedicated application usage make practical the direct operation of the system by user employees rather than specially trained professional computer personnel.
- The use of Pyramid Interpreter software concepts bring the effective cost of magnetic core memory down to the level of rotating drum memory.

WHERE WILL IT ALL END?

Mini, Midi, Maxi or Veni, Vidi, Vici--no one can say what computer, old or yet born will continue to exist, let alone dominate. But one thing is certain, the Computer revolution which only affects 10% of the data base of 10% of the data generating organizations in the United States will one day massage 100% of the data. It is a personal conviction that computer support will eventually become as common and as convenient as telephones and typewriters. Tomorrow, just like today, will be a decentralized world requiring decentralized intelligence. I cannot see how the Mini-Computer with muscle can fail to be a major part of this future. I say this in spite of the intimidating report of a new Micro-Computer whose whereabouts is currently unknown while its inventor gropes for a lost contact lens.