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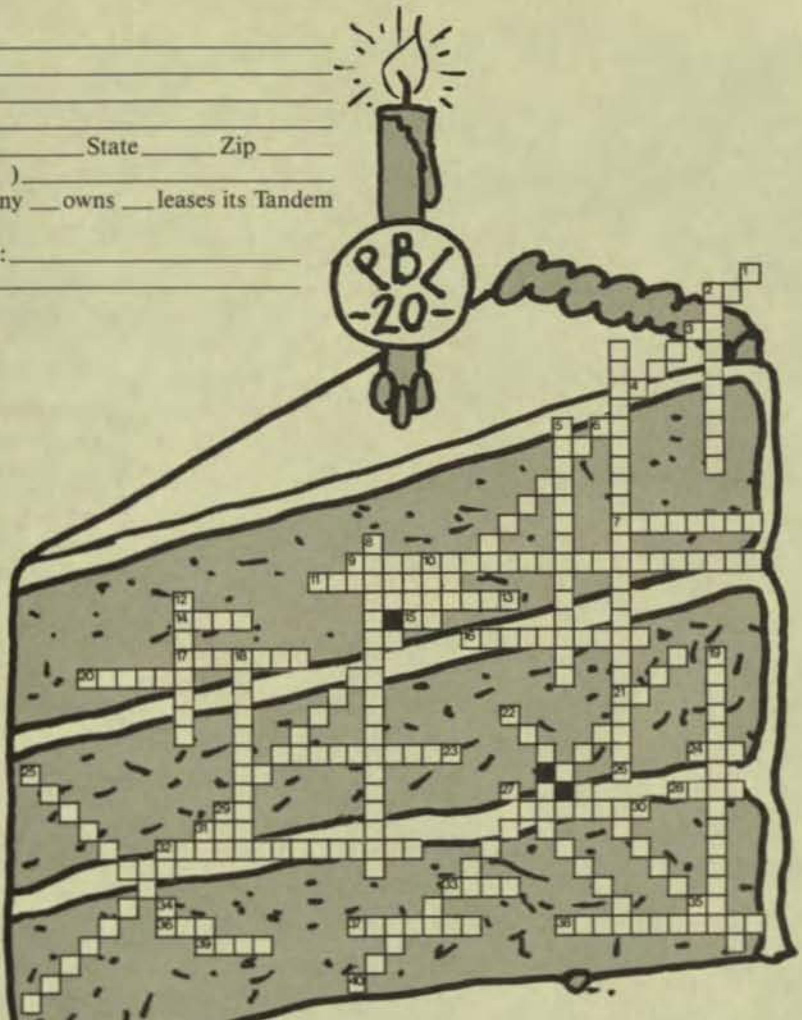
Name______________________________
Company____________________________
Address____________________________

City_________ State______ Zip______
Phone: ( )_________________________
My company __owns __leases its Tandem system(s).
Comments:_________________________



This is no piece of cake

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When you complete as many answers as you can, fill in the name and address blanks. Cut this page off, or make a photocopy. Copies will be accepted.

Then get your entry to us. You can mail it to us, or you can turn it in at the PBL exhibit booth at the ITUG conference in San Diego this October.

If you mail your entry, send it to: **Vince Emery, PBL Associates, 10 Cottage Ave., Point Richmond, CA 94801.** It must reach Vince by 5 p.m. on Wednesday, October 12, 1988.

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10 Instrument type
12 Tandem tuning specs here are not as visible as they could be
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18 Monitors and controls batch jobs
19 PBL system that manages corporate liabilities
26 A PBL system handles these areas of warehouse inventory
29 Our co.
31 Northwest
32 Short for hardware
34 (6 Horizontal) and its counterpart

HORIZONTAL

3 Spielberg movie
4 Artificial intelligence
6 Type of put
7 AB unabbreviated
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11 Kind of programs that can access privileged code thanks to a FUP command
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16 Rarely found device still supported by the latest GUARDIAN release
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20 File attribute that allows anyone who runs a specific program with that file attribute to assume the ID of the program's owner
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23 In Tandem's first directory of software providers, PBL was one of ____ firms.
24 The technical predecessor of the TXP and VLX is the NonStop ____
28 In C releases of GUARDIAN, (30 Horizontal)'s work files can be configured to reside on any ____
29 Physical ed
30 Replaced XRAY
32 Hardware co. where Chairman Perkins worked before TCI
33 PBL packages have been installed on Tandem systems in how many countries?
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25 Vendor relations and supply pricing are two areas of many in this activity which one PBL system manages
27 How Tandem printer ready/busy signals differ from other manufacturer's printer signals
40 This PBL system monitors a company's incoming cash

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ASSOCIATES

PBL Associates
10 Cottage Avenue
Point Richmond, CA 94801
(415) 234-4338
Telex: 172267

 Clue: 13 answers can be *found* in recent issues of *Tandem Users' Journal.*

T18

·Financial reports, industry company reports
Lexis Nexis printouts

·Newsletters

~~Ungerman~~ Ungermann - Bass Inc merger, personnel changes, new products.

T19

·magazines, book, industry report, technical reports

·fault-tolerant system

Technical reports, company reports

About: the NonStop computer systems

of

fail safe. growth outlook.

fault tolerant, competitors

Name ______________________
Company ______________________
Address ______________________
____
City __________ State ______ Zip ______
Phone: ( ) ______________________
My company ___ owns ___ leases its Tandem system(s).
Comments: ______________________
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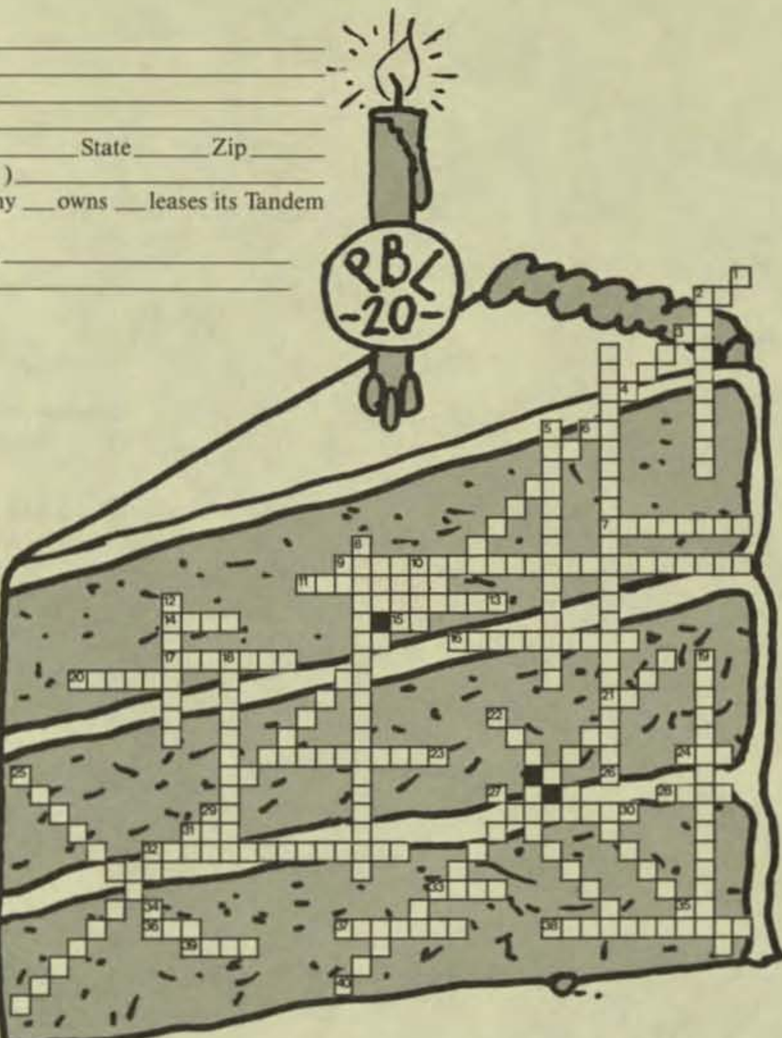

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T 18

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Lexis Nexis printouts

A d
A d · Newsletters
A 3
O 2
4 2'00
4 3
12

~~Ungerman~~ Ungermann – Bass Inc. merger; personnel changes; new products

T19

· magazines, book, industry report, technical reports

· fault-tolerant system

Fault Tolerant Control for Intelligent Manufacturing

by

Glen B. Alleman
Director, Software Development
Triconex, Inc.
Irvine, California

Abstract

Within the factory automation environment, fault tolerant control systems are playing an increasingly important role, especially in situations where a system failure could risk human life, environmental damage, loss of expensive product or costly downtime.

Fault tolerance enables a control system to continue operation in the presence of an internal failure of a portion of the underlying computer hardware. Such systems have a number of benefits in the automation of industrial processes. Improved system safety and reliability are the primary benefits, which in turn impact the user return on the capital equipment investment.

This paper examines the architecture and use of fault tolerant control systems. The evaluation criteria for fault tolerant systems is presented with the intent of providing the reader with a set of guidelines for procuring, installing and operating a fault tolerant control systems. An economic evaluation of a "typical" manufacturing control system is also presented.

Why Have Fault Tolerant Controls?

Truly fault tolerant programmable controllers are becoming an increasingly important option for industrial applications. Originally, control system engineers have traditionally specified fault tolerant systems for only the most critical applications. In the factory such applications would include: safety shutdown, remote and/or unattended processes, exothermic chemical processing, or any application where operational or product costs were extraordinarily high.

However, design engineers have found that features mandatory for critical applications are desirable in more general purpose applications. Significant improvements in system availability and maintainability can be experienced with the installation of a fault tolerant control system. The limiting factor to the installation of a fault tolerant control system was price. A control system designed around a fault tolerant architecture costs 2 to 3 times that of a single control unit.

The return on investment for the first generation fault tolerant computers did not support the installation of fault tolerant controls except in the most critical applications. A fault tolerant architecture designed to meet real time control applications was initially developed through two NASA grants; one at SRI International (the SIFT machine), and another at the Charles K. Draper Laboratories (the FTMP machine). The application of these early aerospace oriented machines to the factory automation and process control industries started in 1978 with August Systems.

The first commercial product was a fault tolerant "minicomputer" with process control capabilities. This product set the pace for the development of an industrial control computer capable of surviving single point failures while maintaining real time control. Third generation Triple Modular Redundant (TMR) products are now appearing in the market place. The price performance of these TMR products is now approaching dual redundant Programmable Logic Controller prices.

Attributes of Fault-Tolerant Computing

Fault tolerant computing can be defined as the correct execution of a specified algorithm in the presence of control system defects. The effect of defects can be overcome by the use of redundancy. This redundancy can be either temporal (repeated executions) or physical (replicated hardware and software).

An important distinction must be made between "Availability" and "Reliability" of fault tolerant systems.

The availability of a system as a function of time, A(t), is defined as the probability that the system is operational at the instant of time, t. Preventive maintenance and repair reduce the time that the system is available to the user. Availability is typically used as a figure of merit in systems in which service can be delayed or denied for short periods of time without serious consequences. [SIEW82]

The reliability of a system as a function of time, R(t), is defined as the conditional probability that the system has survived over the time interval [0,t], assuming that the system was operational at the start of the interval (t = 0). Reliability is used to describe systems in which repair cannot take place or in which the system is serving a critical function and cannot be removed from service to perform preventative maintenance or repairs. [SIEW82]

<u>Hardware Reliability</u>
The reliability of the underlying system electronics is the primary focus of the fault tolerant computer manufacturers today. Each vendor states the system reliability in terms of the hardware reliability figures. The published numbers most often consists of single parameter models that describe the mean time to repair, mean time to failure and mean time between failures.

The reliability and availability equations, even for simple systems which allow repairs, are often too complex to comprehend except (perhaps) in graphic form. Single parameter metrics have been traditionally used to describe the set of continuous time integral equations. These single parameter metrics include:

- o Mean Time To Failure (MTTF) - is the expected time of the first failure in a population of identical systems given a successful startup of the system at the beginning of the measuring period.
- o Mean Time To Repair (MTTR) - is often used to measure the repairability of a system. It is the expected time to restore a failed system to an operational state.
- o Mean Time Between Failure (MTBF) - is the mean time between failures in a system which allows repairs to take place. MTBF is defined as:

MTBF = MTTF + MTTR

Software Reliability

The assessment of software reliability is part of a general system problem of software quality assessment. [MOHA73]. Most software reliability models assume that the software failure rate will be proportional to the number of "bugs" or design errors found in the system, without taking into account that different kinds of errors may contribute differently to the total system failure rate. Software reliability models can be grouped in four categories:

- o **Time Domain Models** attempt to relate software reliability to the number of bugs present in the system at a given time during its development. [SHOO73], [MUSA75], [JELI73].

- o **Data Domain Models** are based on the concept that if sets of all input data values can be identified, an estimate of the system reliability can be obtained by running the program for a subset of input data values. [NELS73], [SCHI78].

- o **Axiomatic Models** are based on the concept that software reliability obeys certain universal laws. Although such models have generated great interest, their general validity has never been proven. [FERD74], [FITZ78].

Fault Tolerance Background

One method of increasing the availability of a control system is to provide redundant processing elements. Using a dual system ,Mean Time Between Failures (MTBF) of 5 years can be achieved. Although dual processor systems increase the MTBF, they also create a new set of problems.

When a failure occurs in the primary system, the backup or hot standby system must switch-over to assume the control of the process. This switch-over time may consume several seconds. Although short when compared to the operational life of the system, the several seconds it takes to switch could cause failures to occur in the process.

A dual redundant processor architecture offers a dramatic increase in system reliability over a single processor installation. To reach the next level of system reliability, beyond dual redundancy and therefore affect system availability, a triple redundant architecture is necessary.

The implementation of a fault tolerant architecture requires careful thought as to what is the goal of the fault tolerant system. Originally, fault tolerant architectures were developed to tolerate "physical" faults that occur because of random failure phenomena in the hardware of a system. More recently, the tolerance of "design" faults, especially in software, has been added to the objectives of fault tolerance.

A consistent and well-defined set of meanings are needed for fault tolerance [AVIZ84]:

- o A Failure occurs when the user of a system perceives that the system ceases to deliver the expected service.
- o An Error occurs when some portion of a system assumes an undesired state. Such a state is usually contrary to the specification of the system or the expectation of the user.
- o A Fault is detected when either a failure of the system occurs, or an error is observed within the system. The cause of the failure or error is said to be a fault. In most cases the fault can be identified; in some cases it remains hidden.

The difference between a failure, an error, or a fault is determined by the location of the service boundary of the affected portion of the system. The service boundary is the "interface" presented to the "user" of the system. The service boundary may be a man-machine interface or a machine-machine interface. The loss of service to the user at the boundary is perceived as a failure.

The goal of a fault tolerant computer control system is:

> **To identify, isolate, and compensate for failed control elements while continuing to maintain adequate control system response.**

Fault Tolerant Architectures

Development of fault tolerant computer systems started in the mid 1960's at the Rome Air Development Center. An early study showed that 80 percent of the electronic failures in computers were intermittent [ROTH67]. Research efforts were applied to development reliable components. The intermittent component failure still remains the primary causes of computer system failures in the 1980's [WALL84].

Accepting the existence of individual component failures (intermittent or permanent) a new approach to fault tolerant architecture was necessary to reach reliability levels above 99.999%. The early research work on fault tolerant computer systems used fault detection and reconfiguration at the component level (flip flops and adders) to acheive high reliability. Later work addressed the failure modes of processing units such as registers or blocks of memory. The computer "building blocks" of 1985 create a new set of problems for the fault tolerant architect. A Microprocessor Central Processing Unit may contain as many as 200,000 transistors embedded in a single wafer. The addition of error detection and correct circuits at the component level is no longer possible.

The current fault tolerant products limit the fault detection and reconfiguration to major system modules or busses. In addition low level error detection and correction components are also used. The combination of module reconfiguration and error correcting memories and busses in a modern fault tolerant computer system can be utilized to control critical manufacturing and process control applications.

Several examples of fault tolerant computer architectures are examined below. Although each is an example of a specialized computer system, together they form the basis for the current generation of "industrial strength" control system computers.

- **Software Implemented Fault Tolerance (SIFT)** is an ultrareliable computer for critical aircraft control applications that achieves fault tolerance by the replication of tasks among processing units. The main processing units are off-the-shelf minicomputers, with standard microcomputers serving as the interface to the I/O subsystem. Fault isolation is achieved by using a specially designed redundant bus system to interconnect the processing units. Error detection and analysis and system reconfiguration are performed by software. The SIFT architecture forms the basis for the August Systems C300. [WENS78]

- **FTMP** is a digital computer architecture which has evolved in connection with several life-critical aerospace applications. The design is based on independent processor-cache memory modules and common memory modules which communicate through redundant serial busses. [HOPK78].

- o ESS is a stored program Electronic Switching System which been under development since 1953. The ESS central processing unit is a dual redundant architecture in which correct operation is maintained by duplicating all functional units within the processor. If one unit fails, the duplicated unit is switched in, maintaining continuous operation. The individual processing elements contain error detection and correction circuits that are controlled through a maintenance processor. The system is designed to recover automatically under trouble conditions as well as providing a manual reconfiguration mode. [TOY78].

- o TRICON is a fault tolerant programmable logic controller based on a Triple Modular Redundant architecture. The Tricon consists of three independent processor modules. Each module is self-contained with a real-time clock, communication subsystem and memory on a single replaceable circuit card. Each processor is connected to the other through a voting bus. Transfers on the bus are voted and corrected so that each processor receives a majority view of the transferred data. Three independent I/O busses connect the main processors to the remote I/O processors that in turn are connected to the field sensors. The Tricon achieves its fault tolerance through hardware and software redundancy. A software "fault analyzer" directs the reconfiguration of failed modules. Error detected and correction is handled through hardware voting circuits. [TOY85]

<u>Full Coverage Fault Tolerance</u>

At its simplest level, fault tolerance means that the control system can compensate for some failed internal elements and still continue unaffected in its assigned tasks.

Full coverage fault tolerance means that the controller is unaffected by any single point hardware failures. In addition the controller will exhibit the following performance characteristics:

- o The controller will keep operating correctly, and keep the plant operating, even though a single point failure has occured.

- o The controller will detect all single point faults, correct the fault without affecting process operation, and allow replacement of the faulty module while the process continues automatic operation.

- o Switchover to manual should be an operator decision, not a control system design requirement.

- o Reliability analyses shows that a fault tolerant central processing system with fault tolerant I/O is more reliable than the single processor controller and backup manual operation panel.

- o The fault tolerant design must have sufficient redundancy and diagnostics to identify and isolate a single point fault to a replaceable module. Hidden or "latent" first faults can then be removed before a second simultaneous fault can occur and affect control.

- o The controller architecture should allow replacement of any faulty module (including I/O modules) without shutdown and without the need to take any control loops off automatic control.

- o The controller should mask transients (electrical or intermittent operation) from any effect on the process, since studies show that transients occur far more frequently than hard failures.

For at least the last two decades, most attempts at fault tolerant control relied on a dual redundant approach. One popular method uses two controllers to monitor the process, but only one has control through a common I/O set. A "watchdog" unit runs tests, ranging from simple timeouts to elaborate diagnostics, depending on the implementation, to help determine the relative health of the two controllers. The "watchdog" initiates a switchover to the backup controller if the primary controller fails a particular test.

Another popular dual redundant controller configuration is fault tolerant to the screw lugs. The controllers operate in tandem, each through its own I/O set. Enough I/O is included to allow sensors to be input to both controllers. Enough outputs are included to allow a "quad voter" connection for critical outputs, so that single output failures cannot affect operation.

Dual redundant systems may be suitable for processes where satisfactory actuator response is much slower than the controller execution cycle. Since dual redundant systems can be expected to output transients during switchover (and in fact may occasionally incorrectly switch to backup), the sluggish actuator response acts as a low pass filter, and the resultant control may be satisfactory.

Triple redundant designs can easily match the fully fault tolerant definition. A Triple Modular Redundant design uses 2-out-of-3 voting in both the I/O and the three central processors to locate and bypass all first faults from input screw lug to output screw lug. Use of triple data communication paths internally means that all first faults can be identified and bypassed by "outvoting" the faulty component with the remaining two paths. These faulty components can be identified to the module level for replacement.

__Factory Automation Applications__
Within the factory automation environment, fault tolerant applications are beginning to play an increasingly important role, especially in situations where a system failure could risk human life, environmental damage, loss of expensive product or costly downtime.

The current architecture for the automated factory is based on a "layered" control system, consisting of the following components, described from the shop floor to the MIS system:

- o Process/Point Control applications which are currently handled through Programmable Logic Controllers, single loop process control computers, and specialized sequence controllers.
- o Cell Control applications which utilize minicomputers or microcomputers to coordinate the activities of the individual process applications.
- o Shop Floor Control applications which utilize minicomputers to plan, schedule and supervise work on a "shop order" basis.
- o Factory Control applications which utilize mainframes to plan and schedule work on a company wide basis.

Within each application the requirements for fault tolerance span a wide range. Product specific requirements always drive the need for reliability and availability. Four classes of fault tolerance are appropriate for the factory floor:

- o High Availability systems share resources when the occasional loss of a single user is acceptable but a system wide outage or common database destruction is unacceptable. On the factory floor high availability systems are applied batch processing applications were the delay of starting the process is less important than the loss of control during the process.

- **Fail Safe** controls that protect production systems through a safety shutdown mechanism. Such systems cannot be maintained by removing them from service, so they are usually highly redundant with enough spares to survive a fault and still continue operation.

- **Postponed Maintenance** controls that are closely related to Fail Safe systems are designed to survive faults until periodic maintenance can be performed. Such system are capable of managing continuous processes in which the control system must survive for long periods of time.

- **Networking** applications that require "group reliability" to maintain system integrity. Networking applications are a superset of the three primary classes of fault tolerant systems.

Economic Considerations

It is for a financial reason of one sort or another that any fault tolerant system is designed and built. Calculating the costs and/or benefits of a given reliability, maintainability or availability is a complex task.

Without direct safety, corporate, or government requirements, the application of fault tolerant control system is primarily based of price and the return on investment.

Impact of Reliability and Maintainability

The purpose of a fault tolerant controller is to survive all first faults, diagnose and locate faults to the screw lugs, and permit continuous operation while replacing faulty components. The reliability/availability of such a system must be very high. The likelihood of a second fault occurring before the first fault is repaired is once in 25 to 100 years if the first faulty module is changed out within 1 to 4 hours of occurrence.

This high availability can be translated into real dollar savings to the system operator. Consider a Programmable Logic Controller with 200 inputs and 100 outputs. A cost spread sheet for a straightforward control project might appear as shown in the following table.

Control Project for a Hypothetical 300 I/O Controller

Expense Item	Single Processor Controller	Dual Processor Controller	Triple Processor Controller
Controller	$20,000	$30,000	$50,000
Panel	$18,000	$18,000	$18,000
Manual Backup	$ 8,500	$ 8,500	$ -0-
Logic	$ 9,000	$ 9,000	$ 9,000
Installation	$ 6,000	$ 6,000	$ 6,000
Training	$ 4,000	$ 4,000	$ 4,000
Documentation	$ 9,000	$ 9,000	$ 9,000
Total Cost	$74,500	$84,500	$96,000
% of Single Processor Sys	100%	113%	129%

Downtime Analysis

A simplified failure analysis shows the advantages of full coverage fault tolerant systems. Assume any single point failure causes a 2 hour shutdown for repair (MTTR = 2 hr.).

Further assume an I/O point failure rate of 1/million hrs and a processor rate of 30/million hrs including power supplies.

Expense Item	Single Processor Controller	Dual Processor Controller	Triple Processor Controller
I/O failures	300X1=300	300X1=300	300 X .002 =0.6
Processor failures	30	.03	.08
Hard failures/yr	3	2.5	.01
Transient trips per yr @ 10X Hard failures	30	25	.10
Downtime			
Hard failures @ 2 hr	6 hr	5 hr	.02 hr
Transients @ 1/4 hr	7 hr	6 hr	.03 hr
Lost Product @ $1,000/ hr	$13,000	$11,000	$ 50
Payback, Yrs over single		(85-75)/(13-11) = 5 yr	(96-75)/13 = 1.6 yr

Benefits of Fault Tolerant Controllers

Fully fault tolerant controllers yield benefits far beyond their potential payback. Emergency maintenance is essentially eliminated, since the first fault in the controller cannot affect control action. Only preventive maintenance is required to remove these first faults. Often it is acceptable to put off the required replacement until day shift. In applications using several fault tolerant machines, maintenance can be scheduled for more efficient use of maintenance manpower.

Added intelligence to the fault tolerant controller means that extensive diagnostic messages and indicators can guide the maintenance staff in the replacement process. Much less training is required to maintain the equipment. Since production is not affected, pressure is off, and maintenance crews are not rushed; fewer mistakes will be made.

When the process is disturbed, the maintenance crew knows the problem is almost certainly in the field equipment (after all, the controller would have requested help for itself long before the process could be affected).

Affordable Insurance
Until recently, the cost of triple redundant voting fault tolerant controllers restricted their use to critical applications, and kept more general control applications from sharing the reliability and maintenance benefits. Now, state-of-the-art technology has reduced costs sufficiently to broaden the range of practical applications. When fully utilized, triple redundant designs may eliminate costly back-up panels to further reduce costs and ongoing maintenance overhead.

Triple redundant controllers are competitive with good dual redundant architectures, primarily because of simpler implementation requirements, reduced need for backup panels, and a ground-up design that is optimized for fault tolerance. Inherent tolerance of first faults and insensitivity to transient upsets makes these systems a natural choice whenever safety, equipment protection, or maximum up time are design requirements.

Ease of maintenance is a significant side benefit. As control systems become more reliable, maintenance crews will have difficulty getting sufficient repair experience. The extensive self diagnosis of triple systems will help the crews sort maintenance problems more rapidly to reduce down time, without need for extensive periodic retraining.

Conclusion
Control system reliability can be improved and maintenance demands can be reduced by including controllers with full coverage fault tolerance in the design. While dual redundant controllers offer some fault tolerant coverage, the newer triple redundant 2-out-of-3 systems are less costly, offer better potential payback, and more complete maintenance diagnostics.

Since Triple Modular Redundant architecure can tolerate first faults without affecting the process, they are well suited in safety interlock systems, particularly for eliminating nuisance trips and subsequent lost production and equipment stress.

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WHO'LL BE BEST FOR BUSINESS? : 57

INDUSTRYWEEK

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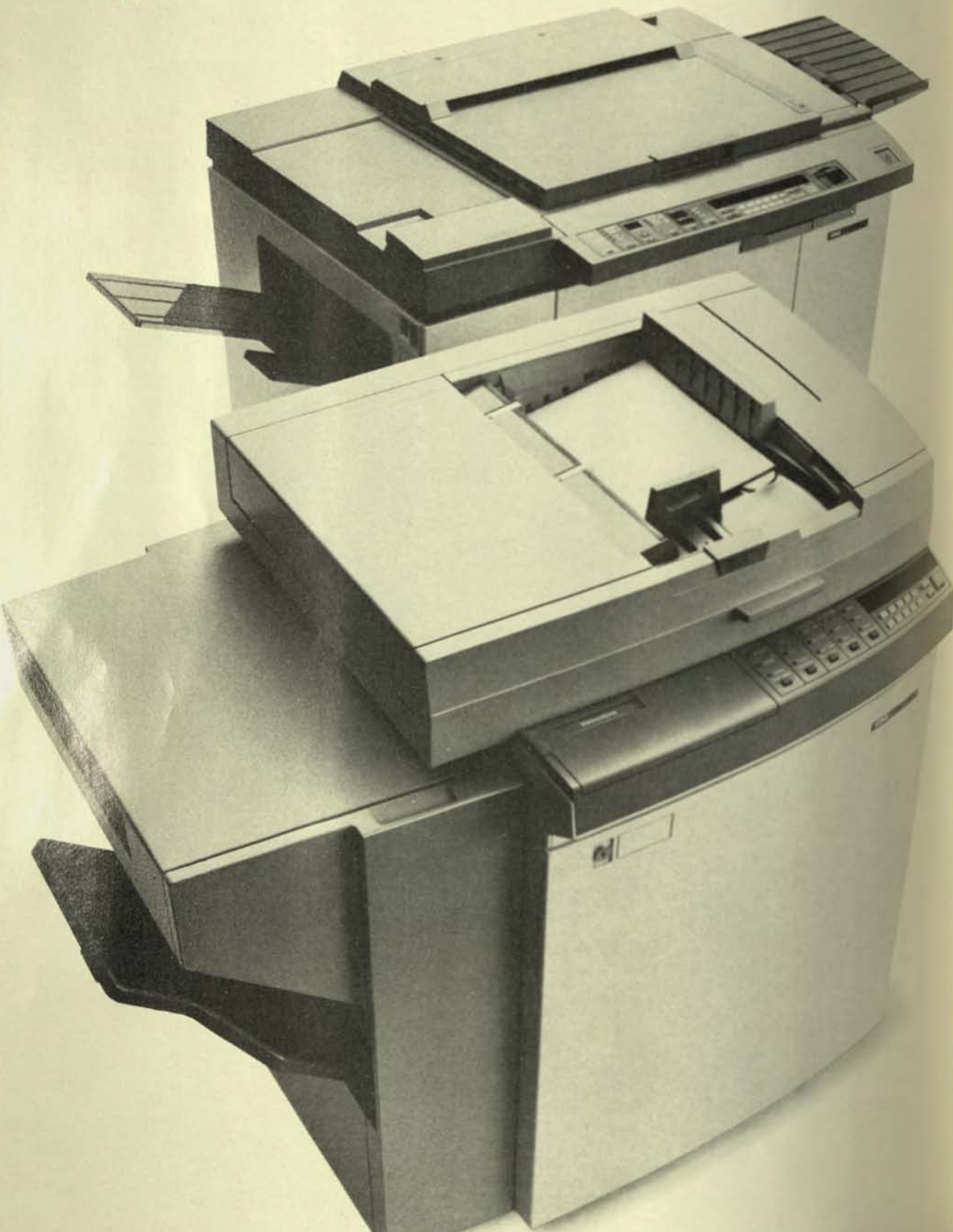

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PENTON/IPC VOLUME 223, NUMBER 2 OCTOBER 15, 1984

INDUSTRY WEEK

THE BUSINESS MANAGEMENT MAGAZINE

FEATURES

With pride and delight, IW honors each of our four Excellence in Management winners with this unique sculpture. The eagle has long symbolized magnificence and strength. But, above all, it represents the pursuit of excellence *in all endeavors. Excellence begins on Page 43.*

Photography: John Watt/Studio 4

DEPARTMENTS

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MEMOS

WORKING SMARTER / LIVING BETTER

Medical bills *can* pay off

If they find that their health-care bill is in error, employees will get 80% of the discrepancy when it is refunded, says United Technologies Corp., Hartford, Conn. It's one way the firm is helping to cut swelling health-care costs, which have reached an annual rate of $250 million. "Keeping health-care costs down is in everyone's best interest," says Carl Lindquist, director of employee benefits.

Coping with parental pressure

Do your children make you feel irritable, tense, detached, or withdrawn? If so, you could be the victim of parent burnout. "Burnout or emotional depletion occurs when your demands and those from others exceed your resources to carry out what needs to be done," says Marilyn Lammert, a professor at Catholic University of America's National Catholic School of Social Service. The potential for burnout around children is greater for women than for men because women are still primarily responsible for children. If signs of burnout surface, seek the support of others with similar problems, carve out time for yourself without parental demands, and recognize your limitations.

Are your campaign gifts deductible?

To be eligible for a tax credit for political contributions, several requirements must be met, reports the Commerce Clearing House. The credit—which cannot exceed $50—is allowed only for contributions paid within the year for which the credit is claimed. Also, only individual taxpayers may claim the credit. If a partnership makes an eligible contribution, each partner is deemed as having paid his or her distributive share of the contribution and is eligible for the credit. Finally, save your written receipts to substantiate that a contribution was made.

Luxury trains back on East Coast

Tired of riding the cramped Eastern Shuttle or Amtrak's Metroliner on trips between Washington and New York? Now you can do it in 1940s-style luxury in your own private railroad car. The service is being offered by American Zephyr Inc., a Gaithersburg, Md., firm that has refurbished two vintage 1940 American Zephyr railcars. The cars will be attached to Amtrak trains for regularly scheduled or charter trips between the two cities, as well as Williamsburg, Va. Hoping primarily to attract business from trade associations and other large groups, the firm is offering an introductory package of $499 that includes two five-course meals on board, two nights in New York's Plaza Hotel, and limo service to and from the train station.

Improve college admissions chances

By taking advantage of early decision policies offered by most colleges and universities, your child's chances of gaining admission to the school of his or her choice next fall can be improved. Since the pool of applicants will be smaller at an earlier date, the competition may not be as fierce. However, if he or she is accepted via an early decision plan, your child is committed to enroll in the fall—so make sure the choice is a sagacious one. Deadlines for early decision applications vary, so check with the admissions department of your designated college or university.

Illustration: Tom Tucker

Stud rights luring investors

With the formation of the Matchmaker Breeders' Exchange, owners and breeders of thoroughbred horses and portfolio managers are now able to buy and sell breeding rights on a weekly basis, using a computerized communications system. Members of the exchange list can respond to bids and offers on shares (the rights to breed one mare a year for the life of the stallion) and seasons (the right to breed one mare for a specific breeding season). Since the opening of the exchange on July 2, $4.2 million in thoroughbred stallion shares and seasons have been traded. For more information, write: Matchmaker Breeders' Exchange, 333 West Vine St., Suite 1630, Lexington, Ky. 40507, or call 800-522-2348.

Luxury hotels offer value

The Leading Hotels of the World, an organization of deluxe hotels committed to carrying forward the spirit of traditional service and excellence not found today in many hotels, has published a directory for cost-conscious travelers who desire both luxury and value for their money entitled *Fall/Winter/Spring 1984-1985 Great Affordables*. A two-night Boston Weekender at the Colonnade, and a four-wheel-drive safari through the desert, Bedouin villages, and fossil sites with accommodations at the Dubai International Hotel, are only two of 49 program choices, which include a price lower than the participating hotel's regular rate and at least one "extra" bonus. For a copy of the directory, write: 747 Third Ave., New York, N. Y. 10017-2847.

Electronic tax files win O.K. from IRS

Corporations reluctant to transfer tax records to electronic filing systems might want to review their respective positions. The Internal Revenue Service (IRS) has awarded a contract for the development of an electronic storage system that will hold 9 million pages of tax returns. IRS Chief Counsel also has approved optical disk files as legally admissible replacements for paper, a decision which the Justice Dept. has confirmed. Although executives who advocate automating federal government procedures will likely cheer the decision, they may be chilled by IRS' rationale: it wants to make its auditors more efficient.

Catalog *is* free, but please send $1

The *Countryside Relocation Catalog* (IW, Sept. 17, "City dwellers find rural relief," Page 5) *is* free, but Relocation Research, P. O. Box 864, Bend, Oreg. 97709, requires $1 for postage and handling.

WASHINGTON
INSIDE THE NATION'S CAPITAL

State surpluses seen shrinking

Although the overall financial health of the 50 states improved in fiscal 1984 and is in better shape than that of the federal government, "the recovery has been far from robust, and a number of states face continuing budget problems," warns the National Governors' Assn. in its annual state-level fiscal survey. For fiscal '85, the report projects that state revenues will grow by 7.1%, while expenditures will rise by 7.9%. Since a majority of the states are required by their constitutions to balance their budgets, many of them will have to dip into their 1984 surpluses to break even, says the report.

Steel-spending shortfall seen

When Congress granted the steel industry a three-year extension of its original Dec. 31, 1982, deadline for meeting Clean Air Act requirements, steel firms estimated that the extra time would enable them to spend between $500 million and $700 million on plant modernization. However, in the two years since the extension, they've invested only $49 million, reports the General Accounting Office. A study by the Congressional auditing agency blames the recession, unclear eligibility requirements by the Environmental Protection Agency, and overly optimistic estimates by the industry for the shortfall.

Will Volcker leave in '85?

If one of the hotter pre-election rumors circulating in Washington can be believed, Paul Volcker (photo), chairman of the Federal Reserve Board, may not stick around during a second Reagan Administration if the President is reelected. If the Fed chief does opt for the more lucrative private sector, speculation increasingly is centering on Secretary of State George Shultz—an economist and a former Treasury secretary—as his replacement. Other observers, however, insist that Mr. Schultz would prefer to remain at State.

Photo: John Neubauer

Embarrassment for Interior officials

Environmentalists and other critics of the Interior Dept.'s "areawide" offshore oil-leasing policy that went into effect last year received some powerful support for their arguments last month. The department held an auction for more than 6 million acres off the North Atlantic coast, but no oil and gas company bidders showed up. Embarrassed Interior officials were forced to cancel the sale and rethink their contention that areawide leasing will lead to a significant increase in domestic petroleum production. Prior to 1983, offshore lease sales were conducted under a system in which companies nominated tracts within fairly limited areas that they'd like to see put on the auction block. But under the new policy—begun by former Secretary James Watt and continued by William Clark—much larger areas are put up for bid.

OMB eases push for contracting out

Ever since the Reagan Administration took office, the Office of Management & Budget (OMB) has been badgering federal agencies to review their operations from top to bottom for activities that could be contracted out to the private sector. Now, however, in the face of continuing criticism from Congress and concern over the morale of federal employees, it is relaxing the effort. OMB Deputy Director Joseph R. Wright has directed agencies to: Concentrate their reviews on 14 specific areas rather than across-the-board; exempt units with fewer than ten employees from review; and solicit bids from other agencies that perform similar functions to see if the tasks can be shared more cheaply. OMB also will set up a clearinghouse to help agencies share information.

New money, old value

Not to worry. A Treasury Dept. proposal for a new currency, still under consideration by an interagency task force, would not mean a monetary devaluation or a vast overhaul of the present currency system. The change would be made mainly to deter counterfeiters, stresses Robert J. Leuver, director of the Bureau of Engraving & Printing. He says the currency would undergo minor redesign—with perhaps a subtle background tint and optical-variable devices on the face of the bills—to thwart the high-technology color-copying machines expected to come on the market within the next few years. Unless Congress dictates otherwise, the new currency would be exchanged one-for-one with the old, he says, and old currency would remain legal tender.

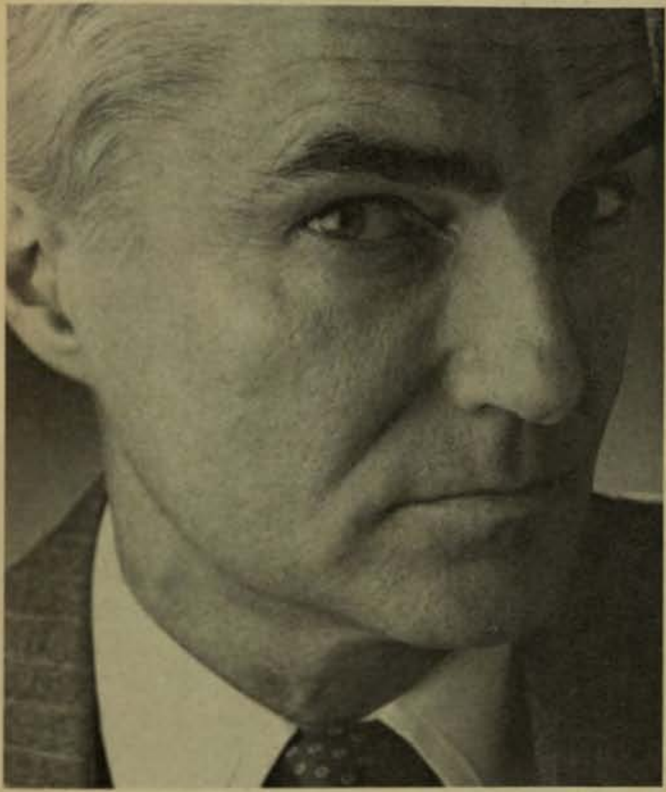
Budget process flops again

In what is becoming habitual, Congress this year again failed to pass most of its appropriation bills by the beginning of the new fiscal year, Oct. 1. Only four of the 13 bills were enacted on time, as lawmakers resorted to a catchall "continuing resolution" to keep the government running. The Congressional Budget Act of 1974 was supposed to impose greater budget discipline on legislators, but since then they've missed the deadline on 90 appropriations measures. In the 15 years before the act was passed, only seven bills were tardy.

Indoor pollution—a coming issue?

If the Consumer Federation of America is successful in its latest effort, you'll be hearing more about indoor pollution. The Washington-based organization, the nation's largest consumer group, has launched a campaign to boost public awareness of what it calls "the No. 1 hidden hazard in American homes" and to make cleanup a priority. As a first step, it has petitioned the Consumer Product Safety Commission to devote more money and manpower to its investigation of the problem. It also has asked the Environmental Protection Agency to reduce consumer exposure to radon, a source of radioactivity that is considered to be the second leading cause of lung cancer.

Can a copier be so friendly, even the boss can use it?



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FOR INFORMATION, CIRCLE NO. 37

EDITORIAL

An exercise in rationalization

It's any politician's stock in trade, but I still marvel at how some of the good ones have honed their ability to weave rationalization into about any stand they take. As a longtime observer (some would say "critic") of the Washington scene, I've heard some of the best. But President Reagan's performance of Sept. 18 has to be considered classic.

That was the day he rejected the recommendation of the U. S. International Trade Commission (ITC) to impose quotas and tariffs on foreign steel even though imports were flooding the market in violation of U. S. law at "unprecedented and unacceptable" levels. The ITC's findings confirmed that the domestic industry is being victimized by foreign producers on two counts: Unfair trade practices such as predatory pricing, dumping, and subsidies; because other countries are imposing quotas and other trade barriers to protect their own industries, a higher percentage of the world's excess steel is being diverted to the U. S. market.

The President's rationale: Restricting imports would force higher steel prices on domestic steel-consuming manufacturers, thus adversely affecting their international competitiveness. He "determined that protectionism is not in the national interest. It . . . raises prices and undermines our ability to compete at home and abroad." He "refused to put at risk the thousands of jobs in steel-fabricating and other consuming industries, whether they make refrigerators, tractors, or automobiles . . . [or take] any action that would put at risk the exports of our farmers and other workers in export industries."

Instead, he unveiled a plan to "consult" with the culprit countries to get them to voluntarily cut back on their exports and stop their unfair trade practices. He promised "effective and swift" action against countries that don't fall into line within 90 days by "vigorously" enforcing U. S. fair trade laws. The action is estimated to reduce the import share of the market to 20.5% from the current 25.4%.

The route the President outlined is less foolproof and won't reduce imports to the extent that quotas and tariffs might. But the net effect would be the same—higher steel prices.

That's what the President built his rationale on in rejecting the ITC recommendation. I can't see a difference, but then I'm not a politician. Being an avowed law and order man, it would seem that the President could have better rationalized support of the ITC recommendation, which was, in fact, based on violations of the law of the land.

The only way to rationalize a difference between quotas that are law and the President's voluntary approach is to anticipate that one will be less effective in reducing imports and firming up steel prices. The variable will be how well the President follows through on his promises. Only he knows that for sure.

Stanley J. Modic
EDITOR

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technology, financial, insurance, and service companies provided the biggest raises this year and plan to give the biggest hikes next year; and, by region, companies on the West Coast gave the biggest raises this year, firms in north central states the smallest, a pattern that is expected to be repeated in 1985.

Community-based PPO—a U. S. first

A network of San Diego County physicians and hospitals has agreed to accept reduced fees in exchange for prompt payment and an expected steady flow of patients. Described as the country's first community-based Preferred Provider Organization (PPO), it was developed by a strong coalition of business, labor, hospital, physician, and third-party-payer representatives. It was begun in July by the Community Care Network, a non-profit corporation, and will promote the appropriate and efficient use of health-care services.

EPA sues 64 for leaded-gas abuse

The Environmental Protection Agency (EPA) currently is prosecuting 64 automotive fleets for tampering with their emission-control devices and/or pumping leaded gasoline into a car designed for unleaded fuel, says *Runzheimer Reports on Transportation* newsletter. Among the suits are one for $330,000 against Atlantic Richfield Co.'s Philadelphia fleet and one for $182,650 against Louisiana-Pacific Corp.'s 56-car Portland, Oreg., fleet. The EPA warned those fleets that "misfuel" that the money they're saving now will be less than they'll pay in repair costs and/or EPA fines later.

Why good guys finish first.

It used to be that the more metal suppliers you had, the safer you were. The logic was simple: If one didn't come through, another would.

Times have changed. Drastically. Today, metal users can't wait for vendors who can't get it right the first time. Result: companies are consolidating their supplier bases by placing more business with fewer, more reliable "Class A" suppliers.

Before you miss the chance to line up the best metal suppliers in your area, take a close look at who's available. Then ask yourself a simple question: Who are the good guys?

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Address ____________________ (Not P.O. Box)

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Executive hiring hits plateau

Executive hiring, which has been at record levels for the last year, reached a plateau in the third quarter, Korn/Ferry International reports. "The economy appears to have stabilized at a high level, and companies are waiting until after the fall election to decide whether to opt for more aggressive expansion," says Lester B. Korn, chairman of the executive-search firm. Through the first nine months, major corporations hired senior executives (those earning $75,000 or more annually) at a pace 29% ahead of a year earlier, Korn/Ferry's quarterly survey indicates. Demand for CEOs represented a record 13% of total hiring during the third quarter. "Job opportunities and vacancies today are at the top of the corporate ladder," Mr. Korn says.

A female variety of bracket creeping

The increase in working women continues to alter the national economy, reports the Conference Board. Nearly 53% of all women are working outside the home (up from 43% in 1970), and working women will account for two-thirds of all labor-force growth during the current decade. They're rapidly boosting modest-income families into the middle and affluent brackets. Over two-thirds of the wives in $30,000-to-$35,000 families work, and more than 70% in households with incomes of $40,000 to $50,000 work. But the earnings gap between men and women remains, the Conference Board says. Women managers and administrators earn, on average, only about half of what men in these types of jobs are paid.

Who smashed this car? Nobody!

Auto-body inspection is getting some new wrinkles, as U. S. automakers seek to improve quality and appearance. The same car appears in both pictures. It wasn't wrecked after the photo on the left was shot. The photo on the right was made through a DiffractoSight, manufactured by Diffracto Ltd., Windsor, Ont. The viewing instrument reveals stretch marks in the sheet metal. Small but powerful halogen lights around the frame of the instrument make irregularities visible to inspectors, who now depend on sight and feel. About 20 of the units have been shipped to automakers in the U. S. and Sweden and to three sheet metal suppliers.

Sales help for U. S. exporters

American exporters will be getting increased exposure overseas, thanks to Thomas Publishing Co., New York-based publisher of the *Thomas Register*. The firm is making 1,000 sets of its 1985 edition, the 75th anniversary issue, available to the State Dept. for distribution to strategic business information and buying centers around the world. The department is conducting a survey in conjunction with the Commerce Dept. to determine the "optimum locations" for distribution. The 1985 edition profiles more than 120,000 U. S. companies under about 50,000 product and service headings.

Competitiveness is top salary issue . . .

"Paying competitively is the most important issue" in determining budgets for salary increases, says Fred Crandall, a principal with Sibson & Co., Princeton, N. J., compensation consultants. Sibson's 11th annual salary-planning survey ranked the competitiveness of the current compensation program first, followed in order by company profits, anticipated budgets for raises at other companies, the rate of inflation, and collective-bargaining agreements.

. . . and it'll take less to compete

Sibson's survey revealed that this year's average 6.6% salary increase will be followed by 6.5% next year, the two lowest increases in a decade, but still ahead of the anticipated inflation rate. Other findings: 32% of the respondents have extended or are considering extending the use of incentive bonus plans, compared with 23% a year ago; 7% of the companies have flexible-benefit plans in place, with 19% considering implementing them in 1985; high-technology, financial, insurance, and service companies provided the biggest raises this year and plan to give the biggest hikes next year; and, by region, companies on the West Coast gave the biggest raises this year, firms in north central states the smallest, a pattern that is expected to be repeated in 1985.

Community-based PPO—a U. S. first

A network of San Diego County physicians and hospitals has agreed to accept reduced fees in exchange for prompt payment and an expected steady flow of patients. Described as the country's first community-based Preferred Provider Organization (PPO), it was developed by a strong coalition of business, labor, hospital, physician, and third-party-payer representatives. It was begun in July by the Community Care Network, a non-profit corporation, and will promote the appropriate and efficient use of health-care services.

EPA sues 64 for leaded-gas abuse

The Environmental Protection Agency (EPA) currently is prosecuting 64 automotive fleets for tampering with their emission-control devices and/or pumping leaded gasoline into a car designed for unleaded fuel, says *Runzheimer Reports on Transportation* newsletter. Among the suits are one for $330,000 against Atlantic Richfield Co.'s Philadelphia fleet and one for $182,650 against Louisiana-Pacific Corp.'s 56-car Portland, Oreg., fleet. The EPA warned those fleets that "misfuel" that the money they're saving now will be less than they'll pay in repair costs and/or EPA fines later.

EXECUTIVE EXCHANGE

Industrial automation: not whether, but when

Either the U. S. and other countries where wages are high must embrace computer-integrated manufacturing or they must accept that their manufacturing costs will be too high and that their product quality and reliability will be too low.

Mr. O'Rourke is president and chief operating officer of Allen-Bradley Co.

By J. TRACY O'ROURKE

Computer-integrated manufacturing (CIM), from a technological point of view, is here with us today. But I doubt that even 10% of our domestic industrial plants now operating really have fully computer-integrated manufacturing and processing, managed with software and communications.

The excitement surrounding CIM, however, is far greater than that statistic would suggest, and the reason for it is very simple. Either the U. S. and other countries where wages are high must embrace computer-integrated manufacturing or they must accept that their manufacturing costs will be too high and that their product quality and reliability will be too low. Absolutely. We cannot compete with people who put things together at 25¢ or 30¢ an hour for direct labor. Our direct labor costs must become a non-issue.

If we are to continue to succeed as a society, it must be as a manufacturing society. We cannot survive and prosper long as an information society alone; if we were to try, pretty soon all we would be manufacturing would be credit cards, so to speak. Excuse me—in the future they would be debit cards.

I don't think that this or any other advanced society can survive in the long-term future with its capital involved in just making debit cards—just processing information.

I don't know that we need to be competitive in every manufacturing industry in the world. But I feel that we must rely on industrial automation technology if we are going to continue as a successful economic power. That's the kind of leadership we must offer—manufacturing goods and services at the lowest possible cost and the highest possible quality.

Quality is free. Every improvement you get in quality in your manufacturing operations results in improvement in quality in your product. Productivity gains and quality gains go hand in hand. And you achieve both with the appropriate computer-based methods. The Japanese have proved that. In fact, if the Japanese had not occurred naturally, U. S. businessmen should have had to invent them. They have driven us to do the kinds of things we're doing right now that we should have done a long time ago.

Let's look at the technologies related to computer-integrated manufacturing. Ten or 15 years ago there was no technological solution for distributed control or any reasonable cost-benefit rationale for it. Today, both exist. There is a reasonable cost-benefit solution to distributed control.

The next issue is factory communication. We've had the capability for some time, but the cost was prohibitive. Now we're doing things on a single chip that just two or three years ago took five or six printed circuit boards. These chips will become standard items, produced in billion-piece volumes, and costs and prices will descend accordingly.

So the technology for distributed control and for communications and the cost benefit are here today.

The key issue today is timing—that is, when the user truly wants his manufacturing environment adapted to computer-integrated technologies. The adaptive control to help bring this about is here now. The quality of the sensors available today, in terms of the amount of work that they can do in feeding back information on a closed-loop basis at very high speeds, is very high. Such sensors will be a key part of the low-cost, high-quality CIM facility.

The factory of the future is arriving by degrees. In manufacturing, plants like the new Windsor (Ontario) Chrysler Minivan facility and newly automated General Motors and Ford operations are helping to lead the way. The new U. S. Steel Corp. continuous casting plant in Lorain, Ohio, is an excellent example in that basic industry. Such companies as Shell in petroleum, Weyerhaeuser in lumber, Anheuser-Busch in brewing, Pillsbury in food products, and similar companies are setting the pace.

Few, if any, companies are accomplishing the task overnight.

As an example, our own finishing operations are already highly automated. And in our programmable controller business we design the printed circuit boards with computer-based equipment, digitize the board with a computer, take the digitized tape and send it through the telephone lines to the factory and into the machines.

Soon we'll be automatically assembling motor starters at a rate of 600 an hour in an unmanned environment and without inventory. A control room will type in individual orders. Each order will be assembled, packaged, and invoiced automatically.

These kinds of computer-based manufacturing techniques permit a company to target its costs, add a reasonable profit factor, and assure that the first unit through the process will meet the cost target. And they assure customers of high quality at a competitive price.

We disagree with those who contend that the U. S. can rely on agriculture and information-processing industries alone and remain a major economic power. It will remain absolutely essential to demonstrate a capability to produce goods, as well as services, at the lowest possible cost and the highest possible quality. ■

In each issue, IW invites an executive to speak out on a topic of his or her choice.

LABOR

Win-Win? Almost

Auto and coal pacts set labor pace.

Photo: ©'84 Russ Marshall

UAW President Owen Bieber (second from right) discusses bargaining progress during a break from negotiations.

By PAUL G. ENGEL/ It's a cliche, to be sure, but the United Auto Workers (UAW), General Motors, and their counterparts in the recently completed coal negotiations seem to have come close to achieving the elusive "win-win" goal that's often mentioned but seldom, if ever, met in contract talks.

Given recent labor history and current economic conditions, that's something of a surprise. The United Mine Workers (UMW) had walked out of every set of coal talks dating back to 1966, and President Richard Trumka built this year's negotiating strategy around a line-in-the-sand nonconcessionary platform. Likewise, rank-and-file autoworkers were in a surly mood after seeing 1982 wage givebacks contribute to record-breaking automaker profits this year. (Indeed, huge numbers of autoworkers remained surly as the agreement got some rough treatment in ratification votes.)

THE REASONS. So why no fractious strikes? A combination of hard-nosed but enlightened personalities, common sense, and the stark realities of worldwide competition staring both labor and management in the face averted all but the brief GM walkout.

"Both sides realized that they're losing markets" to both overseas concerns and non-union operators in this country, says Dale Lawson, a former UMW staffer and now senior labor-policy analyst for Government Research Corp., Washington. That, plus the fact "that neither side tried to out-macho the other," made for relatively smooth discussions.

These latest talks, adds Peter Navarro, a researcher with Harvard University's Energy & Environment Policy Center, are the first time in recent memory in which "the industry hasn't shot itself in the foot; there aren't a whole lot of Lee Iacoccas in the coal companies."

Similarly, both the UAW and GM concluded that the past couldn't be prologue this time around, believes Arvid Jouppi, an auto analyst based in Grosse Pointe, Mich. "There was a realization that the 1979 agreement was defective; it couldn't handle the Japanese or the recession," he says. This time, by tackling tough issues head-on, "they've sowed the seeds for another good agreement in 1987; they'll both still be playing on the same field."

HURDLES. While all the parties are justifiably trumpeting their respective gains—establishment of a billion-dollar "job-opportunity bank" to aid autoworkers displaced by automation or outsourcing, modest wage and pension hikes, health-cost-containment language, cost-of-living adjustment retention, and overtime penalty provisions—there are some remaining hurdles.

The coal agreement "doesn't do anything for out-of-work miners," concedes Mr. Lawson. In some coalfield locals, unemployment is running close to 40%. The UAW deadline for an agreement at Ford passed last Friday, and there is also talk of an early reopener on the Chrysler contract.

Still, the fact that two of the nation's major trade unions can get through watershed negotiations without debilitating work stoppages bodes well for similar talks in coming months. ■

FINANCE

Debt-heavy

But financial health remains good.

By MARILYN MUCH/ The economic recovery has given corporations more liquidity than they have had in years. Aftertax profits for 1984's second quarter were $197.6 billion, more than a 100% increase from $96.6 billion in 1982's fourth quarter, when the latest recession ended.

The strong profit position has given many companies surplus cash, with cash flow far outstripping spending for inventories, plant, and equipment. Nonetheless, a closer look at corporate balance sheets suggests to some analysts that the financial picture is not as rosy as it appears.

During the early phase of past economic recoveries, corporations have typically restructured their balance sheets by paring their short-term debt through long-term bond-market borrowings and equity issuance. However, this time around, that restructuring has yet to occur. Consequently, many companies continue to carry hefty debt-to-equity ratios with a disproportionate amount of their debt burden stemming from short-term borrowings from banks or the commercial-paper market.

SHYING AWAY. Corporate treasurers have shied away from the bond market because long-term interest rates have not come down to attractive levels. Moreover, stock-market prices haven't risen enough to warrant a surge in equity issuance.

The heavy reliance on short-term debt caused short-term business credit outstanding to rise more than $31 billion during 1984's first half, almost

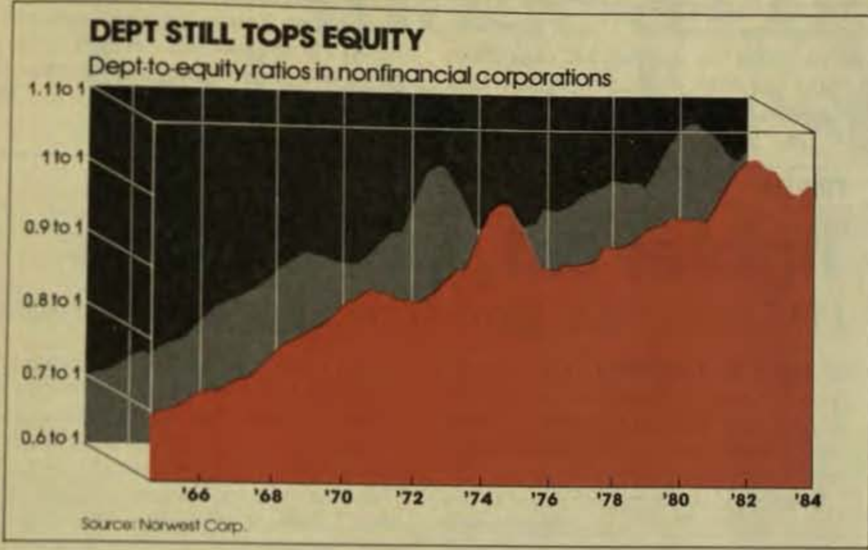

Chart: Margaret Endres

four times the amount added during the preceding six months, calculates Manufacturers Hanover Trust Co., New York.

That could spell trouble for some companies, if, as Manufacturers Hanover suggests, the "high-water mark" for corporate earnings gains has been reached and if outlays for inventories and capital equipment remain strong enough to prompt a heavy reliance on external sources of funds.

"While the return of corporate America to the debt markets doesn't necessarily have to be harmful to corporate financial health—especially if lower cost and/or longer-term debt than [currently] outstanding could be accessed—in today's lofty interest-rate environment, it probably is," the bank warns.

If short-term rates rise sharply next year, the large debt-service burden that some companies are carrying could hurt their bottom lines even more, suggests Dr. Sung Won Sohn, senior vice president and chief economist, Norwest Corp., Minneapolis.

NOT 'WORRISOME'? Other economists are more sanguine, particularly in light of their forecasts for the next several months. The highly leveraged situation is not the "worrisome problem it was two or three years ago when profits were substantially lower," observes Dr. Lacy Hunt, an executive vice president and chief economist at the New York securities firm of Carroll, McEntee & McGinley.

Moreover, it would take a steep downturn in corporate earnings for the leveraged situation to worry analysts. Most financial savants concur with Dr. A. Gary Shilling, president of the New York economic-consulting firm that bears his name. He predicts more attractive earnings growth combined with good cost controls next year.

"This suggests that some companies may be able to work out these large debt run-ups, assuming the forecast works out," Dr. Shilling explains. "If we have more adverse conditions, then we'd be looking at some basket cases."

Indeed, interest rates will creep upward toward the end of the year, but analysts say the increase won't be sufficient to create problems for borrowers. For example, Dr. Henry Kaufman, chief economist at the New York investment-banking firm of Salomon Brothers Inc., predicts that the federal-funds rate (the rate banks charge each other on overnight loans) should rise from its present level of 11¼%-to11¾% to 11½%-to-12% by yearend, with the prime or base lending rate edging up to 13½% from its current 12½%.

The projected interest-rate increases "are not worth worrying about" for corporate borrowers that have taken advantage of the banks' variable-rate loans, Dr. Kaufman says. "These projected interest-rate rises provide no penalty for having borrowed short, considering the current levels of long-term rates." ■

TELECOMMUNICATIONS

IBM rings up ROLM

Intentions unclear. Most rivals happy.

By MARK L. GOLDSTEIN/ When IBM Corp. reached out two weeks ago and permanently touched ROLM Corp., virtually the entire telecommunications industry started to ring. To some, the unexpected $1.25 billion purchase of the Santa Clara, Calif., PBX manufacturer merely reaffirmed the wisdom of their own market strategies, but to others it smacked of Big Blue moving another step closer to being Biggest Blue.

There are several reasons why IBM acquired ROLM, its first outright purchase of another company in more than 20 years. Some experts deduce that IBM's already substantial 23% hold on ROLM wasn't strong enough to give it control over research and product decisions at the fiercely independent company.

Rumors abound that ROLM's advanced digital switch and its voice-messaging system, Phone Mail, were not being developed fast enough or marketed to IBM's advantage. IBM, typically, refused to comment.

LAST-DITCH EFFORT? Still, others see the purchase as a last-ditch effort by IBM to muscle in on advanced PBX (private branch exchange) technology, which handles voice and data traffic in offices. It is a strength conspicuously absent from the computer giant's grip.

"More than anything else, many people see the ROLM purchase as a window into IBM and its problems," says William Zachmann, vice president of technology assessment at International Data Corp. (IDC), Framingham, Mass. In fact, some observers believe the acquisition was IBM's final chance to be a player in the PBX market—particularly before a much-predicted shakeout occurs among the vendors next year.

Eastern Management Group, Parsippany, N. J.-based consultants, estimates that 1985 will witness a 30% drop in new PBX sales before they rise again in mid-1986. Says Al Fross, vice president: "Until they [IBM] bought ROLM, there were no definite survivors we could predict, except for AT&T."

IBM may also have been pushed into the decision. Last month, Wang Laboratories, the Lowell, Mass., office-automation company, announced it had developed a voice- and data-integrated workstation with a start-up PBX vendor named Intecom, located in Dallas.

Wang owns 20% of Intecom.

CULTURE SHOCK? At the same time, reaction is mixed on how much ROLM will benefit from its new parent. For example, its highly touted corporate culture, complete with swimming pool, blue jeans, and paid sabbaticals, may get toned down, causing problems and departures.

Naturally, ROLM will benefit from IBM's massive clout in sales and marketing—particularly among major corporations, which it often has trouble selling to. No doubt it will also take advantage of the vast resources now available for research.

But some observers say ROLM jumped at the chance because its real growth is now in the past. Profits were up only 6% last year, and the competition has become much tougher since the company started 15 years ago in an abandoned prune shed. The divestiture of AT&T unleashed seven regional Bell Operating Companies, along with recent start-ups such as Ztel, a four-year-old venture in Wilmington, Mass., that makes the so-called fourth-generation PBX, which integrates voice and data by combining the telephone-switching system with local area networks.

COMPETITORS. There has also been much discussion about how the purchase will affect other players in the telecommunications industry.

August David, at Walter Ulrich Consultants, Houston, predicts that a flurry of similar marriages will occur in the next 18 months. "It opens a whole new world for the hardware manufacturers," he says. Companies such as Wang and NCR, which own portions of Intecom and Ztel, respectively, could move to strengthen their hold. All four currently deny such a move.

And the market itself is bound to get together. "A year from now, we're not going to see all the same players remaining," says Eastern Management's Mr. Fross. But those companies that do survive will be well-positioned for the upswing in PBX sales in 18 months.

Additionally, many of the smaller companies predict that IBM's move will help their sales. "What it does," says Peter Anderson, president of Ztel, "is legitimize PBXs as the key element in the future of office automation. IBM has a way of blessing a product."

There is one company, however, that is less than happy about the acquisition: AT&T. To AT&T Information Systems (ATTIS), the purchase gives unfair advantage to the No. 1 adversary. "Imagine the outcry that would have occurred had AT&T said it was going to make a similar purchase," an ATTIS spokesman says.

In addition to ROLM, observers point out IBM owns 60% of Satellite Business Systems, a long-distance carrier, as well as 20% of Intel, a producer of microprocessor chips. Complains the ATTIS spokesman: "What's to keep them [IBM] from being just like the old Bell System?" ■

TRADE

Tighter fist, open arms

IMF conference hears from President Reagan.

By DALE W. SOMMER/ "Freer trade" was the gospel according to Ronald Reagan preached at last month's meeting in Washington of the International Monetary Fund (IMF).

Sounds good from a pulpit, but many of the 12,000 officials in congregation representing 148 countries still went away nonbelievers. They have problems of their own that, for example, a larger collection plate would have gone a longer way in solving. But Mr. Reagan, under pressure from forces at home, refused to raise the U. S.'s "fair share" contribution to the IMF's World Bank and blocked efforts to raise the total ante from the $9 billion more annually to $12 billion.

That hard-line decision will limit the financial options of the world's poorest nations, many of whom depend upon interest-free loans from the bank. Still other representatives of already industrialized countries probably sighed in relief that the President did not decide to pursue a policy of U. S. trade protectionism.

EUROPE. In European countries, for example, growth has been so sluggish they could have disintegrated without a receptive U. S. market for their exports. Domestic retail sales in most European countries were sluggish at best in this year's first quarter and fell off (as drastically as 12% in France) during the second quarter, reflecting Europeans' uncertainty about the future, observes Manufacturers Hanover Trust Co., New York.

Sluggish consumption has also dampened capital investment in many of these countries, nor is much impetus expected from inventory building. Thus, dependent on export sales—particularly to the U. S. since trade among themselves is slim—Europe will be lucky to average 2% real growth this year, compared with last year's 1.3%.

JAPAN. Japan's situation—low inflation, low unemployment, and somewhat subpar but still-healthy economic growth—may appear exemplary. But low interest rates there have resulted in major capital outflows from Japan and "extreme unbalance" in its balance of payments, says Thomas R. Robinson, manager-international research, Merrill Lynch Economics Inc., New York. That country, too, hopes to keep up a steady flow of exports to the U. S. to help maintain a positive balance of trade, at least on the merchandise level.

MIDDLE EAST. Even the OPEC nations, once so sure of thriving overseas markets absorbing their oil exports, have fallen on comparatively hard times. OPEC has shifted from essentially a "pricemaker" to a "price taker," points out Aida Der Hovanessian, assistant economist, Chemical Bank, New York.

LATIN AMERICA. Latin America's economies, meanwhile, seem to be on the mend after their "unprecedented" declines of 1983, Chemical economists also note. Especially hopeful was an agreement on austerity which Argentina concluded with the IMF. Coming on the heels of similar agreements with Brazil, Mexico, and Venezuela, it strengthened hopes that Latin American countries can advance from their initial strict concentration on reducing account deficits to balancing economic growth with low inflation in 1985. Accelerating exports, again primarily to the U. S., are aiding many countries toward that goal, Chemical Bank says.

What's in all of this for us? Trade deficits, it's recognized, do serve to ease inflationary pressures by increasing competition and offsetting whatever production bottlenecks may occur in a rapidly growing economy, points out Rajni Bonnie Ohri, economist, U. S. Chamber of Commerce. But conventional wisdom also states that jobs are lost to trade deficits.

This generalization, Ms. Ohri says, overlooks the fact that U. S. exports, contrary to all that has been said, are also growing strongly—30% faster than in the average previous postwar recoveries. And the inflow of foreign capital to the U. S. is fueling jobs in "other" industries. ■


Quality Assurance

RAILROADS

Strategy routes differ

One-stop shopping is not for all.

By BRIAN S. MOSKAL/ Wholesale or retail?

It may sound like a distribution system for plumbing or electrical products, but in fact it's becoming a conscious choice made by the nation's railroads.

Since the advent of the new regulatory climate, some railroads have elected to become total transportation companies and provide a retail-type one-stop shopping service for shippers. Under this system the railway provides all the services connected with a freight movement including sales, billing, customer service, and pickup and delivery.

Other railroads have elected to follow the "wholesale" approach under which they concentrate on the line-haul and cooperate with highway carriers, shippers' agents, shipper associations, and freight forwarders who provide the balance of the transportation service including the pickup and delivery.

CSX Corp. and Norfolk Southern Corp. both seem headed toward providing one-stop shopping for shippers. Meanwhile, Burlington Northern Inc. and Santa Fe Southern Pacific Corp. appear headed in the "wholesale" direction. (The Interstate Commerce Commission [ICC] must still approve the merger of the Santa Fe with the Southern Pacific.)

CSX's recent acquisition of American Commercial Lines Inc. and its water-carrying subsidiary, American Commercial Barge Line Co., points the corporation in the direction of providing retail shopping for shippers. The barge line, recently approved for acquisition by the ICC, joins Chessie Motor Express as water and truck lines to the CSX rail network.

Norfolk Southern has now formally filed an application with the ICC for control of North American Van Lines Inc., a major transporter of household goods, high-value products, and general truckload freight. Norfolk has already reached agreement with North American's parent, PepsiCo Inc., to acquire all of the motor carrier's outstanding common stock for $315 million in cash. Norfolk says the motor-carrier operations of North American "afford opportunities for coordination of service" with its railroads, particularly its handling of truckload freight.

"Working together, Norfolk Southern and North American will reduce transportation costs, enhance operating efficiencies, and offer better and more economical service to shippers," the company says. North American also will provide the trucking line that Norfolk Southern needs to compete with CSX and its Chessie Motor Express.

CONTRA. Running counter to the purchase of non-rail transportation companies by CSX and Norfolk Southern is the corporate strategy of Santa Fe and apparently it is at least the short-term management thinking of Burlington Northern.

In April, Santa Fe agreed to sell the stock of its motor-carrier subsidiary, Santa Fe Trail Transportation Co., to SFTT Inc., a Chicago-based less-than-truckload and special-commodities carrier. No terms were disclosed, but Santa Fe says the sale will not significantly impact earnings. The transaction depletes Santa Fe of its only trucking operation.

As a rule, Santa Fe believes in the wholesale approach. To that end, Santa Fe reduced the number of its freight terminals handling piggyback service from 101 to 38 last year, while still remaining second only to Conrail in intermodal business. Even with the reduction in terminals, Santa Fe's system increased the number of containers and trailers on flatcars from 480,000 through mid-September of 1983 to 512,000 in the comparable period this year.

Burlington Northern Inc., the holding company that controls Burlington Northern Railroad, has also just left the trucking business. Burlington has agreed in principle to sell its two motor-carrier units, BN Transport Inc. and six-month-old Federal Transport Inc.—also to SFTT.

Is Burlington headed away from retail transportation services and pickup and delivery for shippers? "Our future in trucking still has to be considered at the corporate level," says a Burlington Northern Inc. spokesman. "You can't read into this that we won't be in the trucking business in the future." ■

EXPORTS

FSC replaces DISC

But is it incentive enough?

By JOHN S. McCLENAHEN/ Between now and Dec. 15 the U. S. Commerce Dept. is slated to hold 23 conferences to explain the intricacies of the Foreign Sales Corp. (FSC), a Congressionally created tax break for export-generated income that debuts Jan. 1, 1985. FSC will replace the oft-maligned DISC (Domestic International Sales Corp.) tax-deferral device for exporters that's being terminated this year.

But many of this country's major exporters aren't waiting to sit in on the Commerce Dept. confabs—which are primarily aimed at small and medium-sized U. S. firms—before getting their FSCs ready to launch.

Dow Chemical Co., Weyerhaeuser Co., Phillips Petroleum Co., Boeing Co., Westinghouse Electric, and FMC Corp.—all in the ranks of America's 40 largest exporters in 1983—have already chosen to make the switch from DISC to FSC. The basic reason: they can't afford not to. Having a tax exemption for part of their export income is a vital trade incentive. "We didn't have any choice . . . but to go for the new setup," explains a Boeing spokeswoman, a statement that is echoed across industry boundaries.

The process, however, is not a simple "paper" transaction. Among other things, to qualify for a tax exemption (the amount varies from 30% to 69.56%) an FSC doing at least $5 million annually in business must be organized in a U. S. possession (other than Puerto Rico) or a Treasury Dept.-designated foreign country, do its accounting offshore, and have one or more non-U. S. residents on its board of directors.

For companies such as Phillips Petroleum, which has used a "paper" DISC to defer taxes on its incremental export income, the administrative burden is going to grow significantly with an FSC.

For example, moving FSC-related accounting offshore "is just going to be more expensive" than its DISC has been, says Paul H. Durham, Phillips' associate tax counsel.

The transition, on the other hand, promises not to be quite as tough for Dow Chemical. Its DISC has been a substantive, not a "paper" operation, responsible for invoicing customers and all the other activities involved in administering Dow's export business. "It's all quite manageable," says Glenn W. White, the director of Dow's tax department. "For the most part, we're finding it's not been very difficult—or that we're getting great howls of protest from our commercial fellows."

Nevertheless, at least one experienced international corporate counselor is withholding judgment on FSC's effectiveness as an export stimulus. "It introduces a novel concept in that it gives an exemption [from taxes] rather than a deferral," notes Peter M. Cohen, president of Trident Investments Ltd., Atlanta. And only a portion of a company's foreign trade is exempted, he stresses. "Whether or not that is enough of a carrot, I don't know yet," he confesses. ■

EXECUTIVE HEALTH LINE

A FAMILY AFFAIR

Our families play a key role in our physical health. Doctors and psychologists are discovering, for instance, that the way family members interact with one another somehow helps amplify and maintain their children's illnesses, such as asthma, digestive disorders, and diabetes. Family pressures don't *cause* disease, but it's a vicious cycle. Serious illness puts strain on the family—and family stresses, in turn, can make the illness worse. Family therapy has been found helpful in alleviating illness.

DANCIN'S IN . . .

Aerobic dancing is stepping into the corporate world, with dozens of companies adding it to their fitness programs. Executives are finding it's not only fun, but also good for you. A group activity, it's also a good way to bring employees together. Vigorous dancing—15 minutes to an hour, at least three times a week—offers the aerobic benefits of running plus, many believe, much more fun.

BUT SKIPPING?

Skipping also is being hailed as being not only possibly better than jogging for cardiopulmonary benefits, but also less injurious. Since a skipper lands both feet at once, the jolts to the leg bones and muscles are considerably less. Don't expect skipping to ever surpass jogging or running in popularity, however. It's just too darned silly-looking.

TENNIS ELBOW, ANYONE?

There's more to treating "tennis elbow" than elastic bands or surgery. To avoid, or cope with, this form of tendinitis, one medical expert advises: check your tennis form and make sure you're hitting the ball properly. Use a light racket, a 12-12½ oz mid-size graphite model. Don't roll the racket to produce topspin. Strengthen your serving arm. If you hurt, play less tennis. Perhaps take aspirin. Don't push so hard. Relax. Have fun.

ETERNAL YOUTH

Intense exercise can prevent the typical 10%-per-decade drop in fitness, researchers conclude after a ten-year study of 25 Masters runners. These elites, now 50 to 82 in age, were originally tested for aerobic capacity, then retested recently. Those who still ran competitive workouts showed no decrease in aerobic capacity. "If you put bags over their heads, you'd think they were 20-year-olds," the researchers marveled.

IRON IRONY

A subtle form of iron deficiency strikes even champion athletes, particularly distance runners and walkers. Some doctors believe that blood cells are damaged by all that feet pounding. Feeling tired and run-down, grouchy and depressed, and having trouble sleeping are symptoms. If you suspect iron deficiency, doctors advise a serum ferritin test. Don't try to treat it yourself. Then, some solutions: Boost iron intake through supplements or such foods as spinach and red meat; take more Vitamin C; reduce physical training until you're O.K.

SOUNDS FISHY

Another way to help retard aging is to eat more freshwater fish, such as mackerel and salmon. Their oil has been found to be rich in an acid that reduces the severity of amyloidosis—or protein deposits that occur in many disease processes, including arthritis and the aging process itself.

This column has been adapted from a current issue of American Health *magazine. To subscribe at an introductory rate ($11.95), circle No. 120 on the Information Center card.*

cated recruits are just what American enterprise needs.

CREDENTIALS. "They are confident, motivated, can think and reason, are interested in people, and they are taking to the computer age like no other generation," she said. And liberal arts graduates are vitally interested in business, she noted. "At Smith, for example, the percentage of graduates preparing for business careers has soared from 10% in 1964 to 55% in 1983."

Mrs. Conway also noted celebrated studies conducted by Harvard University and the former Bell System. Separately, they concluded that liberal arts graduates outperform their technically trained peers, even though many start lower on the corporate ladder. Because they are more flexibile, "they are more receptive to new ideas and new ways of doing things," she suggested. "They are stimulated and challenged by global competition. Notably, Japanese delegations continue to study our liberal arts educational system," Mrs. Conway said, "because they feel theirs is much too rigid and more difficult to deploy."

One could also infer another conclusion from Mrs. Conway's remarks, delivered to further corporate support of higher education: That "plain old B.A.s" are far more willing to absorb advice from corporate elders than many M.B.A.s. ■

COMPETITION

Eye-to-eye combat

The market's in focus. Let the battle begin.

By MICHAEL A. VERESPEJ/ What's round and thin, costs less than $1.50 to make, and has billion-dollar companies like Nestle, Ciba-Geigy, and Johnson & Johnson eyeing its future covetously?

If you guessed round candy bars or plastic bandages or women's compacts, guess again. It's a soft contact lens.

Why soft contacts? It's simple. Some 120 million people in the U. S.—or half the population—have some type of vision problem. But right now just 12% of them, some 14.4 million, wear soft contact lenses. So the market potential is enormous. For example, if all the people without them but needing them were fitted overnight, there would be an instant demand just in the U. S. alone for 212 million contact lenses. That compares with current annual sales of 17 million soft contact lenses that's bringing in some $360 million in revenues to manufacturers.

What's more, soft-contact-lens wearers, on the average, replace one lens every 15 months. And none of these eye-popping numbers takes to account the marketplace impact of tinted lenses just now coming into the market. "They could be the single largest market yet. They could double the size of the market," suggests analyst Otto Grote at Derby Securities, New York. The reason: over 20% of the buyers of such lenses to date have been people *without* vision problems.

SCRAMBLING. It's clear, then, why there has been so much scrambling lately in the industry, underscored by the planned acquisition, announced last month, of independent but rapidly soaring contact-lens manufacturer International Hydron Corp. (IW, Oct. 1, Page 87) by SmithKline Beckman Corp., whose Allergan Pharmaceuticals Inc. unit holds a strong 20% market share in the solutions end of the business (products used to clean contact lenses). That market's growing even faster than the lens market, and at its current 30% clip it could reach $1 billion in retail sales by the end of 1986.

SmithKline's decision to acquire Hydron comes less than two months after Nestle backed off from its planned acquisition of lens and solution maker CooperVision Inc., Menlo Park, Calif.—which has been growing at a 30% pace—because of Justice Dept. opposition. That shouldn't be a problem, though, for SmithKline because it doesn't make lenses and Hydron doesn't make solutions. (Nestle-Cooper's combined share in the solutions market would have exceeded 35%.)

The reshuffling in the industry, though, seems far from over. Currently, even after over 20 companies bit the dust in the 1970s, some 30 companies remain. And they're all struggling to solidify their positions behind industry kingpin Bausch & Lomb Inc. (B&L), whose market share in both the lens and solutions portion of the business is over 40%.

"No more than six or seven companies have the distribution capability, the cost base, and the full line of products needed to hang on," declares Mr.

Grote. "To compete against Bausch & Lomb, you need strong financial and managerial resources."

He and other analysts believe long-term survival isn't possible unless a firm is in both the lens and solutions businesses. "The solutions business is driven off the lens business, and the synergy between the two is very important," insists Franklin T. Jepson, B&L vice president-investor relations. "It is hard to envision anyone being a major player in the business without being in the solutions business." One reason—as Mr. Grote points out—if there are 20 million lens wearers by 1986, each of whom spends $50 annually on cleaning lenses, that's a $1 billion retail business (about $600 million at the manufacturer's level).

"I am surprised that more manufacturers in the solutions business haven't integrated forward," declares Mr. Grote. "It is exactly the right move for SmithKline. It is exactly whom I would have bought." Not only does SmithKline get a hard-charging company that many expect to be the No. 2 lensmaker behind B&L by the end of next year, but it also protects the $100 million investment SmithKline made four years ago when it acquired Allergan.

TIME FOR ACTION. Most industry analysts believe it's time for all the others seriously interested in the business to make their move. Nestle, they say, needs to get into the lens business, Revlon needs to reduce its costs, CooperVision needs to decide whether to go it alone or be bought, and everyone needs to jump into the spin-cast method of manufacturing that now only B&L and Hydron use.

Because of those uncertainties and the need to have "big bucks" to stay in the game, most industry analysts think that virtually "everyone is up for grabs." In fact, some analysts suggest that even B&L could become the victim of a large enough predator. The reason: its stock is selling for just 12½ times earnings; Hydron was bought for 23 times earnings. Besides, they say, the potential $1.5 billion price tag for B&L would be "peanuts" to a company like Nestle, which recently shelled out $3 billion for Carnation Co.—particularly if the potential is a $1 billion business.

The rapid market changes stem from price drops the last two years of some 50% and new technology that has made soft contacts more available and affordable for people with astigmatism and those who in the past needed bifocals. That has led to more new lens wearers. The traditional 10% increase in new wearers has jumped to 20% in the last two years.

BOTTOM-LINE QUESTION. Will anyone profit? Despite the rapid market growth, some analysts, such as Steven B. Reid of Bateman, Eichler, Los Angeles, are concerned that profits may be non-existent for companies other than B&L. "If some companies couldn't make profits selling lenses for $35, how can they profit at $10?" he asks. (The prices doctors now pay range from $7 to $18.)

B&L's Mr. Jepson admits that margins are down from four to five years ago. But he insists that the "margins are still extremely attractive by the standards of any product manufactured." And he says B&L will use that leverage. "As a low-cost producer, we have a lot of leeway in cutting prices."

Others agree. Mr. Grote says B&L has maintained 20%-plus operating margins, and that its earnings growth will exceed 25% this year and next.

He and other analysts consider companies like Hydron, Revlon, Cooper-

Vision (either alone or as part of another company) and possibly Syntex Ophthalmics Inc. as potential survivors vis-a-vis B&L. But much depends upon how long some of the giant companies are willing to take losses. Some analysts such as Regina Widedenski of the Minneapolis brokerage firm of Adams Harkness don't see giant firms hanging on. But Mr. Grote disagrees: "I don't see them dropping out. They may all be willing to take the losses to hang in there long term because of the huge growth potential and the overseas opportunities." ■

TECHNOLOGY

Chinese cutting edge

Machining tools from mainland rated tops.

By LAD KUZELA/ When archeologists unearthed 4,000-year-old tombs in China, they discovered arrowheads, knives, and body armor made of a metal that is untarnished to this day.

No one knows what the metal is or how it was made, but equally mysterious to outsiders today is the metallurgy used by the Chinese in making steel-cutting tools that promise to revolutionize metal-chip-cutting technology. Already being used by a number of U. S. manufacturers, the steel tools are astounding experts because they are outperforming any other cutting tools on the market, including cobalt, in speeds and feeds. They also last much longer than other tools and don't heat up metals being cut, as other tools do.

The Chinese, of course, aren't saying how they make the steel tools so tough. The steel contains some unknown ingredients and appears to have been super-hardened by heat-treating methods. Also, the tools are designed with an improved geometry. Furthermore, they are priced 15% to 20% cheaper than other products. (UIS International Corp., Culver City, Calif., has been the exclusive U. S. distributor for the tools since 1980.)

THREE TIMES AS LONG. After measuring the performance of some Chinese end mills over a three-month period, Frank Pasillas, plant manager, Purkey Co., North Hollywood, Calif., found that they last three times as long as the best end mills he had been using.

Furthermore, the regrind time on the Chinese mills is "a lot less," thus

Zhang Yuan, vice chief-engineering, Qing Ping Cutting Tool Factory, and part of a Chinese industrial delegation visiting the U. S., checks some of his country's cutting tools.

INTERNATIONAL SCENE

GERMAN STATE'S INCENTIVES

North Rhine-Westphalia, West Germany's largest industrial state, has developed an incentive program to lure small and medium-sized companies interested in joint ventures, acquisitions, or establishing manufacturing facilities. Dr. Peter Gonschior, head of the Economic Development Corp. for the Dusseldorf-Cologne area, who will be in New York in November seeking U. S. companies, explains the incentives: "Beyond substantial tax incentives and other financial resources, our agency is providing active start-up aid on site construction, personnel recruiting, marketing, legal, and tax considerations. We can also be helpful in contacting major public-sector customers."

DRUG DEMAND TO DIP

Unlike other forecasters, Frost & Sullivan Inc. sees pharmaceutical markets in six European nations shrinking by a total of $2 billion by 1988. Government policies in West Germany, France, the United Kingdom, Italy, Belgium, and the Netherlands will fuel the decline, concludes the New York market-research firm. Forced to trim public expenditures, governments will have to abandon or curb certain public-health services; drugs once available for free will carry fees, trimming demand; large numbers of "de-listed" drugs won't be able to be prescribed at all; and government-negotiated price hikes will trail projected inflation rates, Frost & Sullivan seers predict.

GERMAN OPTIMISM

Helmut Kohl's West German government is cautiously optimistic about the future. Gross national product (GNP), it predicts, will rise by 2.5% annually through 1988. Inflation should run just over 3% a year, the government forecasts. However, this year probably won't display the growth gain expected earlier, says West Germany's Commerzbank. This spring's strikes in the metalworking and printing industries will cost the country 0.3 percentage points in GNP. Real growth for 1984 is now estimated at 2.7%, down from 3.0%.

BAD NEWS FOR U. S.?

When the World Bank held its annual meeting in Washington last month, its members had good cause for feeling a lot better than they had just a year before. Real economic growth is occurring at healthy rates among both industrialized and developing nations. And at least for the moment it appears that the worst of the international debt crisis—which has pinched U. S. banks and exporters—has passed. However, as World Bank President A. W. Clausen noted at the meeting, the world's poor countries still face serious problems: a possible 40% to 50% falloff in commercial-bank lending during the next decade, rapid population growth perpetuating poverty, and the poorest countries falling further behind other Third World countries in development. And for the U. S. that could translate into smaller developing-country markets for American exports.

EUROPE'S BILL FOR SERVICES

As U. S. firms with foreign operations already know, the cost of maintaining a salesman in Europe is not cheap. But the expenses don't stop with salary, travel, and entertainment. For example, a bilingual secretary in Zurich runs $18,750 annually. And a two-bedroom apartment in that Swiss city costs $820 a month, the heftiest tab in Europe. By the way, Oslo, Norway, is the priciest place for eating out; a meal for four will run $330. The least expensive? Surprisingly, it's Vienna, where a meal for four runs just $87.

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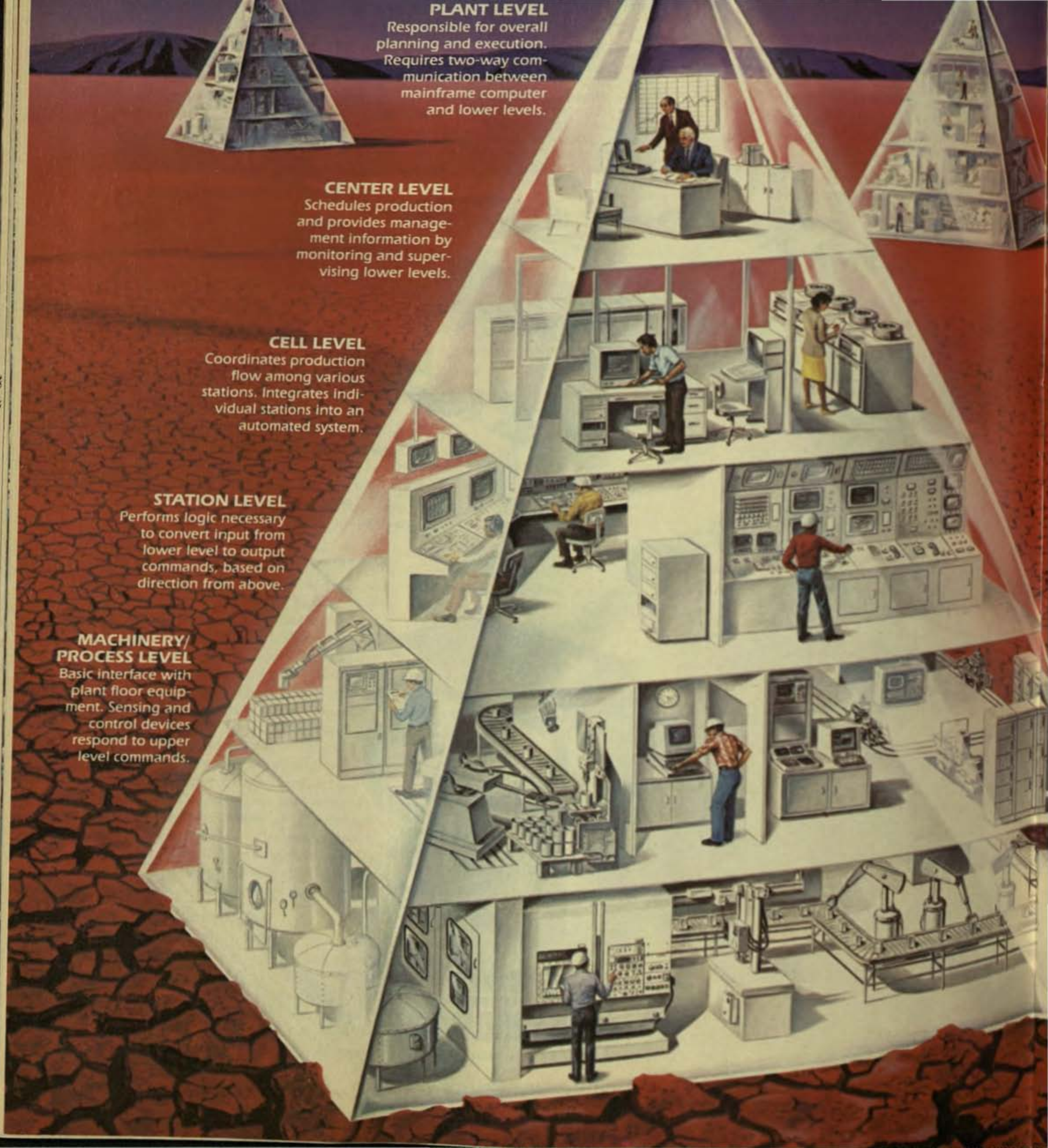
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CELL LEVEL
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STATION LEVEL
Performs logic necessary to convert input from lower level to output commands, based on direction from above.
MACHINERY/ PROCESS LEVEL
Basic interface with plant floor equipment. Sensing and control devices respond to upper level commands.

decreasing the downtime of a machine, adds Mr. Pasillas, whose job shop has been cutting metal parts for the aerospace industry for 25 years. He says he has Chinese end mills on about 25% of the 180 spindles operating in his shop. The machine tools are profilers and duplicators and cut some of the toughest metals, including a hard stainless-steel part being made for the supersonic B-1B bomber.

Another Los Angeles job shop, Standard Tool & Die Co., is starting to use the Chinese tools in production and in some cases has cut metal twice as fast with the foreign-made tools, says Norm Drascich, shop foreman. He believes that his cutting efficiency has been increased 40% and that the lifetime of the Chinese end mill is "definitely" longer. After the metal is cut, it is "barely hot, which is unbelievable," he notes.

At Bell Helicopter Textron Inc., Ft. Worth, William Murdock, a cutting-tool specialist, says he hasn't completed tests yet, but he is "impressed."

The cutting tools are made in China by a government ministry called the China National Aero-Technology Import & Export Corp. The line of cutting tools is called Air Arrow and includes end mills, drills, taps, reamers, tool bits, and files. ■

STEEL

Record pace for service centers

Unlike George Orwell's harsh predictions for 1984, the steel-service-center industry is enjoying unheard-of prosperity that may eclipse the previous record for shipments set in 1974 when the industry shipped 20.5 million tons.

Fourth-quarter shipments are expected to continue trends established in the first three quarters, and total 1984 shipments "stand a pretty good chance of setting an all-time record of at least 21 million tons," says Andrew Sharkey, president of the Steel Service Center Institute, Cleveland. Last year the industry shipped 17.7 million tons.

Two reasons for the record-setting pace:

1) Manufacturing was forced to rebuild inventories in the first quarter of the year, leading to record demand for the industry; 2) Steel centers now handle more than 30% of the carbon industrial steel made in the U. S., up from 20% in the mid '70s. This increase in market share is a result of the industry's ability to support innovative manufacturing techniques like just-in-time delivery, whereby customers are supplied with the exact quantity of steel they need, when they need it, and in the form they need it in.

LEVELING OFF, BUT. . . . "We reached record shipping levels in the first quarter.

"While the highs of that quarter have leveled off, monthly shipments remain substantially higher than they were one year ago," says William T. Gimbel, president, Reliance Steel & Aluminum Co., Los Angeles.

During the first seven months of this year, industry shipments were 30% above year-ago levels. Though they're above past years, shipments in July and August declined from the first-half rate.

The July inventory-to-shipment ratio stood at 4.25 months, with flat-rolled steel accounting for the biggest

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bulge. The inventory situation clouds an otherwise optimistic picture for the industry.

A gradual reduction of inventories to bring them into line with shipments continues to be a high priority for service centers in the final quarter of 1984. "My advice is don't dump your inventory if you can hold on to it, because when you come back into the market, prices are going to ascend quickly to higher levels," says Leonard Kasle, the institute's chairman and president of Kasle Steel Corp., Detroit. The average ton of inventory gained $40 in price between December 1983 and August 1984.

The steel-center marketplace remains very competitive because of the overhang of metal from both domestic and foreign producers. During the first seven months of 1984, about 14 months worth of steel imports came into the U. S. because of the then-pending trade action on steel taken by President Reagan, the institute reports. ■

TAXES

Execs say 'No' to surcharge

Reports from the prestigious New York-based Committee for Economic Development (CED), an influential group of 200 senior corporate executives and university presidents, usually are "gentlemanly." Their prose is carefully crafted. And dissents are restrained.

That is, until a nerve is rubbed raw, as it was last month when a majority of CED's Research & Policy Committee suggested that a temporary surtax on corporate and individual income might be tried as a "last-resort" measure to lower the bulging federal budget deficit—currently estimated at $174.3 billion. Three powerful executives on the panel took sharp exception to the proposal.

"Rather than recommending such a backward step away from desirable reform of our tax system, the CED should be recommending that if it is decided that additional revenue must be raised, the Congress should begin reform by building on extensive European experience and enacting a low-rate national value-added tax in 1985," bluntly dissented Jack F. Bennett, a senior vice president at Exxon Corp., New York. "There is no practical way to guarantee that an income-tax surcharge would be temporary," he insisted. And "there is no likelihood that a surcharge would be enacted in a form which did not intensify the inequities and disincentives of present tax law," stressed Mr. Bennett.

A tax surcharge definitely is the wrong policy direction, agreed Theodore Burtis, a dissenter who's troubled by the prospect of another U. S. economic slump. "Any major tax increase would likely coincide with the anticipated downturn in the business cycle, resulting in the possibility of yet another recession," stated the chairman of Sun Co. Inc., Radnor, Pa.

Finally, picking up Mr. Bennett's claim that a surcharge probably would not redress the deficiencies of the present tax system, Procter & Gamble Co. Chairman Owen B. Butler endorsed "a modest" consumption tax (a national sales tax, a value-added tax, or an excise tax) as the first step toward reform. "While this will not achieve tax reform, it will at least begin to move us in the right direction," Mr. Butler emphasized. ■


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EXCELLENCE IN MANAGEMENT AWARDS

From top: J. Peter Grace, June M. Collier, James G. Treybig, R. Gordon McGovern

Excellence in management can be measured many ways. The traditional yardsticks—profitability, return on investment, what the company's stock is trading at—are readily apparent. Positive numbers translate easily into recognition and reward for the chief executive.

However, society today is redefining what it expects of business. New rules are being imposed by government, and the heightened expectations of employees and local communities are changing the role of the corporate chief executive. Some CEOs are adapting to that new role, and establishing a new standard for excellence in management. Their efforts, however, are too often overlooked. Sometimes they are misunderstood and bring criticism rather than a pat on the back for the CEO because the payback to the corporation is not readily evident. Worse yet, too many CEOs try to ignore the shifts taking place in the business environment and go on with business as usual.

Corporate America has to get more involved in understanding and dealing with shifting societal attitudes. To recognize the efforts of CEOs who have accepted that challenge—and to stimulate others to do the same—INDUSTRY WEEK eight years ago established the Excellence in Management Award. The honorees are chosen in four categories: Those who have become involved in defending and explaining the private enterprise system; those who have reached for new plateaus of public service within their communities; those who have worked to bridge the gap between business and government; and those who have broken new ground in management's relationship with its employees.

This year's search for four outstanding CEOs began months ago when we invited readers to suggest corporate leaders for the honor. The IW Editorial Board then spent many days reviewing the nominees.

The four executives selected were honored at a luncheon at the Plaza Hotel in New York last week. Each was presented a distinctive glass sculpture, the Lalique Eagle, carved in France and mounted on an ebony base by Tiffany's. They are:

- J. Peter Grace, chairman and CEO, W. R. Grace & Co., New York, for outstanding efforts in improving understanding between business and government.
- June M. Collier, president and CEO, National Industries Inc., Montgomery, Ala., for outstanding efforts in promoting the private enterprise system.
- James G. Treybig, president and CEO, Tandem Computers Inc., Cupertino, Calif., for outstanding efforts in promoting a positive employee-relations philosophy.
- R. Gordon McGovern, president and CEO, Campbell Soup Co., Camden, N.J., for outstanding efforts in providing public service to the community.

As part of our salute recognizing their achievements, we present their stories on the following pages with the hope that other executives will be encouraged to follow their lead.

Our congratulations to each of them.

Stanley J. Modic
EDITOR

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J. PETER GRACE

Chairman & Chief Executive Officer, W.R. Grace & Co.

In recognition of your outstanding efforts to improve understanding in the relationship between business and government.

J. Peter Grace, chairman and CEO of W. R. Grace & Co., was lunching in his Manhattan office on Feb. 16, 1982, with publisher Rupert Murdoch when his secretary burst excitedly into the room. President Reagan, she interrupted, wanted to speak with him on the telephone.

"Come on, Cynthia, we are busy," he said, assuming she was putting on an act for Mr. Murdoch. But as he heard the President's soft, unmistakable voice on the receiver, Mr. Grace, who had never met Mr. Reagan, quickly realized the call was legitimate.

He was even more quick to say "yes" to the President's request: that he head a commission of business executives to recommend ways the federal government can save money.

For 71-year-old Peter Grace, the longest-reigning (39 years) CEO of a major U. S. industrial corporation, the unhesitating reply was characteristic. "Every citizen, whether he runs a company or whatever, if he has something to contribute to government, should do so," he declares. "Democracy is fragile. The more capable people have an obligation to exercise leadership."

That sentiment might well have been voiced by his grandfather, William Russell Grace, an Irish immigrant who became a successful businessman in New York, founding W. R. Grace & Co. among his other interests. Although fully occupied with his companies, the elder Mr. Grace agreed—upon being persuaded by New York Democratic party leaders seeking a candidate not identified with Tammany Hall—to run for mayor in 1880. He won, served two terms, and then returned to his businesses.

INVOLVEMENT

Unlike his illustrious ancestor, who'd had no previous background in government, Peter Grace has been active in public affairs throughout most of his business career.

In the 1950s he served five years as an adviser to the Eisenhower Administration on Latin America. (His expertise came from his company's then-massive interests in the region, including ownership of the Grace Line fleet that hauled cargo and passengers between North and South America.)

In the 1960s he served President Kennedy as chairman of a Commerce Dept. committee promoting U. S. private investment in Latin America under Kennedy's Alliance for Progress.

In the 1970s he spearheaded a campaign that helped enact the landmark 1978 law reducing the capital gains tax. W. R. Grace & Co.'s monumental study, the *Disincentivization of America*, and its costly series of ads in leading newspapers are credited with triggering a grass-roots letter-writing movement that put the legislation over the top.

And, early in the Reagan Administration, he ran a full-page ad in the *Washington Post* defending the President's 1981 tax cuts. This action caught the attention of the White House, no doubt paving the way for his selection as head of the commission, officially called the President's Private Sector Survey on Cost Control (PPSS).

BUSINESS COMES FOURTH. Although few CEOs have been as active in public affairs as he, Mr. Grace is heartened by the business community's growing involvement with government since 1945, the year he became W. R. Grace & Co.'s CEO following the incapacitation of his father.

"Businessmen I met as a young man were satisfied to be businessmen and nothing else," he recalls. "They didn't have to worry about the government, and they didn't hold much respect for government people. But now, government is so powerful that businessmen are betwixt and between whether they want to run Merrill Lynch or be Secretary of the Treasury. They're more open-minded about government."

Still, he frowns, "too many business people today are afraid to put themselves or their companies on the line—even on issues in which they believe strongly."

Mr. Grace doesn't hide his anger over refusals by several prominent CEOs to join his successful campaign to lower the capital gains tax. Even though they agreed that the cut would have enormous beneficial effects on capital formation, he says, they begged off for fear that President Carter "would get mad at them" and remove income tax credits for taxes their companies paid overseas.

"To me, that is not the proper attitude," he says. "First, you owe your allegiance to God, then to your family, and your country. Your business should come fourth."

Nevertheless, Mr. Grace praises business for its support of PPSS. To carry out the ambitious project, he organized 36 task forces, each assigned to probe a federal agency or function. The task forces were chaired by 161 top corporate executives who, in turn, loaned 2,000 of their managers to provide staff assistance. The panel came up with 2,478 specific recommendations of ways to cut waste and inefficiency. If implemented, PPSS calculated, the proposals would save the federal government $424 billion in three years and $1.9 trillion *per year* by the year 2000.

LOOKING TO JANUARY

In contrast with most commission reports that are soon forgotten after they're issued, PPSS's recommendations actually seem to be gathering momentum. By mid-July, the Administration reports, some 680 of the proposals either had been implemented or were in the process of becoming so. They add up to a three-year saving of $103.5 billion.

To be sure, the commission has not escaped controversy—or criticism. Both the Congressional Budget Office and the General Accounting Office have quarreled with the panel's cost-saving claims, providing ammunition for sharp attacks at PPSS from election-conscious congressmen. Even the White House's Office of Management & Budget has joined the sniping.

Yet, Mr. Grace is optimistic that, come January, the new Congress will take action on many of the proposals that were considered too politically sensitive to be adopted in 1984's election-year atmosphere. To help bring this about, Mr. Grace has authored a 195-page book, *Burning Money: The Waste of Your Tax Dollars* (Macmillan Publishing Co.), which was released Oct. 4.

Moreover, Mr. Grace is counting on an unlikely alliance with muckraking columnist Jack Anderson—a frequent industry critic—to put grass-roots pressure on Congress. The two men have formed a nonprofit organization, Citizens Against Waste, and hope through Mr. Anderson's column to amass millions of signatures on a petition opposing federal misspending. The petition will be presented to the newly elected President and Congressional leaders in January.

FOLK HERO. Certainly most of the credit for the acceptance so far of PPSS' report is due to Mr. Grace himself. Even though the commission completed its 18-month task last January, he has continued to spend an average of 30 hours a week promoting the recommendations. He is making more than 100 speeches on behalf of the project during 1984, besides an array of television and radio appearances, press interviews, and Congressional committee appearances.

All of this, along with rising public concern about the federal deficit, has made him something of a cost-cutting folk hero. His colorful personality helps. A one-time playboy (he reluctantly gave up a life of polo, sailing, fast cars, and girlfriends when he was thrust into the job of heading the family company), Mr. Grace is an individualistic blend of charm, crustiness, grace, pugnacity, wit, and ebullience. He even carries a gun, fearing terrorists who still link his company with South America.

So personal a stamp has Peter Grace put upon the war against government waste that the panel he headed has come to be popularly known as simply "the Grace Commission."

Of all his government-relations activities, the commission has been "the most all-embracing project," he comments. And he doesn't deny that it has rekindled his interest in government—an interest he admits had waned since the idealistic days of his youth.

"Frankly," he says, speaking primarily of Congress, "there was a higher caliber of people in government 30 or 40 years ago than now. Today the morality level is lower. Everyone focuses on winning at all costs; the end justifies the means."

A CABINET POST? A lifelong Democrat, Mr. Grace admits that he doesn't "know what the hell I am now" when asked his party affiliation. But he says he'll vote for Mr. Reagan next month. Not only does he believe the President would be more likely to push adoption of the PPSS recommendations than would Mr. Mondale, but he agrees strongly with the Administration's defense buildup.

Lifted into the limelight by his Grace Commission leadership, Mr. Grace has been mentioned as a potential cabinet officer in a second Reagan Administration. Would he serve if asked? "It would be a close call," he answers. "I like what I'm doing now."

Indeed, the W. R. Grace & Co. CEO seems to thrive on 18-hour workdays. His heavy, extracurricular PPSS workload often forces him to run his company through post-midnight telephone calls to the firm's executives—and he doesn't mind a bit. He pooh-poohs talk of retirement.

"If I thought I were holding back, I'd get out," he says. "But most of the people in the company are telling me, 'Hey, take the pressure off.' They don't think I'm slowing up."

Furthermore, his single greatest satisfaction has been work-related. That, he says, was restructuring W. R. Grace & Co. from a company almost totally dependent on uncertain, unstable Latin America to a viable, diversified, multinational conglomerate. So complete has been the metamorphosis that none of Grace's businesses in 1945, when he took over, is part of the company today. "Yet," he adds, showing his compassionate side, "we've been able to take care of the loyal employees we had working for us in Latin America."

For him, no accomplishment could surpass that—even if the government were to adopt all 2,478 of his Grace Commission recommendations. ■

[redacted]

"Too many business people today are afraid to put themselves or their companies on the line—even on issues in which they believe strongly."

JUNE M. COLLIER

President & Chief Executive Officer, National Industries Inc.

In recognition of your outstanding efforts to promote the private enterprise system.

Hers is the quintessential American success story. It is one, she would argue, that confirms the opportunity a person has to achieve great things under the U. S. private enterprise system.

Born to extremely modest means—she describes her childhood home in East Prairie, Mo., as "four rooms and a path"—and without a string of earned degrees after her name (she was graduated from high school at 16), June M. Collier is now president and CEO of National Industries Inc., a $100 million diversified manufacturer based in Montgomery, Ala. A one-time office manager for an electrical fabricating firm, Mrs. Collier also is a general partner of Pyramid Oil Co. in Montgomery and has business interests in broadcasting and commercial real estate.

She serves on the U. S. Commerce Dept.'s prestigious Industrial Policy Advisory Committee. She is the only person from Alabama on the Committee of 200, a select group of women business leaders. Mrs. Collier's radio and television show credits include the "Larry King Show" and Cable News Network's "Crossfire." She's addressed both houses of the Alabama legislature, testified before the U. S. Congress, and dined at the White House.

By almost any measure, June Collier has made it. She is firmly established as a leader in U. S. business. She commands respect from colleagues and competitors alike. She is a force to be reckoned with.

Because she knows full well the promise that private enterprise fulfills, she has been a tireless advocate of the system. She averages eight to ten speaking appearances a month; and whether she is talking to the media, politicians, a school group, a service club, employees, a trade association, or other business executives, chances are that June Collier will be extolling the virtues of private enterprise or raising warnings against forces which, she fears, weaken its foundations.

"Free enterprise is a lot simpler than the economists and the professors would have you believe," she tells a group of students. "Free enterprise is the right we all have to perceive a need in the marketplace and then figure out a way to fill that need. Free enterprise includes the right to make money and the right to go broke. It's what allowed us to take National Industries and make it into the largest private employer in central Alabama. It's the same thing that let us move from a colony in the early 1700s to the greatest power in the world in less than 200 years."

TRADE 'TIGRESS.' June Collier speaks her mind—deliberately and effectively. Paul M. Weyrich, a politically conservative columnist and director of the Committee for the Survival of a Free Congress, Washington, approvingly terms Mrs. Collier "The Tigress of Trade" for her controversial call for a 20% tariff on all imported manufactured goods. That levy would, she asserts, preserve American jobs and businesses by offsetting the comparatively cheap cost of labor overseas. She is convinced that "free trade"—including the free-trade policies espoused by the Reagan Administration—is steadily eroding America's industrial base.

June Collier fully appreciates that proposing a tariff brands her advocate of protectionism—a philosophy contrary to the traditional definition of a "free enterpriser." She contends, however, that the two issues must be separated. Free trade is not free enterprise, she insists. "They are not even kissin' cousins," she adds in a light southern drawl.

She does not favor quotas which, in fact, would keep foreign goods out and constitute "protectionism" as she defines the term. Tariffs, she points out, allow goods to come in but equalize the labor-cost advantage that foreign producers now enjoy.

Free trade, she emphasizes, must be recognized as one of the misguided notions that are undoing the U. S. private enterprise system.

The U. S. government, following the free-trade drummer, "is trying to give the world the benefits of the free enterprise system without any of the responsibilities that go along with it," she asserts.

American companies, operating under the disciplines of our system, have to play by the same basic set of rules, she observes. Not so for foreign firms, she says; they dont't have to conform to our rules and regulations. And "even the best-run American companies cannot compete against companies that do not have the same restrictions as ours do," she states. "When we give foreign competitors the right to play by *their* rules in *our* marketplace, we have set up our economy for failure.

"We are trying to raise up the lesser-developed countries, but we are only lowering ourselves," she asserts. "We are paying the price for our generosity in higher taxes and unemployed people—and we are losing our industrial base in the process," she insists. "If we are weak, with no industrial base, what are we going to do?" she inquires. "Who is going to be the hope of freedom in this world?"

MINIMUM GOVERNMENT ROLE

It would be easy to dub June Collier a latter-day "America Firster," an isolationist. And it would be incorrect.

Though she might not fully appreciate the compliment—for she claims to prize things simple—Mrs. Collier is far too complex and sophisticated a person to be adequately—or accurately—characterized by such expressions.

For instance, her ringing defenses of the American private enterprise system—and they have been legion over the last several years—contain an unexpected twist. June Collier admits that government has a role to play in regulating business.

"Free enterprise presumes that the government has no place in the private marketplace, except as a sort of referee to make sure everybody plays by the same rules," she says. "[But] when government exercises even a *valid* function in the private marketplace, that means the system is no longer completely free. There is no such thing as a 'pure' marketplace or 'total' freedom . . . nor would any of us really want it. What we must strive for is a *minimum* government role in the free enterprise system."

As an example of a "valid" government function, she cites the antitrust laws. "At one time we were a little guy," she notes, an allusion to the fact that 21 years ago National Industries had seven employees and about $250,000 in sales. "Were it not for antitrust laws when we started rattling people's chains, National Industries would not be in business [today]," she states. "And when you even relax the antitrust laws at all, you are going to knock out small business—which is absolutely the cornerstone and strength of this nation. Small business keeps the *Fortune* 500 honest!"

Neither does Mrs. Collier have a problem with government intruding into the marketplace to protect people from inpure food and drugs. "In a purely free market the maker of a dangerous drug would eventually go out of business—but maybe hundreds or thousands of people would die before everybody got the message that, perhaps, that drug was not the best remedy on the market," she says. Government intervention in such a circumstance is reasonable and responsible—though it makes the system less free, she believes.

However, June Collier is critical of what she views as *unreasonable* government intrusions into the private sector.

Unreasonable wage rules really irk her. When government weighs in and states that all workers are worth the same amount of money regardless of the quality of work they produce, both the business owner and the worker suffer, she argues. Whether the "owner" is one person or a million stockholders, the freedom to run the enterprise is eroded when government steps in, she says. And unreasonable wage rules tell the worker that "there is no longer a premium on quality," she claims. "It takes him out of the profit loop—at least in the short run. He doesn't work as hard, because it doesn't matter to his paycheck how hard he works," Mrs. Collier says.

"As a result, productivity goes down, profit goes down, prices to the consumer go up, not as many people as before can afford to buy the product, fewer products are sold, the companies that used to make the products close plants, the employees who used to be in those plants are out of work, [and] government has to tax more heavily the people who still have jobs," she reasons.

'NO STAKE.' It is important to remember who the rulemakers are, June Collier emphasizes. They're mainly people without a direct stake in the smooth functioning of the private enterprise system—people who "think they have no stake in profits and losses," she says. These are people "who are concerned with the smooth operation of government, not industry."

It would not be overstating her position to say that Mrs. Collier sees misguided trade policies and unreasonable regulations as posing a "clear and present danger" to the American private enterprise system.

"We used to feel that government's role was to support our economic system, to be a referee," she says. "Government was supposed to do those things that would allow things to flow smoothly."

In contrast, "now . . . we seem to feel that government is the reason that the system exists, and that the system's function is to make government's job easier," she states. "instead of government supporting free enterprise, it's now free enterprise that supports government."

Too often, the people who make the rules and write the regulations in government forget that private enterprise is a concept that goes beyond a single company or an individual industry, she states. "It's the underpinning of our whole social system."

And so, "whether you go into manufacturing, or farming, or mining, or a service industry, or government, you have a responsibility to the system of economics that has made this nation what it is," she says. "If we all understand that, we can start identifying some of the dangers to that system, and we can work to eliminate them."

Whether or not you agree with June Collier's conception of the U. S. private enterprise system—its promises and problems—there's no denying that she makes you think. And that may be the best kind of promotion the system can have. ■

"We used to feel that government's role was to support our economic system, to be a referee . . . Now . . . we seem to feel that government is the reason that the system exists . . . . Instead of government supporting free enterprise, it's now free enterprise that supports government."

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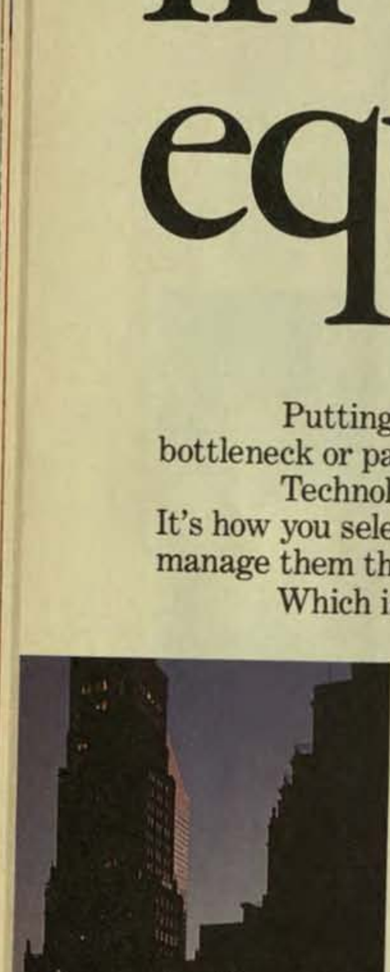

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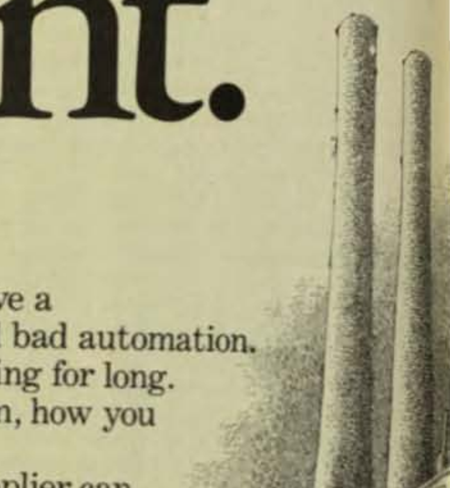

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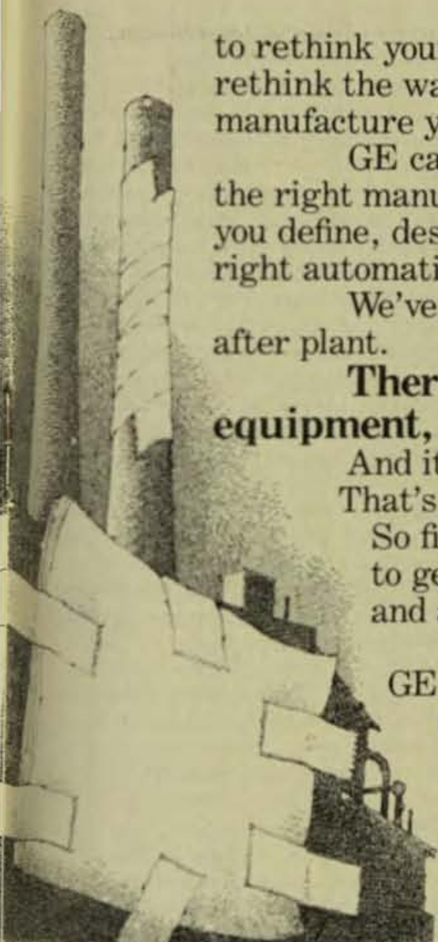

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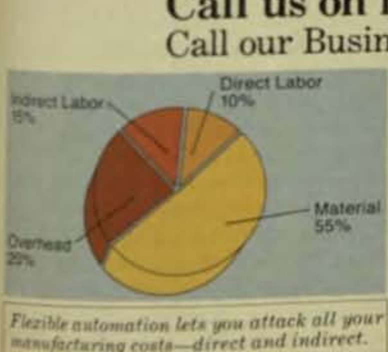

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FOR INFORMATION, CIRCLE NO. 15

JAMES G. TREYBIG

President & Chief Executive Officer, Tandem Computers Inc.

In recognition of your outstanding efforts in implementing and maintaining sound employee relations.

Silicon Valley is a 30-mile strip about an hour's drive south of San Francisco. More important, it's also of course where much of the country's leading-edge computer technology, the work of ingenious and furiously industrious entrepreneurs, originates. In the popular imagination, Silicon Valley now represents no less than the American Dream in action, replete with the usual Horatio Alger cast of bigger-than-life characters.

One of the most inspiring Silicon Valleyites is a 44-year-old engineer with a gift for seeing the open window in already crowded markets. The window that James G. Treybig, now president and CEO of Tandem Computers Inc., Cupertino, Calif., perceived some ten years ago was the on-line transaction-processing market.

Back then, Mr. Treybig served as marketing manager of Hewlett-Packard Co.'s computer division. The window began to open during his work on a project for Holiday Inns Inc. "The company wanted a computer that would run big hotel sites," reflects Mr. Treybig, explaining that the hotel chain sought to replace a cumbersome arrangement of standard minicomputers linked together.

The future Tandem chief sensed that other companies had a similar need. He tinkered with the numbers a bit and tallied up a market worth potentially $350 million. "And it was a 'sell' market—not a 'rental' market. It looked as though you could grow a big company real fast," recalls Mr. Treybig.

His instincts told him that banking, manufacturing, and communications operations also were about to enter a period in which they would need to automatically capture, update, process, and deliver voluminous amounts of information.

Mr. Treybig left Hewlett-Packard and took a job at Kleiner & Perkins, a San Francisco-based venture-capital firm. (The Kleiner of Kleiner & Perkins, incidentally, was a former Hewlett-Packard general manager who invited Mr. Treybig aboard specifically to provide him with the time and resources he needed to prepare his business plan.) As a part-time venture capitalist, Mr. Treybig, who is a Stanford M.B.A. graduate, was impressed early on by a harsh lesson in the creation of new businesses. He saw "start-ups flourish and then suddenly flounder when key people left because they weren't treated right."

Mr. Treybig—most people call him Jim—realized that making his idea go and grow required good people. He became determined to give Tandem "a people philosophy" that would make it a great place in which to work.

Tandem began in 1974 with four employees sharing a tiny office. Today the company employs 5,000 people in 30 countries—with 80 locations in the U. S. alone. Last year, its revenues totaled $418 million—enough to make Tandem the nation's 500th-largest company.

"The key to success is to involve *every* employee in the company," notes Mr. Treybig, his voice sometimes dropping into the south-Texas accent of his upbringing. "You've got to stay close to your employees and make them feel they're important—that the company cares."

OPEN DOOR. Tandem's philosophy is to keep the lines of communication open; to keep the creative juices flowing; and to foster strong professional and social bonds. Matching its words with deeds, Tandem has a tradition of sharing the wealth. Every year each employee receives stock options. In 1983, employee stock purchases contributed $25 million to Tandem's coffers. And every four years each employee is awarded an extra six weeks of vacation in the form of a sabbatical leave.

Characteristically, Mr. Treybig is quick to point out the help he has had in creating such programs. "We are lucky to have a good board of directors who value people and think they are important. A lot of presidents might have these ideas but their boards might not support them."

Besides financial remuneration, Mr. Treybig believes in the power of communications to create the homogenous will, purpose, and direction that a company needs to sustain initiative. Basic to this belief is the approach of structured and unstructured communication, the latter spanning job functions with no impeding hierarchy. "Structure is good when you want to give direction, but it's no good for creativity," declares Mr. Treybig, explaining the limitations of organizational charts.

To shake that structure, the company has initiated a number of programs. The most novel, perhaps, is its TV network. The company has placed satellite earth stations—at a cost of $6,000 each—in most of its U. S. offices and in Canada.

Within 30 minutes, Mr. Treybig or any of his management team in Cupertino can be on the air to other Tandem sites. The cost: about $400 per hour. (It's not surprising, then, to discover that Mr. Treybig is an inveterate ham—radio operator, that is. His idea of getting away from it all is to lug his gear to some remote island, say, off the coast of Africa, to work the airwaves.) Every year, the day before the annual meeting, the Tandem management team broadcasts an extensive briefing to employees on what will be said during the formal meeting the next day. And throughout the year the closed-circuit network provides technical updates, news of financial performance, and other information.

"We want interaction," Mr. Treybig explains. "No one has all the answers. And good exchanges can help clear the air and clarify issues."

For example, a recent program dealt with the subject of how to better control expenses. One aspect centered on getting the least expensive routing for airline fares. "We haven't found the answer yet," admits Mr. Treybig.

To encourage interaction, employees may submit their questions anonymously.

CREATING SOLUTIONS

Another communications avenue is the company's electronic-mail system. "Mail is an integrator of people over distance," says Mr. Treybig. Unlike many companies in which only management or a development team can use electronic mail, everyone at Tandem can send electronic messages. "A person can say 'help' to 5,000 people," notes Mr. Treybig. "And, instantly, everyone knows what the problem is—and that kind of joint experience will call up a lot of possible solutions."

It can also put a crimp in a new management plan. A new vice president recently sent out a new company policy via electronic mail and, that very same day, received over 400 messages—all against it. "He said he believed in our 'people philosophy,'" laughs Mr. Treybig, "but it would take awhile to adjust to this democracy."

Another program that involves unstructured communication is TOPS—for Tandem Outstanding Performers. Throughout the year, 7% of the company's best employees gather at a resort in groups of 70 or 80 to get to know each other and to discuss problems. It's a cross-functional meeting at which an assembler, for instance, can talk to an accountant or a sales person or any one of the company's 12 top managers who are present. "Then I can hear it the way it is. There's nothing standing between me and what an assembler or a clerk sees as going on," says Mr. Treybig. "That keeps me in touch."

But the most popular event is the company's weekly beer blast—or "popcorn party," as it's now sedately called. Each Friday, from 4:30 p.m. to 6:30 p.m., everybody at the firm's headquarters gets together socially. The beer and popcorn cost the company about 50¢ per person, a bargain for the good will it brings. Many good ideas have been passed along and also, occasionally, some abuse. "One day a guy walked up to me," remembers Mr. Treybig, "and chewed me out for 30 minutes. And he was right. He was frustrated, and for a good reason." Mr. Treybig smiles in his down-to-earth manner and adds: "And I have a chance, of course, to give it back. I'm not hesitant to do that."

Each of these programs encourages the company's two fundamental goals: quality and productivity. At its Austin, Tex., plant, as at the others, these programs are combined with weekly and daily participatory-management meetings that deal with specific issues such as quality.

The Austin plant is a "paperless" factory in which all incoming materials are inventoried and tracked by computer. Each employee workstation has a computer that will give an employee feedback on just how well a part is performing at each location. "The terminal," reflects Mr. Treybig, "becomes the tool of the worker—not a tool of management to monitor the worker. I think we provide leadership in this area."

But even the most enlightened CEO must acknowledge a sad fact of business life—letting people go. The one area of the company's people philosophy in which Mr. Treybig feels there is still much work to be done is firing. In a sense, Mr. Treybig feels that Tandem is a victim of its own policies. "In general, we don't let people go," he says. "And generally, people don't want to leave because we have such good benefits." That can be a big problem for an entrepreneurial company. Says Mr. Treybig: "There are people who are wasting their lives here. Either they don't have the capabilities, or they don't work hard enough. The problem is: how do we help people to leave when they no longer have a career here?"

Though the company has a process for firing, and Mr. Treybig believes it protects the rights of the employees and assures all of fairness, "We don't do it really well," he laments. "It's something we are still learning. I don't ever want to *like* firing," he adds, "But then, if you don't fire, you will never be a good manager."

How does Mr. Treybig see himself? He says he thinks he is good at strategy, at seeing trends and windows, at creating enthusiasm, and "at attracting people better than myself."

In fact, Mr. Treybig believes that good hiring is a key to keeping the company healthy, and he regularly interviews two or three job candidates each week.

But what makes Jim Treybig so successful? Part of it is that he genuinely likes and cares about people. And that, in part, is what makes Tandem so successful, too. ■

[redacted]

"You've got to stay close to your employees and make them feel they're important—that the company cares. . . . We want interaction. No one has all the answers. And good exchanges can help clear the air. . . ."

R.GORDON McGOVERN

President & Chief Executive Officer, Campbell Soup Co.

In recognition of your outstanding efforts in public service, reflecting a sense of corporate responsibility to the community.

R. Gordon McGovern strides purposefully through the corridors of LaGuardia Airport just as he might walk the halls outside his office in Camden, N. J. It's not surprising, really. The president and chief executive officer of Campbell Soup Co. spends more than one-third of his time traveling, which often makes an office out of bustling airports.

At 58, Mr. McGovern has headed the 115-year-old food company for three years, spending a hefty portion of that time visiting tomato fields, packaging plants, regional offices, and supermarkets worldwide. He has met virtually every employee at the company's Camden plant, to say nothing of the vast sales teams and distributors he regularly sees.

With a schedule that often keeps him far from his desk, Mr. McGovern seemingly would have little time for anything not related to managing his company's 1,000-plus products—more than 100 of which have rolled out during his short tenure. Yet somehow, the smiling, confident Mr. McGovern keeps several burners going at the same time; and on one simmers a community-relations program that has attracted national attention.

Why spend precious time and money on projects that don't sell food? Part of the reason is Mr. McGovern himself. He self-consciously concedes that the label of "maverick"—which employees and the press pin on him—is accurate. Indeed, stories about his battered Volkswagen Beetle are famous: it seems his car was so conspicuous in the executive parking lot that one day it was mysteriously given a fresh coat of paint. "The old car never looked better," he recalls.

But Mr. McGovern is quick to point out that, in his case, being a maverick is nothing more than being creative and open-minded. His marketing techniques at Pepperidge Farm Inc., a Campbell subsidiary, got him noticed—and later promoted—by the board of directors. And that maverick style, based on new ideas, helped to develop a diverse, and what he calls a "responsive," community-relations program. Under Mr. McGovern's guidance, Campbell Soup has initiated a host of programs, including:

- A company-subsidized day-care center at its Camden headquarters for children of employees and other local companies.
- A health and fitness program for employees that cost Campbell Soup more than $700,000 to inaugurate.
- An improved maternity-benefits package that includes parents who adopt children.
- A grant of $125,000 for the Camden City Summer Program in 1983, which gave more than 5,000 community youths employment and recreation opportunities.
- Donations of more than $1 million in food products during 1983 to food programs across the country.

But, clearly, the company's time and contributions have not blunted its bottom line. Net sales in fiscal 1984 rose 12% from fiscal 1983—from $3.3 billion to $3.7 billion. At the same time, net earnings jumped 16%, hitting $191 million versus the preceding year's $165 million. Similarly, earnings per share increased from $5.12 to $5.93. And the active, shirts-sleeve role that Mr. McGovern has found to be successful in helping to boost sales and earnings has also found its way into the company's community programs.

CIVIC BOOSTER. Campbell Soup—and Mr. McGovern in particular—have taken an active role in working to improve the city of Camden, an economically depressed suburb of Philadelphia. Mr. McGovern, for example, is chairman of the Cooper's Ferry Development Assn., a group dedicated to upgrading land and real estate along the city's waterfront area. The $100 million project is slated to develop a large office and research complex, a retail center to support the business center, and a moderate hotel facility for visitors. Campbell Soup also supports local Boy Scout camps, contributes to area educational scholarships and institutions, and, perhaps most important, maintains its headquarters in Camden at a time when many companies have pulled out of depressed locations.

"I can't really imagine us leaving," says Mr. McGovern. "There are some pretty bad areas here, but I think corporations have a responsibility to help people and the cities. You can't solve a city's problems by packing up and running away."

At the same time, Mr. McGovern acknowledges that the reasons why Campbell Soup involves itself in these projects are not wholly altruistic. There is a pragmatic side to this maverick: "The programs that benefit Camden also work to the benefit of Campbell Soup," he says. By developing a positive image for the company and creating pleasant working conditions, Mr. McGovern hopes to keep attracting quality employees to Campbell Soup. The new community day-care center, for example, provides working mothers with a nearby place in which to safely keep their children. The company offers most employees the convenience of "flex-time," enabling mothers to visit their children on breaks. "It not only helps our employees with important parts of their lives, but also improves productivity. Mothers aren't spending as much time worrying if their children are safe and happy. They can go see for themselves," Mr. McGovern says.

Moreover, the considerable sum devoted by the company to its new physical-fitness program can also be seen as a benefit to the company; it boosts company morale and lowers medical-insurance costs. "It's by far our most popular program. We can't accommodate all the people who want to take part," he says, emphasizing that the saving will make up for the initial costs of the program. "We think it will come back in spades."

SMART BUSINESS

Perhaps some people think that the glitter of community programs dulls somewhat when they're linked so obviously to corporate well-being, but not Mr. McGovern. As he explains it, it's just a fact of business life. A company is primarily responsible to its shareholders for maintaining a strong company and stable profits; and one of the best ways to achieve that goal, he says, is to create programs for employees and the community that improve the quality of life. "It's good business," he says.

It's also smart business. It improves the corporate image—so important to a consumer-oriented company—furthers the symbiotic relationship between the community and the company, and offers opportunities to the area that it might not otherwise have, such as the day-care center. "If all [these programs] were left to the government, I doubt if Camden would have these benefits available," Mr. McGovern says.

Yet, Campbell Soup seems to be more than a community benefactor. Its adoption program is one of the first in the country started by a company. And some of its other programs also have a broad impact. They reflect more the CEO's maverick side than his pragmatic one: it is Mr. McGovern's forward thinking that resulted in Campbell's recognition by *Savvy* magazine as a company that provides excellent opportunities for women. Mr. McGovern hired the first two women vice presidents in Campbell's history and is in the process of hiring others.

The company has also embarked on a program to ease the plight of migrant workers at farms where it—and other companies—obtain produce. In Ohio, for instance, the housing requirements for migrant workers on farms with Campbell tomato contracts are more stringent than the state's own codes. A company spokesman says Campbell paid half of all the construction costs and loaned the remaining 50% to farmers at low-interest rates. Additionally, Campbell has started a pilot health-insurance program for migrant workers that will run throughout the 1984 harvest. Finally, when Campbell recently slimmed its pudgy "Campbell kids" to reflect the growing awareness of healthy diets in America, it instituted a "fitnessgram" for school-age children that encourages them to engage in a variety of exercises. The youngsters involved receive a computerized report card assessing their scores.

OPEN DOOR, OPEN MIND. While many of the details of Campbell's community-service programs are handled by Ray Page, vice president for community relations, it's clear that Mr. McGovern's philosophy and management style are the wellspring of much of the programs' energy. The extensive communication with every department at Campbell that takes up so much of Mr. McGovern's time also gives employees a chance to express their views and ideas.

"In fact," Mr. McGovern says, "it was at one of these small sessions, with about 20 people, that the idea for the day-care center first came up. One of the women suggested it and we said, 'Well, why not? We might as well take a look at it.' We never dreamed it would be this successful.

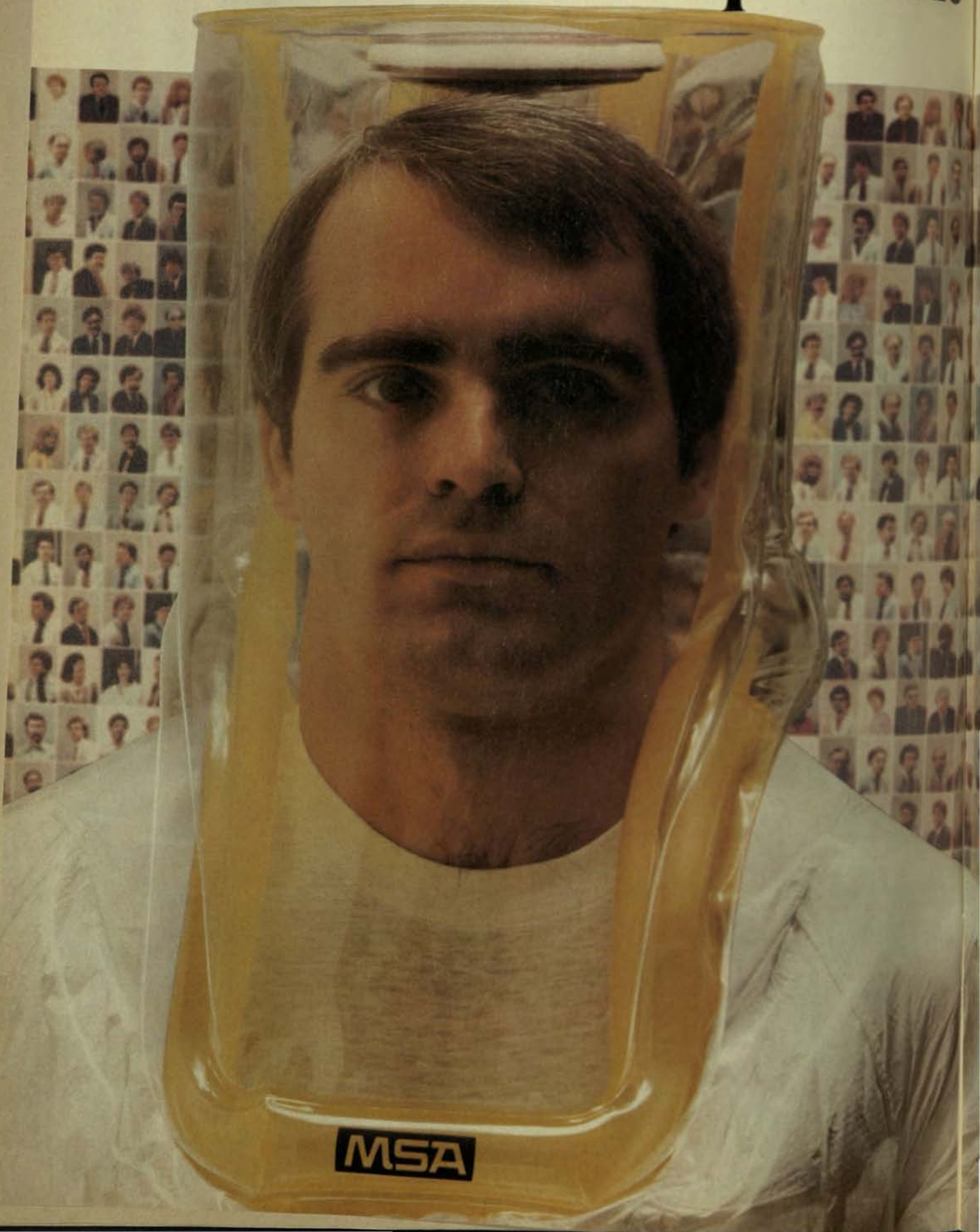
"I think a good communications policy, a kind of open door, is essential to any company. A manager can never afford to cut himself off from the ideas of his employees. You have to be able to listen—and to accept new ideas if they can benefit the company and the community in some way," he says.

While Mr. McGovern concedes that Campbell Soup is not the only company that employs good communication to its advantage, some companies seem less aware of its importance. And one clue might be found in the products a company markets. "As a company that manufactures and markets food," he says, "we have to be very consumer-oriented. We are always out there talking with consumers, with regular people, and finding out what they like and don't like, and what their concerns are. We have to be able to respond to their needs to keep our products up with the times."

It is perhaps this same philosophy—a necessary ingredient in the company's marketing recipe—that has influenced Campbell Soup's community-relations program. As Mr. McGovern says: "If you go to sleep in this business, you die pretty quick. Keeping on your toes is what keeps you alive." ■

"I think corporations have a responsibility to help people and the cities. You can't solve a city's problems by packing up and running away. . . . You have to be able to listen—and to accept new ideas if they can benefit the company and the community in some way."

MSA tells who is responsible



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EXECS RATE THE CANDIDATES

One politically prominent CEO will probably sit out the 1984 Presidential election. But most business executives have picked their tickets. Reagan scores points for his management "style."

Photo: Stephen Brown/Picture Group

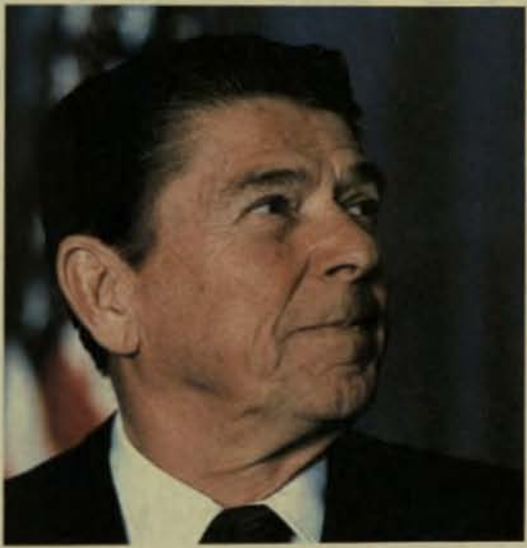

Photo: Shepard Sherbell/Picture Group

By JOHN S. McCLENAHEN

If Congoleum Corp. Chairman and CEO Byron Radaker, usually an enthusiastic Democrat, remains disgruntled, neither former Vice President Walter F. "Fritz" Mondale nor President Ronald W. Reagan is likely to capture his vote on Nov. 6. In fact, Mr. Radaker very well might sit out the upcoming Presidential balloting—just as he did in 1980.

"I am sort of on the horns of a dilemma," confesses a clearly discouraged Mr. Radaker. Walter Mondale, the executive asserts, "is straight out of the past"—rekindling the liberal throw-money-at-problems approach, "which hasn't worked." Yet, at the same time, Mr. Radaker insists it'd be difficult for him to "overtly support" the Republican ticket of Reagan and Bush. "I'm not sure they're where my heart is, either," he says.

Mr. Radaker appears to be a rarity among top U. S. business executives who are willing to talk about their Presidential preferences. Few are as dissatisfied with the candidates as he. Most are comfortable in rallying behind either President Reagan or Mr. Mondale. (Several senior executives, however, declined to be interviewed.)

E.M. "Del" de Windt, chairman and CEO of Cleveland-based Eaton Corp., will vote for President Reagan "because he deserves reelection." Inflation is down, government spending has been slowed, and taxes have been lowered, he observes. "If Reagan can be given a second term, and a more like-minded Congress can also be elected, the nation will experience the full benefit of the ideas he introduced so successfully three and one-half years ago," says the Eaton executive. "It is a question of national direction. Reagan is leading the country in the right direction."

Mr. Reagan's conservative course also draws approval from Robert H. Malott. Echoing the President's acceptance speech at the Republican National Convention in Dallas, where he was an alternate Illinois delegate, the hard-driving chairman and CEO of FMC Corp., Chicago, contends that the U. S. "is presented with the clearest political choice in half a century."

Because the President and the Vice President have vigorously supported private enterprise, deregulating business, and encouraging entrepreneurs, "I am totally supporting the Reagan-Bush ticket," matter-of-factly declares Robert A. Mosbacher, chairman of Mosbacher Production Co., a Houston-based oil and gas firm.

STYLE. Mr. Reagan can count on the votes of Boise Cascade Corp. Chairman and CEO John B. Fery and Empire of America FSA President and

lation from point of view.

We're writing more on-time guarantees than we ever have in the past. We're offering price incentives. We're even negotiating contracts with companies who operate their own trucking fleets.

We've got the ammunition.

It's 1984, our guns are loaded. We can go against trucks almost anywhere a truck travels. Interstate 5 between Portland and Los Angeles, for instance. Eight-hundred-and-fifty-thousand semi's roll on this highway a year.

Our goal is to quadruple our business in the corridor. Our strategy is straightforward: to reduce the cost of transportation to customers; and to guarantee on-time deliveries, every day of the year.

A two-pronged attack.

We're accomplishing our goal by servicing both ends of the I-5 corridor.

Southbound, our intermodal speed train, a 35-hour express, is breaking every record in our book. We introduced it in February. Today, it's hauling five thousand tons of freight a week.

Northbound, our box car program flies in the face of conventional railroad thinking. "Dispatch empty equipment to its original point of departure" has been a rule of thumb since before we fired a steam engine in the Willamette Valley more than a hundred years ago.

Recently, we worked out a competitive arrangement to challenge that philosophy. As a result we've consummated 102 one page contracts since the middle of last year. We're now shipping to Portland a potpourri of consumer goods—diapers to tires, detergent to tuna—business that hasn't seen the inside of a box car along I-5 in nearly two decades.

We're coming to you.

Our I-5 Program and our Intermodal speed train are succeeding against trucks in the Pacific Coast Corridor. They are examples of what we're accomplishing throughout the system. Working every hour of every day we're satisfying our customers.

John Breen, Los Angeles Manager for Intermodal sales, sums it up beautifully:

"I don't care how trivial a customer's problem might be to someone else, *I'll* solve it."

Southern Pacific Transportation Co.

CEO Paul A. Willax—in part because these seasoned executives like the President's management style.

That's an assessment that undoubtedly will raise the eyebrows of some business colleagues who have read that the President is not sufficiently involved in issues or those who saw Reagan aide Michael Deaver confess on television that the Chief Executive sometimes dozes off during cabinet meetings.

Be that as it may, the President "does a very good job of pacing himself," believes Boise Cascade's Mr. Fery.

"You've got a manager in there with a style that befits the needs of The Company right now," says Empire's Mr. Willax. Mr. Reagan is an effective manager because he's a good actor, argues the Buffalo, N.Y.-based savings and loan association president. "He has an ability to judge the audience, the progress of the play, the message he's trying to get across, [and] the effect he's having on the various people who are involved in this thing," states Mr. Willax. "I'd hate to see that style interrupted," he says.

MONDALE MEN

The President's acting ability doesn't figure in Harry A. Jacobs Jr.'s choice for President. The chairman of Prudential-Bache Securities Inc., New York, will pull the voting-booth lever for Mr. Mondale because he believes the former Vice President will be better for business—at least *his* business. Mr. Mondale is more likely than Mr. Reagan to reduce federal-budget deficits which, in turn, will cut interest rates, improve the function of the nation's capital markets, and stimulate the securities business, reasons Mr. Jacobs, an active Democrat for the last 12 years.

Democrat Don L. Gevirtz, chairman and CEO of Foothill Group Inc., finds the former Vice President, whom he's known since 1974, "extremely well-trained and experienced" for the Presidency. And the Los Angeles venture-capital firm chief is particularly impressed with Mr. Mondale's proposal for eliminating capital-gains taxes on investments in small companies. It's an "innovative" approach that "would help create a better environment for entrepreneurs," asserts Mr. Gevirtz.

Irving S. Shapiro, who retired as chairman of DuPont Co. in April 1981, worked closely with Mr. Mondale when the Minnesotan was Vice President. Mr. Shapiro was then also chairman of the Business Roundtable, a prestigious group of business leaders concerned with national and international issues.

Mr. Shapiro recalls being favorably impressed with the former Vice President's "personal qualities and his basic political philosophy."

And now, "while I don't agree with all of his policies, I think, on balance, he holds the greater promise for an effective Administration," says Mr. Shapiro.

When the country renders its collective judgment, in just three weeks, votes cast by these and other executives will certainly be influenced by the candidates' views on business-related issues. At right is a synopsis of their positions. ■

FISCAL POLICY

REAGAN Seeks inflation rate no higher than 3.5% by yearend 1989. Would increase taxes in 1985 only as a last resort. Favors "balanced-budget" constitutional amendment and Presidential line-item veto for appropriations bills. Will receive Treasury Dept. report on tax reform *after* the 1984 election. Is implementing a six-year program to boost government efficiency. Has established council to reduce government fraud, waste, and abuse.

MONDALE Vows to cut the projected fiscal-year 1989 deficit ($263 billion) by at least two-thirds (to $86 billion). Expects to raise taxes in 1985. (Mr. Mondale is contemplating a 10% personal income tax surcharge on upper-income individuals and a 15% minimum corporate income tax.) Would eliminate the capital-gains tax on long-term investment in small businesses and on gains that are rolled over into new small businesses. Favors "equitable" tax reform.

EMPLOYMENT

REAGAN Expects 1 million people to be trained annually for private-sector jobs under the 1983 Job Training Partnership Act. Supports a sub-minimum "Youth Employment Opportunity Wage" for summer jobs.

MONDALE Proposes a new jobs bill—which would include community and public-service jobs—to boost employment among youths and adults generally and to improve opportunities for women. Pledges "ambitious" programs to retrain displaced workers.

DEFENSE

REAGAN Pledges that defense outlays will rise to 7.7% of gross national product by 1988. Will build 121 new ships. Seeks "limited" deployment of MX "Peacekeeper" missile in existing Minuteman missile silos. Wants 100 B-1 bombers operational by 1988. Will continue research and development of advanced-technology "Stealth" bomber. Opposes nuclear arms freeze. Promises to meet Soviets "halfway" in getting arms-reduction talks moving again.

MONDALE Supports moratoriums on the testing and deployment of space weapons and new strategic missiles. Would halt the testing of anti-satellite weapons and the deployment of nuclear-armed, sea-launched missiles. Supports a "mutual and verifiable" nuclear freeze. Opposes production of the MX "Peacekeeper" missile, the B-1 bomber, and poison nerve gas. Supports "Stealth" bomber development. Opposes new nuclear aircraft carriers. Wants annual meetings with Soviet leaders.

TRADE

REAGAN Generally advocates "free trade" principles, but has protected the auto, textile, and steel industries. Is counting on his three-year tax-reduction program (the 1981 Economic Recovery Tax Act) and continued government deregulation of business to improve U. S. competitiveness overseas. Is promoting a new round of international trade negotiations (specific agenda not yet clear). Seeks an agreement with America's Western allies to restrict the flow of militarily sensitive technology from the West to the Soviet bloc.

MONDALE Has supported trade-restricting domestic-content legislation for autos, but may be backing off the measure. Would use the Export-Import Bank of the U. S. and the Commodity Credit Corp. "aggressively" to counter unfair foreign subsidies and to bring about negotiated reductions in foreign trade barriers. Pledges to apply antidumping and countervailing duty statutes "swiftly and effectively." Would initiate new round of world trade talks to extend international rules to insurance, banking, transportation, and other services.

BUSINESS REGULATION

REAGAN Has deregulated the banking and intercity bus transportation industries. Proposes to "change" 27 sets of rules and regulations—in addition to the 76 federal regulatory programs already revised or eliminated.

MONDALE Would relax antitrust restraints on pooled research-and-development efforts that would increase U. S. competitiveness. Endorses the creation of a business, labor, and government council to help restructure and revitalize ailing industries.

Illustration: Chuck Wimmer

A RISING SUN
OVER SERVICES, TOO

Japan's fast-expanding service sector now accounts for 60% of the country's national income. U. S. firms would like a bigger slice of the action, but the market is being jealously protected by legal and administrative barriers.

By MICHAEL McABEE

Early last year a report prepared for the U. S.-Japan Trade Study Group in Tokyo revealed that some 80% of all CAD-CAM systems used in Japan are imported from the U. S. Japan's Ministry of International Trade & Industry (MITI) quickly sought to alter the existing computer-software copyright laws in favor of Japanese companies. For a variety of reasons, MITI failed—this time.

However, the software dispute is just one of the new storm warnings ahead for U.S.-Japanese trade, as the elemental battle shifts from merchandise to services.

No wonder. Services are the fastest-growing segment of Japan's economy. Service firms, including distribution outfits, account for 60% of the national income and employ 56% of Japan's workforce—a 25% expansion in employment since 1975.

As the Japanese flex their service muscles against U.S. firms, the Reagan White House is pressing hard for an international code of conduct for trade in services.

Too, the Japan Federation of Economic Organizations (Keidanren)—a leading employers' group—has been lobbying the Japanese government for "a substantial reduction of administrative intervention" in service-sector trade in order to ensure an adequate domestic response to Japan's accelerating shift to a service economy—and to cope with outside criticism.

Lawrence F. Snowden, then president of the U. S. Chamber of Commerce in Japan (ACCJ), last year stressed to a special committee of the Japanese legislature that finding common ground for trade in services represents "our greatest challenge."

Although tariff cuts and procedural reforms have steadily pared away official barriers to imported goods and direct inward investment, foreign firms in many service fields continue to face high legal and administrative walls against entry into Japan.

The reasons: the unique problems of different types of service companies dictate against their mounting a concerted effort to advance a program agreeable to all; the lack of internationally agreed standards corresponding to the GATT codes for customs valuation, testing standards and so forth. Most often U.S. firms cry for reciprocity—"Do unto me in Japan as the U.S. would do unto a Japanese company"—an entreaty that reaches deaf ears in Tokyo. ▶

INKAGE

Some U. S. executives working in Japan agree that basing arguments on reciprocity doesn't pay off. The only way the U. S. can remove some of the barriers hindering trade in services, they assert, is by linking them in bilateral trade talks with Japan's booming merchandise exports.

Negotiating, say "automobiles and airline seats at the same table", especially appeals to Clyde McAvoy, Tokyo-based vice president, Far East, of Continental Air Lines Inc. His is a service industry long troubled by bilateral trade friction.

The Japanese, for example, are angered by the thrice revised 1952 Civil Air Transportation Agreement that, they argue, was drafted at a time when American passengers dominated transpacific air travel—a balance that has since swung to the Japanese—and furthermore stands as an unfair vestige of World War II U.S. occupation.

"Japan wants to see the designation of a single carrier from each country to operate each air route," explains a JAL spokesman, "with equally shared and predetermined capacity." Washington's policy of deregulation of the aviation industry, JAL asserts, "is not well-suited" to air transport, and attempts to extend it to international aviation "are unacceptable to Japan."

American businessmen working in Japan, meanwhile, are quick to point out that liberalization of laws and regulations won't end the problems of competing in Japan's market for services.

Ocean shipping has yet to erupt into a high-profile dispute between the two countries, but U. S. carriers do complain of Japanese restrictions. For example, stevedoring and trucking, until 1980 off-limits in Japan to firms with less than 85% domestic ownership, are now technically open to foreign shipping lines. Warehousing also is technically open to foreign firms. But all three businesses require Japanese operating licenses, and foreign-flag carriers have not as yet been able to obtain one. They are thus denied the option of offering their own intermodal door-to-door transportation services.

Ministry of Transport policy is to promote the "stability" of the companies—all Japanese-owned—already in these three service fields by excluding new entrants, Japanese or foreign.

Another trade barrier, which prevents foreign carriers from offering services at lower cost, involves the "high-cube" container for ocean shipping. These 9.5 ft x 40 ft x 8 ft steel boxes are accepted on the roads of all major trading nations—except Japan.

PREMIUM BUSINESS. Access has not been a problem for foreign-owned insurance firms. The Ministry of Finance, which has not licensed a new Japanese-owned life insurance firm in 40 years, has approved 18 foreign firms since 1973. Forty non-life insurers are also writing policies in Japan. Yet, foreign insurance firms are far from being a major factor in the market.

Innovative coverage and control of costs , say U. S. insurers in Tokyo, are the industry's top competitive cards. Yet in Japan a company cannot sell both life and non-life insurance, and premiums for most non-life categories are set by officially recognized cartels. Types of coverage new to Japan have been slow to gain government approval.

On the legal front, approval for attorneys is all but nonexistent. Though Japanese attorneys can enter private practice in trade centers like New York, London, and Dusseldorf without having to requalify locally, in Japan the same privilege for foreign attorneys was written out of the law in the 1950s. As a result, there are fewer than a dozen American lawyers in private practice in Tokyo— and they are there under a "grandfather clause."

SERVICE SUCCESSES. Not all service industries face conspicuous restraints against operating in the Japanese market. Major U. S. accounting firms are alive and well in Tokyo, engaging in the full range of accounting and auditing services. Management and industrial consulting, consumer finance, and fast-food franchising are other fields where U. S. entrants have scored and, in some cases, introduced innovations that have altered Japanese practice.

Foreign banks may be the next entry in the success column, as the effects of a financial liberalization package announced last May are gradually felt. Shaped during months of negotiation between the Ministry of Finance and the U. S. Treasury Dept., these changes in financial regulation aim ultimately to give the yen a bigger role in world finance and—it's hoped—bring it into more realistic alignment with the dollar in exchange markets. A more immediate effect is to lower many of the barriers most often complained of by foreign bankers in Japan—rules that restricted their sources of funding and limited the volume and variety of their services.

IGHTING THE SYSTEM

Japanese Prime Minister Yasuhiro Nakasone has taken an activist line toward reducing barriers to foreign business. But the domestic political price of inward trade liberalization has grown higher as favor-swapping talks begin within Mr. Nakasone's own Liberal-Democratic Party in preparation for the party's presidential election late next month.

American businessmen working in Japan, meanwhile, are quick to point out that liberalization of laws and regulations won't end the problems of competing in Japan's market for services. Any new rules must be translated into practice by a bureaucracy that remains strongly protective of Japanese industry. There is still little transparency in the formulation of guidelines within the Japanese administrative ranks, and few channels of appeal from their rulings.

Beyond government reach lies a long-established system of Japanese business ties and loyalties that doesn't easily tolerate newcomers—whether foreign or Japanese.

The focus of reform in Japanese trade regulations so far, admits Keidanren in a recent policy paper, "has been limited to the technical aspects of systems, procedures, and inspections without any accompanying changes in attitude." One aspect of this attitude: "Officials will not hesitate to hold up ninety-nine problem-free transactions to deal with one exception."

For U. S. service firms that want to show what they can offer to the Japanese market, the long slog to beat the system may be just beginning. ■

P&G FIGHTS

This 147-year-old company has been taking a "get tough" approach to improve plant efficiency and recapture ground in the marketplace. The "work team" concept is in. It's time to shape up or ship out.

—

Just ask the folks in Kansas City.

BACK

MARKET PRESSURES SPUR INTERNAL CHANGES

By THOMAS M. ROHAN

Photos: Richard Norton

Mar. 7, 1984 . . . A red-letter day in the corporate offices of Cincinnati-based Procter & Gamble Co. (P&G).

Word flashes through the 11th-floor executive suite that United Steelworkers Local 2028 has been ousted by workers at the P&G soap plant in Kansas City, Kans. Company officials consider it an important triumph in a broader effort to radically change work practices—and improve efficiency—in many of the firm's 50 U. S. plants and mills.

Union leaders deplore it as a defeat for organized labor—additional confirmation, in their minds, of P&G's hostile attitude toward "outsiders" who might threaten management's strict control over the operation of its facilities.

Less biased observers see it as another example of the feisty spirit that helped make P&G the 23rd biggest company in the country—and the kingpin of the U. S. household-products industry.

P&G—which has 23,000 employees in the U. S., 64,000 worldwide—has no intention of surrendering either title. Not without a knock-down, drag-out battle, at any rate.

The fact of the matter is that the 147-year-old company is being pushed, hounded, and threatened to an almost-unprecedented degree. Recognizing that reality, the company is embarked on a two-front war: An external struggle against competitors who have sliced into the market shares of some of its products, and an internal one against what it sees as obstacles that could stymie management's attempts to reshape its approach to labor relations and plant operations.

UNDER PRESSURE. The push-back and get-up-and-go style marking the P&G corporate culture today is in sharp contrast to the confident, self-satisfied atmosphere that prevailed in the past when P&G appeared to be an invulnerable fortress.

That image began cracking from without as Kimberly-Clark Corp. grabbed up increasingly bigger slices of the disposable-diaper market, a particularly ominous development inasmuch as diapers represent about 20% of P&G's profits. Simultaneously, Lever Brothers was making inroads into P&G's share in the soap and detergent market.

It began cracking on the inside in 1980 when dissatisfied employees in the Kansas City plant elected the powerful United Steelworkers of America (USWA) to serve as their advocate.

Adding to the troubles were the disappointing performance of such products as Pringles potato chips, and financial losses on Coldsnap Homemade Ice Cream Mix, Wondra hand lotion, and Rely Tampons—all three of which were introduced and withdrawn in the last four years.

The corporate balance sheet reflects the toll this has taken. "P&G's pretax earnings were down 16% in the March quarter and 13% down in the June quarter," observes Hercules Segalas, senior vice president and stock analyst at Drexel Burnham Lambert Inc., New York.

"I don't recall such a decline in the last decade. This is a reflection of the pressure it is under and the money it is spending to relieve that pressure," adds Mr. Segalas, a former P&G manager who is considered an authority on the company.

Looking at a brighter side, he observes: "The important development today is that P&G has recognized and is countering the problem of eroding markets while simultaneously putting more new products into the test market than at any other time in history."

WORK TEAMS. While public attention has been focused on P&G's marketplace counterattack, an equally intense and equally critical campaign has been underway within the firm's manufacturing operations. This one is aimed at improving efficiency and increasing productivity.

Hallowed policies and time-honored traditions are being scrapped in the process. And no one—from executive down to factory hand—is immune to the changes.

Some indications of what is going on:

- **The work team concept,** in which production and maintenance workers—called "technicians"—are required to master and use a second skill, is being extended throughout P&G's operations.
- **The lifetime-job tradition** which once made P&G workers the envy of their bluecollar coun-

▲ *Procter & Gamble takes over the huge Kings Island amusement park for two days each September to treat 30,000 Cincinnati-area employees and their families.*

◀ *Members of USWA Local 9028 staged a protest at P&G's Kansas City soap plant over lack of pay raises and failure to agree on a contract.*

terparts elsewhere is giving way to layoffs.

- **The corporate paternalism** of the past is yielding to some hard practicalities as executives and workers alike are being put on notice that plants that don't measure up on productivity, cost, and quality will be shut down.
- **A determined management** is vigorously resisting attempts by organized labor to dictate how P&G's operations should be run. (In about ten of the firm's 50 domestic plants, workers are represented by international unions like the Steelworkers. The other plants are either non-union or have local "independent" unions which, typically, lack the muscle of international unions.)

TOUGHER MANAGEMENT STANCE

P&G's spirited response to the problems confronting it are seen as a reflection of the management philosophy of John G. Smale, who was named president and CEO three years ago.

Observes John Thomas, a one-time P&G manager and now president of E. N. Wilkens Co., a Chicago management recruiting firm: "P&G has a tougher management approach from the top down since Mr. Smale took over. But it is not a brutal firm, and never will be." He emphasizes that P&G is simply making necessary adjustments.

That view is echoed by Paul Hubert, an independent Cleveland-based consultant who spent 18 years with P&G in organization, development, product research, and other fields. "They [P&G management] play a disciplined, competitive business game," he says. "Very tough, but fair and honest. When you're in a game with them, you know that you're playing hardball—in anything you choose."

That "hardball" approach was reflected in P&G's four-year confrontation with the Steelworkers local in Kansas City. Workers there affiliated with USWA in May 1980 after P&G discontinued an incentive-pay plan.

GAUPP
"Procter & Gamble took it as an insult that somebody would dare go outside to a union."

P&G responded to the USWA certification by suspending regular pay raises (given at other plants without negotiations) and by refusing to pick up increases in hospitalization insurance premiums. Contract negotiations there became a testament to futility: 75 negotiating sessions over three years failed to produce a contract.

Wages and fringe benefits for workers at the Kansas City plant have fallen about $400 a month behind those paid to workers in other P&G plants, estimates Gene Gaupp, former president of the Steelworkers' Local 2028 who now heads the independent union in the plant.

"Procter & Gamble took it as an insult that somebody would dare go outside to a union," says Mr. Gaupp. "Their attitude was: 'We know what's best for you.'"

The feud escalated. The USWA International and the AFL-CIO announced a boycott of P&G products, distributing 10 million flyers listing P&G brand names. USWA also wrote to institutional investors urging them not to invest in P&G, staged protests at annual meetings, and launched an international organizing effort in P&G plants. Angered by what its leaders regard as an anti-union philosophy at P&G, the AFL-CIO last year placed the company on its so-called Dishonor Roll.

The feelings of hostility and distrust were mutual. P&G management, for its part, viewed Local 2028 as an obstacle to its work-team "technician" concept which has boosted productivity at other plants.

OUSTED. It took two decertification votes to oust the Steelworkers. In 1982 the union prevailed by a 214-149 count. But by March of this year its grip at Kansas City had weakened and the union lost by a margin of 180 to 133.

Capitalizing on the result, within weeks of the decertification vote P&G rented the Kansas City Convention Center for a series of employee meetings to explain the work-team approach and to relate its critical importance to productivity and profitability.

Managers put workers on notice that dramatic changes would be made at the plant to prevent it from being priced out of the market by aggressive competitors such as Lever Brothers and Colgate-Palmolive Co.

The Kansas City meetings were consistent with the thrust management was making throughout the company.

Earlier, Senior Vice President David S. Swanson had written to other plant managers advising them that the company was being forced to expand the work-team concept, and adding a dire warning: *Plants resisting the change would soon become obsolete and would eventually be closed.*

The letters were conveniently left out in the open so that foremen and workers alike had an opportunity to read them.

P&G is already reaping some tangible and impressive rewards from its aggressive strategy. Observes Mr. Hubert the consultant:

"P&G is pushing it [the work-team concept] very hard right now because that approach, combined with capital improvements, has given the company 20% to 40% more productivity from its capital assets than it was realizing five years ago. And so they haven't had to build any new plants at all. They don't need them."

While the company is clearly putting new emphasis on the work-team concept, it doesn't represent a dramatic shift in management thinking, insists Charles Hedrick, corporate director of employee relations. It is "a natural evolution," he says. "All plants have some semblance of these plans. We don't talk about them much because it makes people at other [P&G] plants nervous and apprehensive."

SHOWCASE PLANT

The non-union P&G plant at Lima, Ohio, where workers make Biz, Downy fabric softener, and Era detergent, has become what might be called a showcase plant. Workers there operate under the "open system" concept in which teams are virtually self-governing in making decisions on production goals, the means of achieving those goals, and job rotation. Each group even determines, by vote, which workers can belong to it.

Because of the unusual success at Lima, P&G has assigned fast-track managers to work there and then moved them to older and larger plants to convince skeptical managers that the system works.

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Today, Matrox owns one building, rents a second, and is starting construction of entirely new headquarters to house not 2, but over 200 employees. Over 95% of Matrox's production is exported, primarily to the United States. Clients for their microcomputer displays and systems include General Electric, Xerox, and McDonnell-Douglas. And sales have grown, year after year, at a compound annual rate of over 50%, and will exceed $20 million in the current fiscal year.

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Mr. Hubert notes that P&G toilet-goods plants have been almost totally shifted to the work-team concept. This includes the unionized Charmin plants in Green Bay, Wis.; Cheboygan, Mich.; and Foley, Fla.

This is not to say that the workers are greeting the new approach with unabashed enthusiasm. Reportedly, the idea has run into resistance in some older plants—such as the one in Baltimore. Even more worrisome for corporate leaders is that the resistance is coming not only from hourly-paid workers but from first-level and sometimes second-level supervisors as well.

Workers have reasons for their apprehension. Increasing productivity, loss of market shares, automation, and other factors have already resulted in fairly substantial layoffs at some P&G plants—a traumatic experience for a company that once prided itself on guaranteed work even in the Great Depression days of the 1930s. (In that grim period, P&G management provided make-work jobs such as painting buildings or landscaping to keep employees on the payroll.)

P&G has trimmed the workforce by as much as 10% at the Charmin Plant in Cheboygan, the paper plant in Mehoopany, Pa., and the Folger Coffee Co. plant in Dallas (where workers assumed they'd be exempt from layoffs because they had rejected USWA in a representation election four years ago).

MANAGERS, TOO

Managers and whitecollar workers have also been vulnerable to the efficiency ax. "It's becoming a company where there's no place to hide," says Mr. Thomas, the one-time P&G manager. "They're no longer willing to go along with somebody in a sensitive spot if they feel he is not firstrate.

"In the last year and a half," he adds, "they've asked two divisional managers to leave. This has never happened before to anyone there who rose so high. I mean, never in the history of the company."

Despite the changes at P&G, one thing remains constant: management's tendency to rely on in-house talent rather than outside consultants in shaping the course of the company. (Nationally known behavioral scientists have been invited to talk to P&G managers, but plans are developed and implemented by the managers themselves.)

"Outsiders just don't have any feel for the caliber of our people," says Mr. Hedrick, the P&G employee-relations director. "Our people set up these technician programs themselves, and no consultant has worked with our hourly people. The success of a personnel program depends on how well it is implemented, and most consultants bring in programs that die before they leave."

Some might regard such a management attitude as arrogant. Yet, P&G views it as a sign of confidence in the talent and enterprise of its corporate and managerial staff.

Mr. Hubert the consultant recalls a meeting with four key managers from a P&G branch plant. "It was fascinating to listen to them," he says. "They felt in their guts, almost at an inarticulate level, the compulsion to change for the better—to improve. It's a way of life at P&G."

It's conceivable that this spirit develops from P&G's management-development philosophy. The company rarely hires even low-level managers from other firms. For the most part, they are recruited while in college and trained on P&G turf.

The incentives are impressive. The starting salary is attractive, benefits are lavish, opportunities for assignments around the country (along with the depth of experience that these bring) are excellent, and access to top management is uncommonly good.

Management also exercises great care in hiring hourly employees. Each prospective worker is tested, pre-screened, and interviewed by at least three people.

GENEROUS BENEFITS. Production workers are paid hourly rates equal to the highest wages paid by other employers in the area—using a formula based on quarterly wage surveys of about a dozen plants. Workers also get fully paid medical and hospital insurance, although this is becoming an increasing burden on the company.

All of this helps to explain why only about ten P&G plants are represented by international unions. And most of those were inherited through acquisitions.

P&G workers participate in a profit-sharing plan and are expected to accumulate enough from the guaranteed yield on the investment to be comfortably situated upon retirement. Profit sharing amounts to about 15% of annual pay after a few years.

P&G management tries to maintain strong links with its employees. A top corporate officer visits each plant at least once annually, talking with workers about their grievances and soliciting suggestions without any local manager being present.

These visits are usually in conjunction with the twice-a-year "Dividend Day," considered major celebrations at P&G plants. In the Cincinnati headquarters area, for instance, where there are five company locations, the firm takes over Kings Island—a huge amusement park—for employees and their families for two days. Attendance reaches 40,000 persons.

Other dividends for employees include hundreds of scholarships for their children, tuition-reimbursement plans, paid time off for civic and charitable work, alcohol- and drug-abuse programs, and even programs aimed at helping workers adopt children.

HOT LINE. P&G maintains exceptionally close links with consumers and distributors as well. Hundreds of market researchers conduct 1.5 million interviews with the buying public annually, and all products have toll-free telephone numbers on boxes or packages as a convenience for those wishing to register a complaint or make an inquiry.

This backfired last year when the company was barraged with some 15,000 telephone calls in the wake of groundless rumors that the P&G symbol revealed some link with Satan.

But P&G weathered that storm. And few people doubt that it will surmount the challenges it now faces. ■

THOMAS
"It's becoming a company where there's no place to hide. They're no longer willing to go along with somebody in a sensitive spot if they feel he is not first-rate."

Altos Computer Systems

Jackson's back

To build, not gamble with the future.

If time really does heal all wounds, then Altos Computer Systems is feeling little pain these days. Only six months ago, three senior executives—including the chief executive officer—left Altos, shaking the San Jose, Calif., microcomputer company's credibility on Wall Street. But when they left, 47-year-old David Jackson took over again, and the voluble founder, chairman, and second-time CEO quickly revived Altos.

Not only did fourth-quarter sales jump 57% from the same period last year, but by the end of the fiscal year, June 30, Altos had also increased sales 38% from the year before, to $103 million, and net income was up 23%, to almost $10 million.

Traditionally, the company has been financially healthy. Altos has turned a profit every month since its birth in 1977. Pretax profits are often between 15% and 20% of sales, and the company currently has $62 million in cash on hand. Moreover, Mr. Jackson projects another "record" quarter, with fiscal first-quarter results "well above" the same period last year.

But it has never been the numbers that have bruised Altos. The company's sore point, instead, has often been in organization, especially marketing and sales. Even Mr. Jackson concedes that much of management was "guesswork" until a year or so ago. In fact, it was to correct that very problem that he hired David Hanna, a former IBM Corp. marketing executive, as CEO. Although Mr. Hanna's stay at Altos was short, Mr. Jackson is quick to praise him, particularly for healing the marketing arm and hiring Philip White, another marketer from Big Blue. When the chairman returned, Mr. White stayed on, helping to implement much of the strategy developed by the former CEO.

Mr. Jackson insists the management team is now stable and marketing has recovered its health.

HERE TO STAY

"I think we've been able to position ourselves well and iron things out. Wall Street is learning that Altos is here to stay," he says. The company's product line, he adds, is "exactly where we want it to be."

There is only one problem: half a dozen other companies, including IBM, also want to be in the same position as Altos is right now—that is, the low-cost producer of multi-user systems (under $25 million) for small business. And, with IBM in the hunt, that's no small problem. Still Mr. Jackson is confident and characteristically nonplused. "You can't beat someone as big as IBM, so you look for ways to go around them."

So far, Altos has successfully circumvented the computer monolith. Altos has sold almost 50,000 systems in a market that Dataquest, a high-tech research firm, estimates will be a $12 billion industry by 1987. In working to "go around" IBM and its new, competitive PC AT, Altos is marketing its models 586 and 986, multi-user micros for five and nine people. While the IBM AT has higher performance specifications, including an 80286 chip, IBM's computer supports only three to five users simultaneously and is generally more expensive to operate per user. Mr. Jackson admits that his low-end model, the 586, may "feel some impact" from the AT, but he says the 986, allowing up to nine users, will continue to sell strongly. Additionally, Mr. Jackson expects to market his own version of the 80286 system sometime next year.

Some analysts contend that if Altos is in any danger, it won't come from IBM or shrinking distributorships—since the company has kept those channels open—but from a similar system introduced at a lower price. Unable to match IBM's power and condemned to a mid-range price, Altos could be caught between the proverbial rock and a hard place, they say. "But," counters Mr. Jackson, "that's life. Someone is always going to try to undercut us. We don't claim to be the cheapest system."

Mr. Jackson's rationale, of course, is simple: he wants to keep Altos' profits moving higher while retaining market share.

HOLD THAT MONEY

"Some companies tend to lose sight of the fact that you're in business to make money and that you never spend more than you earn," Mr. Jackson declares. "Keeping things like assets and profits high is part of the difference between building a corporation and gambling with the future." And by concentrating on research, the chairman says he is trying to build his corporation. "While everyone else is out cutting prices, we're introducing the next advancement in technology. By the time they catch up and cut prices again, we'll be another jump ahead." At least right now, Mr. Jackson is putting his money where his mouth is: more than 10% of revenues gets sunk back into research, and more than 40 people have been added to the company's engineering staff since his return, boosting that department to 100 employees in a company that numbers just over 500.

Altos also owns 30% of a Silicon Valley start-up called Wyse Technology, a venture expected to go public soon. Wyse manufactures display terminals, and observers believe Altos will market Wyse computer products, to complement—and fill gaps—in its own line.

But, most important, Mr. Jackson says Altos will now keep its focus on working to improve market and technology. He hopes the company will lead in the development of the next generations of micros. "If anyone is able to do it, I think it's Altos," he declares.

— Mark L. Goldstein

Pillsbury Co.

Illustration: Marge Swyt

How Bill Spoor swung into trouble

As chairman and CEO of Pillsbury Co., Bill Spoor has created his share of news. But seldom has the 61-year-old executive received as much attention as he did for a recent golf lesson.

The one-time Dartmouth College football and track star, on his first time out on a golf course, used a five-iron and aced the par-3, 135-yard second hole at Woodhill Country Club in suburban Minneapolis. "It went right in," laughs Mr. Spoor. "I figured this game is easier than I thought." But it was more like beginner's luck. On the third and final hole of the lesson, he shot a 15. ■

Carlisle SynTec Systems

Photo: Dan Eisenhart

Bob Brown's rooftop profits

Single-ply roofing? Sexy it's not. But Bob Brown doesn't care. Since joining the Carlisle SynTec Systems division of Cincinnati-based Carlisle Corp. in 1978 after a quarter-century with Firestone Tire & Rubber Co., he has headed up a growth cycle as division president that's gone . . . well, through the roof.

SynTec's sales jumped from less than $10 million in 1977 to close to $120 million last year; the division has emerged as *the* big moneymaker for its parent company. For the last two years, SynTec Systems' pretax earnings of $56 million have represented more than half of Carlisle's total intake.

Basically, single-ply technology works the way it sounds; sheets of synthetic rubber are stretched across a roof and held down with adhesives, a stone ballast, or snap-on fasteners. Mr. Brown attributes much of single-ply's success to shortcomings in more traditional roofing methods. A roof of asphalt and felt is labor-intensive, and materials have skyrocketed in cost and decreased in quality. That means that leaks and other failures have become recurring headaches. In contrast, fixing a leak in single-ply roofing can be as easy as patching a tire.

With a 35% market share, Bob Brown is in the single-ply driver's seat—at least for now. But his rearview mirror shows a lot of approaching traffic. Single-ply's projected annual growth rate of 42% is attracting heavy hitters like Goodyear, Firestone, GenCorp. (General Tire) as well as some 70 other smaller firms.

The situation has stabilized from the brutal price wars of a year ago, but Mr. Brown concedes that some shivers will continue as the industry shakes down. As for his division, "We didn't get here by being shoddy amateurs. We're going to keep dancing with the gal we brought."

A $4 million research-and-development facility SynTec opened this year will provide more ammo. "The gun was loaded when I got here; all I had to do was pull the trigger," says Mr. Brown. ■

Scripto Inc.

Photo: Drew Levitan

Doug Martin has his firm on fire

Doug Martin doesn't smoke. But he's rarely without his favorite lighter. "I light everybody *else's* cigarettes," the Scripto chief glows.

Since leaving rival Gillette Co. in 1978 to become president and CEO of Scripto, the 44-year-old Mr. Martin has done a lot more than just light cigarettes. He has lit a fire under the Allegheny International subsidiary that lost $2.7 million in 1978. Scripto—which gets 60% of its sales from disposable lighters—became profitable in 1981, says Mr. Martin, and has made "a profit every year since."

Equally as delightful to the former Gillette executive is that earlier this year, Scripto moved past Gillette's Cricket lighters into the No. 2 spot with a 20% market share. (Bic Corp. has 55% of the market; Cricket, 16%.) Scripto's share has since risen to 24%.

The reasons for Scripto's success: aggressive marketing and innovative products like the company's new Electra, the first mass-produced disposal electric lighter. No longer need one rub his (or her) thumb against a wheel, because this high-tech model has no flint, sparkwheel, or battery. With the new piezoelectric crystal, a gentle touch produces the flame.

Mr. Martin believes that all lighters will be made with this technology in the near future. But for now, only Scripto has it, and he expects the Electra to help Scripto continue to increase its share of the $250 million disposable-lighter market (450 million units annually).

Scripto also stands to gain market share if the rumored withdrawal of Gillette from the market takes place. Scripto's success under Doug Martin is allowing Gillette to leave a market in which it had been losing money, but maintained a presence, analysts say, to keep pressure on Bic. Had Gillette pulled out before anyone else was strong enough to challenge Bic, Bic probably would have raised its lighter prices and then plowed that money into razors and blades, which are Gillette's bread and butter.

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clining cigarette consumption, Scripto's chief expects the disposable-lighter market to continue growing at 6% to 8% a year. All those folks who still use matches—four out of ten smokers, declining steadily—are a major target. For all those smokers, Doug Martin has his hand out. Anybody want a light? ■

Medart/Charmglow Cos.

Bill Rentschler's on the rebound

Life was not always so promising for Illinois businessman William H. Rentschler.

An unsuccessful candidate for a GOP senatorial seat from Illinois in 1970, Mr. Rentschler was indicted in 1973—and pleaded guilty in 1976—to defrauding Citibank by providing false financial statements to obtain a business loan.

Subsequently, all of Mr. Rentschler's business loans were called in, and he nearly went broke. But since that setback—stemming from charges that Mr. Rentschler still strictly denies despite his guilty plea (he attributes them to "a political vendetta" on the part of U. S. Attorney James R. Thompson, now governor of Illinois)—the 59-year-old entrepreneur has reestablished himself in business and financial circles.

Since 1981 the Lake Forest, Ill., businessman has glued together a honeycomb of loosely affiliated low-tech manufacturing firms under the banner of Medart/Charmglow Cos. (he's chairman and CEO). First, he and his partners bought mundane Medart Inc.—a Greenwood, Miss., maker of steel lockers, basketball backstops, metal bifold doors, range hoods, and shelves—for $3.3 million in June 1981 even though it was in bankruptcy proceedings. Since then, sales have grown to nearly $23 million, and profits exceed $1 million per year.

Mr. Rentschler has since purchased a material-handling company, a steel-forging company, and, this year, Charmglow Products—all companies whose sales were flat or dropping. All together, his businesses are projected to surpass $100 million in sales by next November, up from $85 million this year.

His strategy for reviving his acquisitions and for future growth? "We are nudging all of our companies into the consumer-product area, while strengthening the industrial, commercial, and institutional markets."

A strong believer in low tech who dismisses the theory that high tech is nirvana, Mr. Rentschler's latest rescue mission is Charmglow, a maker of seasonal products such as gas grills and insect-control devices.

Sales of $24 million notwithstanding, its growth has been flat for four to five years. "It went from a dominant factor in the business to stagnation," asserts Mr. Rentschler. But he plans to change all that by giving Charmglow year-round products to sell, using direct consumer marketing and distribution, and adding an imported line of oil-filled space heaters.

How quick is Mr. Rentschler expecting results? Overnight. He says Charmglow's sales will nearly double to between $45 million and $50 million by next November. If they do, it'll be Bill Rentschler's competitors—not he—who will feel the heat. ■

DHL Worldwide Courier Express

Joseph Waechter, the delivery man

Talk about an identity crisis. Despite having annual revenues of $600 million and over 70% of the small-package market worldwide, DHL Worldwide Courier Express—the oldest and largest international courier service—remains largely an unknown in the U. S. It has never been able to become the household name that competitors like Federal Express have become in domestic overnight delivery.

Adding insult to injury, Federal Express and other competing courier services are now trying to slice up DHL's international pie.

Yet if DHL President Joseph Waechter is worried, he doesn't show it. His confidence in DHL's ability to prosper remains undaunted. "No one has the international network we do [500 offices in 125 countries], and it will take someone an awfully long time to catch up," he asserts. "To talk of starting an international courier service is one thing, but to actually do it is another."

In fact, the young (30), easygoing president—who started as a courier-driver for DHL 11 years ago—not only intends to preserve DHL's international dominance; he's taking dead aim at Federal Express, the U. S. leader in overnight-delivery and electronic-mail.

DHL has unveiled a $10 million advertising campaign employing the testimonies of CEOs satisfied with DHL's services. Among them: Ted Turner of Turner Broadcasting System Inc. and John Fairchild, CEO of Fairchild Publications.

DHL is also planning a full-scale war in the 2-hour delivery market sometime next year when it introduces NetExpress, its answer to ZapMail, Federal Express' 2-hour electronic-mail service that started up in July (IW, Sept. 3, Page 73).

Not only will the start-up cost of NetExpress fall well below the potential $1.2 billion price tag of ZapMail, but Mr. Waechter believes DHL's image-transfer system will be technologically superior. And Mr. Waechter says DHL will be able to capitalize on Federal Express' advertising blitz that's explaining electronic mail. That should make NetExpress' entry into the unproven market much easier, he says.

No stranger to success, Joseph Waechter, it seems, wants to give DHL the same meteoric rise in the U. S. that he's had at DHL. All he must do is verify the claim Ted Turner makes in DHL's ads: "The only thing they can't deliver is a pennant for my Atlanta Braves." ■

LIMITED ISSUE, LIMITED TIME. UNLIMITED POTENTIAL.

THE OLYMPIC UNCIRCULATED SILVER DOLLARS.

For only $28 you can collect one of the most unique coins ever created, with one of the brightest futures. Consider the facts in your favor.

1. Historical Perspective

In 1935 the last cartwheel silver dollars were struck. Today either of the famous Morgan or Peace dollars in flawless condition would sell for hundreds of dollars more than their original value. For example, in 1935, 1,964,000 Peace dollars were struck in San Francisco. Today an excellent price for this coin would be $1,400, if its condition was choice.

2. Extraordinarily Low Mintages

Consider the maximum mintages of the flawless 1983 and 1984 Olympic uncirculated silver dollars.

1983P (Philadelphia)	Discus Thrower	920,000
1983S (San Francisco)	Discus Thrower	550,000
1983D (Denver)	Discus Thrower	550,000
1984P (Philadelphia)	Coliseum Silver Dollar	650,000
1984S (San Francisco)	Coliseum Silver Dollar	500,000
1984D (Denver)	Coliseum Silver Dollar	500,000

Compared to the classic Morgan and Peace dollars, these mintages are extraordinarily low. The mintage of the Peace dollar fell below 550,000 only once, in 1928, when 360,649 Peace dollars were struck in Philadelphia. Today a flawless 1928 Philadelphia Peace dollar would sell for more than $1,300.00.

3. A Very Bright Future

No one can predict the future value of any fine collectible. But the beauty and dramatically low mintages of the Olympic uncirculated silver dollars strongly suggest that they have a very bright future.

4. Numismatic Classics

No professional numismatist would argue the point that scarcity, historical significance and the condition of a coin are the major elements that determine its numismatic value. The Olympic uncirculated silver dollars meet all these criteria.

5. A Once-In-A-Lifetime Opportunity

Unless the U.S. hosts another Olympics, we will never mint another Olympic coin. Only the host nation has that right. *Most importantly, no orders for any Olympic coins will be accepted by the U.S. Treasury postmarked after January 18, 1985.* So you must order soon.

6. They Are Precious Gifts

Giving Olympic coins is a perfect way to commemorate any occasion. They become a cherished memory of your thoughtfulness, the occasion and of the Games themselves.

And remember that for each silver coin you order, $ 10 will be donated to our Olympic movement. That in itself is all the reason any American should need to buy a beautiful Olympic silver dollar.

Here's How to Order

The coins are beautifully gift packaged and their gemlike condition is protected by special crystal-clear capsules. You may only order the 1983P and 1984P uncirculated coins individually. The Collector's Sets contain all three uncirculated dollars. The 1983 set contains the P, S & D Discus Thrower silver dollars. The 1984 set contains the P, S & D Coliseum silver dollars.

Olympic Silver Dollar Specification:
Same size as traditional cartwheel silver dollar.
Weight: .86 troy oz., .900 fine silver.

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MB0571015G1B

VERY IMPORTANT – PLEASE READ: Yes, please accept my order for Olympic coins. I understand: All sales are final and not subject to refund, and verification of my order will be made by the Department of the Treasury. The United States Mint. My coins will be delivered registered mail and may be in multiple shipments. My order placed by credit card will be charged immediately to my account and may result in finance charges or other fees prior to delivery of coins. I understand orders will be processed as they are received, and if bullion prices rise significantly, the Mint has the right to discontinue order acceptance. Once order is accepted, however, it will not be cancelled for that reason. I have read, understand and agree to the above.

QUAN.	OPTION	ITEM	EACH	TOTAL PRICE
	6	1983 Collector's Set	$89.00	
	11	1984 Collector's Set	$89.00	
	8	1983P Uncirculated Silver Dollar	$28.00	
	9	1984P Uncirculated Silver Dollar	$28.00	
		TOTAL		
		Shipping & Handling		$2.00
		GRAND TOTAL		

Method of payment ☐ Check ☐ Money Order ☐ VISA ☐ MasterCard   Exp. Date

Account No

Name ________ Address ________

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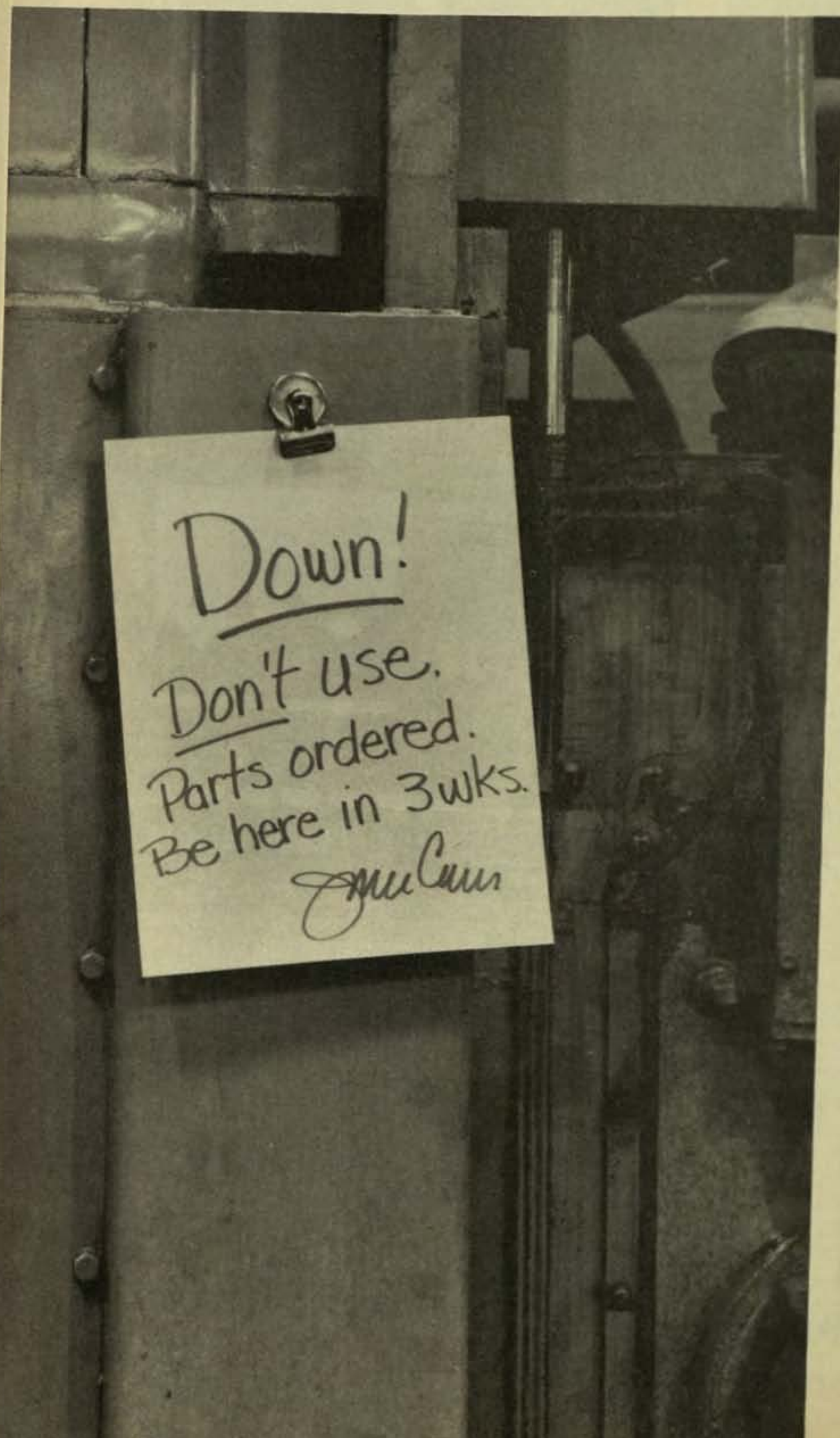
Allow 6 to 8 weeks for delivery. To place a credit card order by phone and confirm shipping date call toll free your nearest Official Olympic Coin Distributor: PandaAmerica Corp. (CA) 1-800-472-6327 • Numismatics Ltd. (CA) 1-800-421-0678 • Manfra Tordella & Brookes Inc. (NY) 1-800-223-5818 • Paramount Corp. (FL) 1-800-327-9853

FOR INFORMATION, CIRCLE NO. 43

Purchase discounts disappear fast when repairs and downtime start to add up...



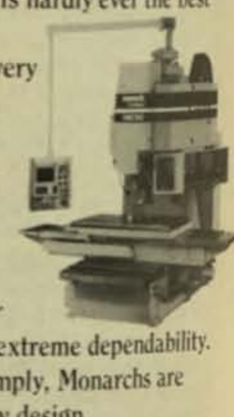
The long-term cost of a machine tool can be far greater than just the initial purchase price. To make the right choice you need to look past the bottom line and into the future.

You want a machine that is stable, precise, tough. A machine that will produce your parts efficiently and economically.

But most importantly, you want a machine that will give you the maximum up-time possible. A machine that's dependable . . . that will work hard, day after day, year after year. Because every minute that machine is down, you're losing money.

You want a Monarch.

Sure, you can buy a machine for less than a Monarch, but as you know, the lowest price is hardly ever the best value.



You see, every Monarch design decision, every production process, every material selection is based on two objectives: higher productivity and extreme dependability.

To put it simply, Monarchs are worth more . . . by design.

Look seriously into your future and you'll find that purchase discounts are not the bargain they appear to be. For solid, reliable performance take a closer look at Monarch. You'll see where real value begins. The Monarch Machine Tool Company, Sidney, Ohio 45365

Invest in excellence

monarch

Building value for 75 years

FOR INFORMATION, CIRCLE NO. 22

MATERIALS

Will GaAs dethrone silicon in chipmaking?

In Gigabit's GaAs factory, says Bryant M. Welch, vice president-manufacturing, "a key feature is our Class 10 clean room." That means dust-particle counts are restricted to fewer than ten particles per cubic foot—and air purity is essential in getting high yields of chips.

By WILLIAM PAT PATTERSON/ Made from sand—abundant and therefore cheap—silicon has been the basic material in the manufacture of semiconductors ever since vacuum tubes gave way to integrated circuits (ICs) more than 30 years ago. But silicon has been pushed about as far as it can go in terms of its properties, purity, and so forth.

With ICs shrinking and becoming more densely packed as the one-megabit chip approaches, something better is needed. That something not long ago was thought to be Josephson junctions, tiny metal switches made from superconductors such as niobium. These junctions are fast and generate almost no heat, but function only if the circuitry is kept supercold—about −269 C.

IBM Corp. had high hopes for the Josephson and put its money where its hopes were, thinking it could use the junctions to build a computer the size of a basketball that would process data much faster than today's most powerful central processing units. IBM dropped the Josephson last November. "It is our judgment that the Josephson junction is not winner technology," says John A. Armstrong, vice president-logic and memory, IBM's Research Div.

HEIR APPARENT. The rumor was that Big Blue threw in the towel monogrammed "JJ" because it believed that work in advanced semiconductor materials such as gallium arsenide (GaAs) was progressing much faster.

GaAs, obtained as a byproduct of aluminum and copper smelting, has become an heir apparent to silicon because it's five times as fast as silicon, permits lower operating voltages, and leads to enhanced switching speeds. Unlike silicon, GaAs chips don't overheat or self-destruct at extremely high speeds.

Gigabit Logic Inc., Newbury Park, Calif., began shipping 12-part families of 1-micron-sized GaAs devices in June. "We've designed integrated circuits superior to anything now available," says Dr. Fred A. Blum, Gigabit's president and one of three executives who left Rockwell in 1981 to found the company.

Dr. Blum, who acknowledges that the original shipments were to IBM, expects Gigabit sales to hit $20 million this year and $100 million annually within five years.

Gigabit's chief U. S. rival is Harris Semiconductor, Orlando, Fla., and its overseas competition includes Hitachi and Fujitsu in Japan and Plessey Co. Ltd. in Great Britain. Plessey is committing $73 million over the next five years to GaAs.

DRAWBACKS. Before GaAs can overtake silicon, however, some major obstacles must be overcome. One is cost, with a basic GaAs substrate ranging from $25 to $50 per square inch, compared with $5 to $10 for silicon. GaAs also is more fragile.

But the biggest problem may be lack of widespread understanding of the seven-year-old GaAs process. Manufacturers also are unlikely to commit to a technology that has so few companies actively involved in advancing it.

And the extremely fast switching speeds—in the picoseconds rather than nanoseconds—will impose tough new requirements on printed-circuit-board producers. To maintain signal quality, the boards must have reduced surface area, a greater number of layers, and a shrinkage in physical circuit dimension.

"This is going to tax the technological and financial resources of most boardmakers," maintains Edward Henderson, president of Henderson Ventures, Los Altos, Calif. "Yes, there will be many investment opportunities in this potentially large and fast-growing market, but we have to remember that GaAs will account for only 6% of total U. S. semiconductor consumption by 1990. Silicon will continue to monopolize the market for some time to come." ■

SPEECH PROCESSING

Voice messaging goes public, but is market there?

By MARK L. GOLDSTEIN/ Some people talk to themselves, and others talk to plants. But those people who talk to their computers had better watch out. Computers are beginning to talk back.

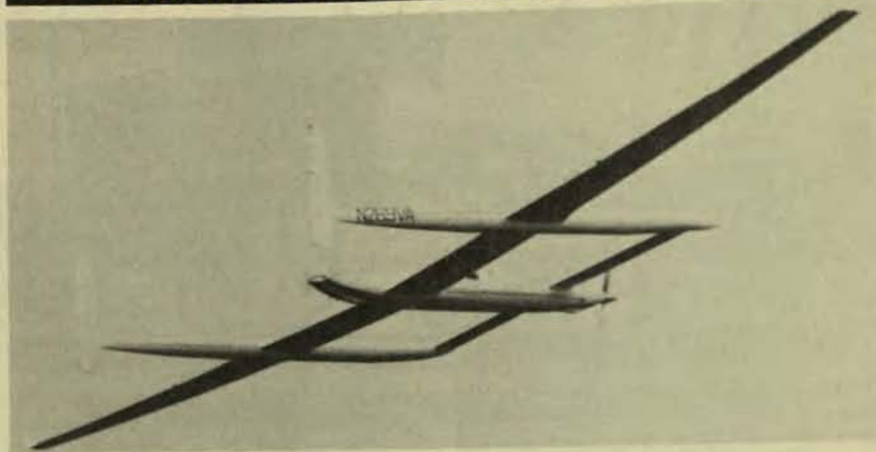
Researchers have tinkered with speech processing and so-called voice chips for more than a decade, but not until recently has progress evolved to where a market actually existed.

There are currently three categories of speech processing, each of which is developing at a different pace. The first, and probably the oldest, is voice store and forwarding, a voice-messaging technology that converts spoken language into digital code and stores it in computer memory until it's retrieved.

Until recently, voice store and forwarding, also known as voice mail, was limited to corporations that purchased standalone systems or systems integrated with private branch exchanges, supplied by companies such as Wang Laboratories, ROLM Corp., and IBM Corp.

VOICE 'MAILBOX.' There have also been a few companies offering voice messaging services to corporations, but last month GTE Corp. spoke up, becoming the first large company to pro-

EMERGING TECHNOLOGIES



AROUND THE WORLD NONSTOP

When the Rutan-designed Voyager makes its nonstop globe-circling flight, promoters of advanced composites will have yet another dramatic example of weight-saving potential. Built of graphite-reinforced plastic, the Voyager weighs 1,858 lb empty and 11,300 lb when loaded with the 1,400 gallons of fuel the 25,000-mile flight will require. The wingspan is 111 ft, equivalent to that of a Boeing 727, yet the 25-ft fuselage has only one seat plus a tub-like bunk for the relief pilot. Engine selection was made with the help of NASA's Lewis Research Center, Cleveland. The pilots, Dick Rutan and Jeana Yeager, are inviting contributions. Donors of $100 or more are listed in the plane's log, which is destined for the Smithsonian National Air & Space Museum. Write to Hangar 77 Airport, Mojave, Calif. 93501. Phone: 805/824-4790.

GRAPHICS WORKSTATIONS

Applications from process control to complex integrated-circuit layout and simulation can be handled on a new family of intelligent workstations offered by Tektronix Inc., Beaverton, Oreg. Included are an instrument controller, five new 32-bit workstations, four new graphic displays, technical and professional software, and supported peripherals. The workstations can be used as standalone systems, networked together with standard interfaces, or linked with a mainframe. Display features include window management, fast vector performance, smooth text scrolling, multiple fonts, variable cursors, and area fill. *CIRCLE 113*

COLD-ROLLED STRIP

What's the best way to measure and control surface defects on cold-rolled strip moving at speeds of up to 6,000 fpm? That's what six steel companies and three aluminum companies hope to discover in a project instituted by the American Iron & Steel Institute and conducted at Westinghouse Electric Corp.'s Research & Development Center, Pittsburgh. After evaluating computerized defect detection and classification approaches, Westinghouse will build, test, and operate a prototype system in a mill. The participants are Armco Inc., LTV Steel, Cyclops Corp., Bethlehem Steel Corp., Inland Steel Co., National Intergroup Inc., Kaiser Aluminum & Chemical Corp., Alcoa, and Reynolds Metal Co.

HUMAN-FACTORS CAD SYSTEM

By using Sammie, a 3-D human-factors CAD system, a designer can check ergonomical standards as well as placement of components well before fabricating an expensive prototype. Capable of simulating a car, cockpit, office, or home, the modeling system depicts a human model (any size or shape) with built-in reach and sight capabilities that simulate the movements of a person within those confines. Analytical capabilities include looking out on the designed objects or environments with the model's eyes. The user can also interactively test the model's reach capability to any point in the workplace and can analyze the "fit" of differently sized "human" models. Made by Prime Computer Inc., Sammie also communicates data to Prime Medusa (a 3-D solids-modeling package) and PDGS, a CAD system.

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vide a nationwide voice-mail service, called Telemessager, to the general public.

For about $30 a month GTE will give customers a voice "mailbox" and an access code. A subscriber calls a toll-free number, gives his code, and presses a single key to either receive or give a message to the computer.

GTE tested Telemessager in the Dallas-Ft. Worth area for 18 months before introducing it nationwide, and observers will undoubtedly be watching the service closely as a bellwether for voice mail's success. Indeed, there have always been some doubts about whether voice mail could ever appeal to more than a limited market.

Naturally, GTE thinks it can. Although Arvind Jadhav, vice president and manager of Telemessager, admits that subscribers were slow at first to pick up the service, he says it has grown by more than 200% since January. He expects Telemessager to be so successful that much of its customer base will come from residential subscribers by 1986.

$1 BILLION? To some extent, research indicates the market is there. Eastern Management Group, Parsippany, N.J., predicts that revenue from voice messaging will exceed $214 million in 1984 and easily surpass $1 billion by 1990.

There is currently an installed base of about 1,200 systems, and the group's survey estimates that 26,000 systems will be operating by 1990. Voice-mail systems—or at least service—is expected to sell especially well with telephone companies, which will then resell the service. Several of these firms, including NYNEX Corp. and Pacific Telesis, are said to be looking into them.

Still, the skepticism lingers. Most analysts say that residential customers will never make up a large share of voice-mail service, and one potential competitor to Telemessager says, "I'm just glad that GTE jumped in first. It's awfully noble of them." Says Brian Thompson, senior vice president of MCI Communications Corp.: "It's been our impression that the market simply isn't there yet." He admits, however, that MCI will continue to watch the industry closely.

The doubts mostly converge on one point—that voice mail is little more than a glorified tape-answering machine. Says George Gagliardi, a technology analyst with Arthur D. Little Inc. (ADL), Cambridge, Mass.: "It's just a secretary with a good memory."

(Continued on Page 82)

Aerospatiale is turning a 20-ton puzzle into a 200-passenger jet... with help from a proven technology of Control Data.

Bernard Cayla is a design engineer at Aerospatiale, the leading French aerospace company. He enjoys the challenge of a good puzzle. But this is no ordinary puzzle. He's part of a team charged with fitting together a dynamic new aircraft from 20 tons of parts being made in 4 different countries simultaneously.

The plane is the Airbus A310. Parts for this new fuel-efficient commercial jet are being designed and manufactured by Aerospatiale and companies in West Germany, Britain and Spain. Aerospatiale has to be sure everything fits, precisely.

It's a monumental task. Fortu-

(Continued from Page 78)

With so many new technologies proliferating, the biggest obstacle is educating the public, and voice messaging is no exception.

Even GTE's Mr. Jadhav agrees that the market will not reach its potential until people understand the value of the service. He explains that most companies at first limit their service subscription, but then expand it once they discover its benefits, which he says include lower phone bills and increased staff productivity.

PLUNGING AHEAD. In the meantime, many companies, including GTE, are not waiting to evaluate the success of voice mail. They are already working on the next two steps, voice synthesis and voice recognition.

Voice synthesis, also called speech output, converts display text to voice. Its uses will soon include personal-computer speech prompting, which can make computers easier to use; attention and alarm systems; telephone-access remote data retrieval; and electronic-mail access. Although the industry is still young compared with voice mail, it already accounts for $14 million in revenues for 1984, and it is expected to develop at a rapid pace, says Stuart Lipoff, a market analyst with ADL.

Two companies already make systems for remote data retrieval, Digital Equipment Corp. (DEC) and a Silicon Valley start-up called Speech Plus. By using a push-button telephone to input data, users can access databases for order entries and inquiries and simple information-checking. Boston's Shawmut Bank, for example, uses DEC's machine, called DECtalk, to answer telephone balance inquiries on corporate accounts. Both DECtalk and Speech Plus' Calltext, have natural-sounding voices. In fact, DECtalk has eight different voices that convert text, including one of a sensuous woman.

Michael Carabetta, director of DECtalk marketing, says the company hopes to soon market DECtalk Access Mail, a system that will convert anyone's electronic mail to speech. The system may be available by early 1985, and will probably be followed by similar systems from Wang and GTE. Says Wang's Larry Drinkwater, a product-development manager: "Synthesis is going to really be the next barn-burning technology."

Of the three industries, voice recognition is developing the slowest, since the technology is still being perfected. Although ADL's Mr. Lipoff estimates that a $25 million market currently exists, most voice-input vocabularies are limited to fewer than 200 words, making them incapable of wide-ranging applications. Systems based on vocabularies of 50,000 words are probably five to ten years away, most analysts say.

Still, some limited voice-to-text systems are being developed, and GTE's Mr. Jadhav expects his company to produce a voice-recognition system by November in which a small amount of speech can be converted to text, although the translation will take more than an hour.

The ultimate, of course, will be a system that incorporates both synthesis and recognition with the software of artificial intelligence. Once that occurs, says one observer, "voice technology will take office automation out of the office." ■

INFORMATION MANAGEMENT
continues on Page 87

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22 - **Monarch Machine Tool Co.**—"The Productivity Planner" outlines its broad line of CNC Turning Machines and Machining Centers.

23 - **Universal Machine Co. of Pottstown, Inc.**—Builders of thread milling and circular form milling machines.

24 - **White Consolidated Industries, Machine Tool Group**—Brochure describes the machine tool group, its individual divisions and their products.

Continued on next page

ENERGY MANAGEMENT

FUEL-CELL TEST

Westinghouse Electric and Southern California Edison Co. have teamed up to design a 7,500-kilowatt prototype fuel-cell powerplant. Initial design work will take approximately nine months; the plant is expected to go online sometime in 1988. The plant will be built around an air-cooled phosphoric-acid fuel-cell system and will convert natural gas into hydrogen for use in the cells. It's a technology particularly well-suited for electric utilities; the efficient, environmentally benign cells allow for expansion in small increments, cutting both leadtime and financial risk. In addition, their modular construction means increased siting flexibility.

REPORTS AVAILABLE

The Electric Power Research Institute (EPRI) has technical reports available on a wide range of energy-related topics. General subject areas include advanced power systems, coal-combustion systems, energy analysis and environment, energy management and utilization, and nuclear power. For ordering and pricing information, contact EPRI, Research Reports Center, P. O. Box 50490, Palo Alto, Calif. 94303 (telephone 415/965-4081).

DOOR SYSTEM

A high degree of insulation, tough construction, and an affordable price are all reasons to look at the Thermospan sectional overhead door from Wayne-Dalton Corp., Mount Hope, Ohio. Polyurethane is poured, cured, and bonded to the door's inner and outer steel skins, forming a thermal break between the two skins, thereby increasing insulation properties. The hot-dipped galvanized doors have a baked-on pebble finish. Frost and condensation aren't a problem—meaning that corrosion damage is kept to a minimum. They come in standard sizes ranging from 8 ft by 8 ft to 16 ft by 14 ft. *CIRCLE 118*

ENERGY AWARDS

Here's one example of government funding that's hard to complain about. The energy-related inventions program, conducted jointly by the National Bureau of Standards and the Dept. of Energy, provides evaluations and money to aid in the marketing of promising energy-efficient projects. So far this year, 25 such inventions have received an average one-time-only grant of $80,000; they include a new centrifugal pumping system, a coal-desulfurization process, a new apparatus for making asphalt concrete, a mechanism for reducing or eliminating gas-lock problems with oil-well pumps, and a process to remove snow from city streets by melting it instead of hauling it to dump sites. The selection process for funding is rigorous; of the 20,000 inventions submitted since the program was started in 1975, only 265 have qualified for assistance.

BOILER ADVANCE

Wormser Engineering Inc., Woburn, Mass., has introduced a coal-burning system that allows for burning a wide variety of coals, cuts air pollution, can be retrofitted to existing oil/gas furnaces, and achieves combustion efficiencies of more than 97%. Based on fluidized-bed combustion technology, the Wormser grate system reduces many of the problems that have vexed similar systems for years: equipment cost, reliability, coal handling, load-following ability, and capacity for burning low-cost forms of coal. Dirt and nuisance headaches are eliminated by a coal-feed train that converts the fuel to a dry powder for pneumatic conveying to the boiler, and all storage and conveying components are sealed. *CIRCLE 119*

COOL WATER HEATS UP

The Cool Water Coal Gasification Program, sponsored and underwritten by a combination of utilities, oil refiners, and private research groups, recently notched its first success: the start-up of an integrated gasification combined-cycle powerplant designed to fill the energy needs of some 100,000 households. Located in Daggett, Calif., the 100-megawatt plant was built by Bechtel Power Corp. It uses proprietary technology developed by Texaco Inc. The first step involves a 1,000-ton-per-day gasifier that converts coal to a clean synthesis gas. The hot product gas is used to generate high-pressure steam while being cooled in preparation for firing in a gas turbine. The syngas and steam are then used in the facility's combined cycle-system turbine generators.

order to provide options for managing and distributing information, and traditional programming and applications development are just two aspects of the new role. By continuing to redistribute spending within computer department budgets, companies will further the pattern now emerging, that of supporting computer usage outside the data center and spreading responsibility across a broader portion of the company. ■

The Dead automate

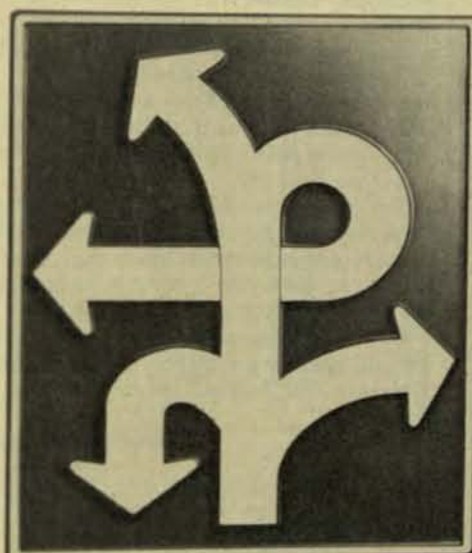
The legendary rock band, The Grateful Dead, has made the leap into computers. The band travels an average of 200 days a year, spending much of the time on planes and buses and in hotel rooms. Two members of the band, bassist Phil Lesh (right) and drummer Mickey Hart (left), have purchased the 9-lb Portable from Hewlett-Packard Co., Palo Alto, Calif. to take notes and compose lyrics. Also, Mr. Hart is writing a book about the history of percussion and uses the computer to manage the huge database he has collected on the topic. The most interesting application for the computer will be controlling the various devices members of the band use to alter the sounds of their instruments and voices.

Automating sales calls

Office automation doesn't have to exclude the field sales organization. A new system based on "lap" computers, sales-application software packages, and a central office minicomputer is designed to reduce the time and effort required for the nonselling activities of a salesman, reports Envoy Systems Corp., Waltham, Mass. It doesn't introduce any new functions to a salesman's daily activities, but merely makes accomplishing existing tasks easier, adds Kermit L. Stofer, president. The software targets order entry, sales reporting, customer database, electronic mail, and personal office management aids. *CIRCLE 111*

To request additional information, circle number on Information Center card

The confusing new world of deregulated trucking. Before you make a wrong turn, stop and ask directions.



Deregulation of the trucking industry has given you many new alternatives that can improve the efficiency of your interstate trucking operations. But should you opt for private carriage? "Toto" carrier? Contract carriage or owner operators? Trip lease, single-source lease, common carriage or transportation subsidiary? Ryder System, long acknowledged as the world's leading transportation company, can help you choose the right direction to go.

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ADVERTISER INDEX

† Demographic Edition
§ Regional Edition

LETTERS

Also prefers imports

I certainly agree with Mr. Roberts of Utica, N. Y., [Letters, Sept. 17, Page 127] that "imports are superior."

. . . I, too, have driven American-built cars for over the last 50 years and, as a salesman, that was quite a few.

I used to buy a new car at least once a year and for many years I had to take it to the dealer for *at least* the first 90 days over and over again for both major and minor problems that should have (I think) been caught with the "inspection" that I was always charged with.

I never bought an American car that came with what I wanted on it—I always had to pay extra—and the company *always* told me that they were getting all the MPG that could be gotten out of my new car.

I'm sorry that GM didn't take a long strike by the "bearded characters" that already are paid much more than they should be for a very poor job, and they want job security—don't we all?

So far as I am concerned, Datsun or Renault are for me and my family from now on and I much prefer foreign-made.

Stewart Stanley
Joplin, Mo.

Even better

Your new format is readable, comprehensive, interesting, and inspirational. You have made a good publication better.

William N. Pitchford
Madison Heights, Mich.

No, thank you

Say it ain't so, Stan! You can't mean "a constitutional conventional is a crisis we need" ["California may do it again," Sept. 3, Page 9]! Shame on you; you're beginning to sound like an editorial Dr. Strangelove.

Do we really need such a convention—the most desperate of constitutional undertakings—to deal with budget deficits? It does seem a monumental risk, particularly since the political landscape is littered with so many right- and left-wing kooks who'd relish the opportunity to muck up our Constitution.

If the Founding Fathers in 1787 could ignore the strict limitations imposed on them by the states and the Continental Congress and write a new Constitution while deep-sixing the Articles of Confederation—what's to keep a contemporary convention in line? The last thing we need is a bunch of modern-day delegates playacting "floundering" father with the fundamental law of the land. Playing Russian roulette with the Constitution is exactly what we don't need. No thanks on this one, Stan.

Mike Gildea
Rockville, Md.

Outside directors

Thank you for the fine article ["An inside look at outside directors," Sept. 3, Page 37]. I know you got tremendous awareness of the article because everyone I have talked to (executives and secretaries) seems to have read it.

But the comments I really want to pass on to you are that people feel that the *article* was one of the best ones they have seen on the subject of outside directors. There have been very few *good* articles on the subject and yours was outstanding for giving an understanding of what outside directors really do.

Good job!

Stuart J. Northrop
CEO
Huffy Corp.
Dayton, Ohio

Reputed for training

Jones & Lamson Textron has always "reached out and touched its customers." We have gained the reputation as a company that sells its products through application engineering, service, and training. Therefore, we take exception that demonstration and training areas were as indicated in your article ["Toolbuilders reach out," Aug. 20, Page 33] invented by Cincinnati Milacron, Warner & Swasey, and Mazak. The first Technical Training Center for NC Lathes was established by Jones & Lamson in Springfield, Vt., in 1969. It is now known within the industry as "The White House" and has been responsible for the training of 19,000 end users of Jones & Lamson equipment over the last 15 years.

Jones & Lamson has regional centers throughout the U. S., in Chicago, Cheshire, Philadelphia, Detroit, and Los Angeles. All of these centers have their own demonstration rooms. Training and local service is available through these centers. . . .

Albert B. Albrecht
Cheshire, Conn.

ECONOMIC TRENDS

RECOVERY SO FAR

How close to the mark?

Generally, the economy has outperformed expectations of a year ago.

By DALE W. SOMMER/ It's uncanny how the economy of mid-October 1984 so closely resembles the economy of mid-October 1983.

Exactly one year ago, retail sales fell into a slump and industrial production began to slow. Both trends were written off, at least partially, as strike-related to the telephone industry. Total personal income slowed during the strike, and consumers pulled back for a while. This year it's autos that may explain a two-month decline in retail sales; inventories going into the strike were lower than final demand, and many economists say the current slowdown is more supply-related than a reflection of final demand.

Given a pickup in inventory building in both the auto industry and retail in general, some resumption of economic growth is expected, much as it developed a year ago.

But a year ago there were still fears that the economy could overheat once the temporary setback was overcome. Inflation, it was feared, could pick up once again. This fall most economists are fairly certain that a successful "soft landing" into lower rates of overall growth has been accomplished. And it has been done without a tightening of monetary policy that might have sent interest rates up again. There are also few fears of overheating inflation in today's forecast.

How closely is the economy measuring up to expectations of a year ago? It's a bit stronger, but not far off in some sectors.

Retail sales, for example, were forecast to finish 1984 at a monthly average of $107.4 billion. Today it looks like a total of $107.2 billion for the year. The composition of sales, on the other hand, has differed widely from expectation: durables have been considerably stronger (about $3 billion) and nondurable sales have been weaker than expected a year ago.

The shift in what we're buying can be explained by two key ways the econ-

RETAIL SALES

(Billions of dollars, seasonally adjusted, quarterly and annual data at average monthly rate)(3)

	TOTAL	DURABLE GOODS	NONDURABLE GOODS
1975	49.0	15.2	33.8
1979	74.9	25.2	49.7
1980	80.1	24.4	55.7
1981	87.0	26.3	60.7
1982	89.5	27.0	62.5
1983	97.8	32.1	65.7
1984: I	105.3	36.4	68.9
II	108.1	37.8	70.3
III*	**106.7**	**36.8**	**69.9**
IV*	**108.7**	**37.6**	**71.1**
1984*	**107.2**	**37.2**	**70.0**
1985: I*	**111.2**	**38.6**	**72.6**
II*	**113.6**	**39.4**	**74.2**
III*	**116.0**	**40.2**	**75.8**
IV*	**118.5**	**41.0**	**77.5**
1985*	**114.8**	**39.8**	**75.0**

INCOME & SAVINGS

(Billions of dollars, seasonally adjusted annual rate)(3)

	DISPOSABLE INCOME	PERCENT CHANGE†	SAVINGS RATE (% OF INCOME)
1975	1,096.1	+ 9.8	8.6
1979	1,650.2	+12.0	5.9
1980	1,828.9	+10.8	6.0
1981	2,041.7	+11.6	6.7
1982	2,180.5	+ 6.8	6.2
1983	2,340.1	+ 7.3	5.0
1984: I	2,502.2	+12.1	6.1
II	2,554.3	+ 8.3	5.7
III*	**2,605.2**	**+ 8.0**	**6.1**
IV*	**2,658.6**	**+ 8.2**	**6.0**
1984*	**2,580.1**	**+10.3**	**6.0**
1985: I*	**2,715.8**	**+ 8.6**	**6.0**
II*	**2,770.1**	**+ 8.0**	**5.9**
III*	**2,826.9**	**+ 8.2**	**5.7**
IV*	**2,882.0**	**+ 7.8**	**5.6**
1985*	**2,798.7**	**+ 8.5**	**5.8**

PRICES—CONSUMER & PRODUCER

(1967 = 100)(1)

	CONSUMER	PERCENT INCREASE†	PRODUCER (FINISHED GOODS)	PERCENT INCREASE†
1975	161.2	9.1	163.4	10.8
1979	217.4	11.3	217.7	11.1
1980	246.8	13.5	247.0	13.5
1981	272.4	10.4	269.8	9.2
1982	289.1	6.1	280.7	4.0
1983	298.4	3.2	285.2	1.6
1984: I	306.4	4.4	290.3	4.5
II	309.7	4.3	291.4	1.5
III*	**313.0**	**4.3**	**292.2**	**1.1**
IV*	**316.6**	**4.6**	**294.2**	**2.7**
1984*	**311.4**	**4.4**	**292.0**	**2.4**
1985: I*	**320.4**	**4.8**	**296.6**	**3.3**
II*	**324.4**	**5.0**	**299.4**	**3.8**
III*	**328.6**	**5.2**	**302.5**	**4.1**
IV*	**332.9**	**5.2**	**306.0**	**4.6**
1985*	**326.6**	**4.9**	**301.1**	**3.1**

UNEMPLOYMENT

(Percent of civilian labor force, seasonally adjusted)(1)

	TOTAL
1975	8.5
1979	5.8
1980	7.1
1981	7.6
1982	9.7
1983	9.6
1984: I	7.9
II	7.5
III*	**7.4**
IV*	**7.1**
1984*	**7.5**
1985: I*	**6.9**
II*	**6.9**
III*	**7.0**
IV*	**7.2**
1985*	**7.0**

(*) IW forecast (1) Source: Historical data from the Labor Dept. (2) Source: Historical data from the Federal Reserve System (3) Source: Historical data from the Commerce Dept.
(r) Revised (†) Yearly changes from year before; quarterly changes from preceding quarter at an annual rate. N/A Not Available

omy has outperformed the forecast of a year ago. Unemployment by this point was expected to remain at about 8.5%, one full percentage point higher than it is now. And disposable incomes were expected to increase about 8.7% for all of 1984; today a 10.3% increase is expected.

As a result, the consumer sector is far better off— financially as well as psychologically—than expected and is making bigger purchases. Attitude surveys say sales should pick up once again.

The current economy is also performing better than expected on the inflation front. A year ago it was expected that consumer prices would increase 5.0% in 1984; today a 4.4% increase seems likely for this year. But today's forecast for the coming year is nearly identical to 1983's forecast for 1984: a 4.9% increase in consumer prices is expected for 1985.

Regarding total economic growth, the recovery through the first half of 1984 was clearly far higher than expected a year ago. But the slowdown during the second half may be more jarring than was expected. Real gross national product increased at yearly rates of 10.1% and 7.1% in the first two quarters of this year; 4.4% and 4.6% rates were forecast a year ago. But now it's estimated that real growth slowed to a 4.2% annual rate, at best, during the third quarter (the Commerce Dept.'s "flash" forecast estimates an even lower 3.6% rate of increase), and a year ago a 4.6% rate was forecast for the period. For the fourth quarter, last year's estimate of 4.2% growth has melted to a current forecast of 3.6%.

Where 1984's economic performance has faltered most below expectations is in international trade. The most recent monthly statistic (for July) shows that the U. S. trade deficit has nearly quadrupled in only two years, a "horrendous" performance, as one bank recently called it.

Recent efforts to become more competitive in the area of foreign trade led to massive new capital-spending projects, a hallmark of the recovery so far. With continued strength in business investment and the expected resumption of consumer sales, it's unlikely the economy will stall down to recession in the near future. ■

GROSS NATIONAL PRODUCT

(Billions of dollars: quarterly data at seasonally adjusted annual rates)(3)

	TOTAL GNP	PERCENT CHANGE†	GNP IN 1972 DOLLARS	PERCENT CHANGE†
1975	1,549.2	+ 8.0%	1,231.6	− 1.2%
1979	2,417.8	+11.7%	1,479.4	+ 2.8%
1980	2,631.7	+ 8.8%	1,475.0	− 0.3%
1981	2,957.8	+12.4%	1,512.2	+ 2.5%
1982	3,069.3	+ 3.8%	1,480.0	− 2.1%
1983	3,304.8	+ 7.7%	1,534.7	+ 3.7%
1984: I	3,553.3	+14.9%	1,610.9	+10.1%
II	3,644.7	+10.7%	1,638.8	+ 7.1%
III*	**3,717.6**	**+ 8.0%**	**1,656.0**	**+ 4.2%**
IV*	**3,792.0**	**+ 8.0%**	**1,670.9**	**+ 3.6%**
1984*	**3,676.9**	**+11.3%**	**1,644.2**	**+ 7.1%**
1985: I*	**3,865.9**	**+ 7.8%**	**1,685.1**	**+ 3.4%**
II*	**3,945.2**	**+ 8.2%**	**1,699.4**	**+ 3.4%**
III*	**4,012.3**	**+ 6.8%**	**1,706.2**	**+ 1.6%**
IV*	**4,092.5**	**+ 8.0%**	**1,717.3**	**+ 2.6%**
1985*	**3,979.0**	**+ 8.2%**	**1,702.0**	**+ 3.5%**

MOOD OF THE ECONOMY

	PERIOD ENDED	LATEST READING	PREVIOUS READING	ONE YEAR AGO
Building permits, private, issued (millions, annual rate, adjusted)	Aug.	**1.51**	1.57	1.67
Business failures (five-week moving average, Oct. 1983 = 100)	Sept. 21	**82.3**	81.6	N/A
Civilian labor force unemployed (millions)	Aug.	**8.5**	8.5	10.6
Consumer confidence (1969-70 = 100)	Aug.	**90.8**	91.0	84.2
Help-wanted index (1967 = 100)	Aug.	**128**	138	97
Industrial building costs (1926 = 100)	2nd qtr.	**948**	941	929
Industrial vacancies (percent of space available in 13 major cities)	2nd qtr.	**4.7**	4.8	4.9
Leading indicators (1967 = 100)	Aug.	**164.5**	163.7	158.9
Manufacturers' new orders (billions of dollars, adjusted)	July	**192.45**	190.62	174.45
Producer (wholesale) **price index** (1967 = 100)	Aug.	**310.9**	312.0	304.9
Weekly workweek, manufacturing	Aug.	**40.4**	40.5	40.3

Business barometers

	PERIOD ENDED	LATEST READING	PREVIOUS READING	ONE YEAR AGO
Aluminum output (thousands of tons)	Aug.	**378.7**	384.9	327.1*
Appliance shipments (millions of units)	Aug.	**3.14**	3.24	3.07
Auto output (thousands of units)	Sept. 29	**157.0**	109.0	161.8
Bituminous coal and lignite production (millions of short tons)	Sept. 15	**19.8**	17.4	17.2
Electric power output (billions of kw-hr)	Sept. 22	**45.3**	48.7	44.1
Freight car orders (thousands of units)	Aug.	**0.79**	0.61	0.29
General aircraft shipments (thousands)	Aug.	**0.23**	0.14	0.25
Housing starts (privately owned, millions at annual rate, adjusted)	Aug.	**1.54**	1.76	1.87
Industrial supplies & machinery (new orders, 1977 = 100)	July	**120.3**	119.1	103.1
Lumber production (Western Woods region, millions of feet)	Sept. 22	**354**	358	369
Machine tool orders (cutting type, millions of dollars)	Aug.	**135.4**	135.9	91.0
Manufacturers' inventories (billions of dollars, adjusted)	July	**279.99**	277.48	257.70
Oil refinery output (millions of barrels, daily avg)	Sept. 21	**11.3**	11.1	11.2
Paperboard production (thousands of net tons)	Sept. 22	**667.9**	675.6	651.0
Prime interest rate	Oct. 2	**12.50**	12.75	11.00
Railroad revenue ton-miles (billions)	Sept. 22	**19.3**	19.1	17.1
Raw steel output (millions of net tons)	Sept. 29	**1.36**	1.46	1.64
Retail sales (billions of dollars)	Aug.	**106.2**	107.8	98.3
Television sales to dealers (thousands of units)	Aug.	**1,650.6**	1,345.1	1,375.8

(*) IW forecast (1) Source: Historical data from the Labor Dept. (2) Source: Historical data from the Federal Reserve System (3) Source: Historical data from the Commerce Dept. (†) Revised (+) Yearly changes from year before; quarterly changes from preceding quarter at an annual rate. N/A Not Available

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The human side of deregulation

It would appear that deregulation . . . clearly has resulted in a lower-priced product for many people. . . . However, that does not mean it is an unalloyed plus, because the product offered is not precisely the same. . . .

By MICHAEL K. EVANS

Recently I ended up flying People Express Airlines. I wasn't trying to save money necessarily. It was just that with the exegencies of my schedule, that was the only way I could get in and out of Burlington, Vt., and still keep all my appointments.

I wasn't expecting a joy ride exactly, and in fact the experience really wasn't as bad as I had feared. The stories I'd heard about backpacking weirdos slobbering up the aisles were greatly exaggerated. Maybe it's because those types don't get up early enough to make a 7 a.m. flight; I don't know. But instead I was struck by the large proportion of people on that airplane who had obviously flown seldom before, if at all—you could tell because they listened raptly when the flight attendants described the safety features—and who indeed were much better behaved than many jaded business types who look on one more crowded airplane as the last place they would like to be and act accordingly. For these new passengers, deregulation of the airline industry has clearly been a boon, rescuing them from the drudgery of overnight bus trips at a price far lower than they ever imagined. But what about the rest of us?

It isn't even so much that the service on these "cattle-car flights" is worse than the so-called name-brand airlines. In fact, it is my perception that service on the majors has purposefully deteriorated to the point that it is no longer any better than the off-brand variety. But in any case, it would not be fair to say service on People Express is any worse than anywhere else.

The difference between these discount air flights and the regular airlines does show up in two key areas, though—and both of these center on reliability. Most of the major airlines still make an honest attempt to have equipment ready to go at approximately the scheduled time, and while the long delays at major airports this summer were extremely annoying to all travelers, it was not something the airlines themselves encouraged. People Express, by comparison, takes a more relaxed attitude about whether the planes will be there on time, presumably on the basis that time is not so much of the essence for these off-peak travelers.

The other issue that's handled more cavalierly by People Express is honoring reservations. Overbooking is not considered so much of a sin, presumably on the grounds that People's customers will still get to where they are going in a reasonable length of time—faster than taking the bus, which is about their only alternative.

To bring my travel ruminations back into an economic framework, it would appear that deregulation of the airline industry clearly has resulted in a lower-priced product for many people, in this case providing air travel to many who otherwise would not have considered it. However, that does not mean it is an unalloyed plus, because the product offered is not precisely the same in terms of service and timeliness for those whose time is valued and who must arrive at specific destinations at prearranged times. And the greatly increased number of airplane flights as a result of deregulation has spawned massive delays at most popular airports, which inconveniences everyone who flies. Finally, the general quality of service on all airlines seems to have deteriorated with the advent of deregulation. Since all airlines are struggling under greater cost pressures because of deregulation, they have cut corners wherever possible and have somehow managed to breed a more surly brand of in-flight employees. These nuances never show up in the price indexes or measurements of productivity, but they affect the quality of life nonetheless.

The same general result has occurred in other industries that have recently been deregulated. The bank teller who snarls at you when you try to get a check cashed and you don't have an account with a $10,000 minimum balance—and then puts a 14-day hold on your deposit—reflects the fact that bank management tries to discourage small depositors because they are less profitable now that interest is paid on checking accounts. Yet it is not at all clear that the $100 or so per year earned by the average small depositor is worth the additional ill will imposed by the tellers every time one enters into a banking transaction.

The telephone company provides an even more blatant example of how service has deteriorated under the aegis of deregulation. Whereas phones used to be repaired courteously and quickly, the would-be customer is now verbally accosted with the harsh reminder that he has called the wrong phone company, that the problem wouldn't have happened if he had leased (or bought) the phone in the first place, and that all repair persons are busy anyway. Furthermore, days-long delays are now routine for installing certain types of data lines.

None of this should be taken to mean that we should go back to an era of rigid re-regulation, which would stifle the innovative spirit far more than any short-term market aberrations. But it does mean that before economists unanimously applaud each and every adventure into further deregulation, they ought to consider the social and humanistic as well as the strictly economic benefits and costs of each such move. ■

Dr. Evans is president of Evans Economics Inc., Washington, and chief economist for McMahan, Brafman, Morgan & Co., New York.

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ERRATA

After the final version of this report was completed, a number of companies provided additional detail and requested corrections. These are outline below.

CHAPTER III: TANDEM

Page 7 (and Exhibit III-3): James Katzman is in charge of the Tandem Management Development Program; the Tandem Executive Institute is a separate function.

Page 8: Tandem employees get 10 days vacation during their first year and work their way up to 15 days in the 6th year. Employees are eligible for the sabbatical after completing 4 years with the company.

Page 12: The Tandem 16 processor, including memory control, occupied two boards out of eight available slots. If all remaining six slots were populated with the densest memory (192KW), the total memory would have been over 1MW, although the maximum physical addressibility was 1MW (20 bits).

Page 20: A single SEND instruction can transmit up to 32KB (not 64KW). The processor "hang" due to the SEND instruction affects only the sending processor.

Page 24: Battery back up lasts up to 8 hours, not 4.

Page 24: The system may be generated for more resources than those installed, to accomodate planned growth. Until these become available, Guardian markes them as "down".

Page 30: The NonStop II CPU has 7 slots available; 3 slots are taken by the IPU board (instruction processing unit), memory and Dynabus control board, and the CCD board, which has the I/O channel controller and the OSP diagnostic data transceiver.

Page 49: ENFORM™ is not merely a report generator but also incorporates a query facility.

Page 65: Pathway™ did not replace ENVOY™, which is still being used. PATHCP supervises the control of terminals, but Axcess components actually do the terminal control.

Page 87: The 1 km restriction is the maximum distance between nodes on the ring; all nodes must be within 2.2 km radius. This fiber-optic LAN product will be available in April, 1983.

CHAPTER IV: STRATUS

Page 7: The arrangements with software third parties does not include royalties.

Page 18: The paragraph beginning with "A similar process..." should be replaced with the following text:

> A similar process takes place when a freshly-repaired memory board is reinserted. The processor-pair execute an "on-line copy" program to bring the new memory to "mirror" condition with the surviving memory. Although this process has a high priority, it can be interrupted by higher priority tasks. Stratus calculates that the re-education of a 4 MB system should take no more than two seconds.

CHAPTER VII: OTHERS

Page 24: PARALLEL COMPUTER. Emanuel Wittel's title is Chairman and Chief of Technology. Hardware and software development is handled by Narasimha

CHAPTER I

EXECUTIVE SUMMARY

A. OBJECTIVES AND AUDIENCE

This study provides:

- o A comprehensive analysis of the technological and market forces behind the current popularity of fault-tolerant systems.

- o A detailed market forecast for fault-tolerant systems in 1986 in four market segments: on-line transaction processing, process control and industrial automation, word processing, and microcomputer networks. Reliable base data and a clear explanation of all the assumptions used in deriving the 1986 figures highlight the market forecast treatment.

- o A detailed examination of four leading fault-tolerant system suppliers (Tandem, Stratus, Synapse, and August), including corporate and funding history, management, personnel and facilities, marketing philosophy and distribution channels, and product concept, along with detailed hardware and software product description and recovery (fault-tolerance) strategies.

- o A discussion of corporate background and fault-tolerant product strategies, less detailed but still fairly extensive, of seven additional suppliers (Computer Consoles, Computer Technology Ltd., DOSC, Parallel Computer, Parallel Computers, Syntech and Syntrex).

- o A brief discussion of six additional firms which offer relevant systems, or which are believed to be readying such systems (ATEX, BTI, High Integrity Systems, Formation, Modcomp, National Semi).

- o A complete address and telephone number list of the firms mentioned above, and an annotated bibliography of readily-accessible literature on the subject of fault-tolerant computing.

The study is addressed to:

- o Product planners, product marketing managers, and leaders of development departments who wish to gain a detailed understanding of the market participants and their product offerings.

- o Marketing executives and corporate planners who need to gain a "feel" for the dynamics of the fault-tolerant markets, and the potential impact of fault-tolerant systems on suppliers of conventional systems.

- o Venture capitalists and business planners who need authoritative data for justifying new fault-tolerant ventures and for constructing their business plans.

B. METHODOLOGY

Data presented in this report on companies and products are based on one or more of the following sources:

- o Interviews with company staffers, either on site, at trade shows and conferences, or by phone.
- o Presentations by company staffers at various conferences and in the professional and trade press.
- o Company issued materials, including where relevant annual and quarterly reports, SEC registration statements, offering prospectuses, forms 10K and 10Q, press releases, and product specifications literature.
- o Trade and business press reports.

All companies presented in this report, except those in the "Miscellanous" section of Chapter VII, were given the opportunity to review the draft sections of the report relating to their company. This should in no way imply that these comapnies have "sanctioned" their descriptions. ITOM alone is responsible for all the material included here, including factual data as well as market forecasts and company assessments.

No effort has been spared to assure the highest level of accuracy in the factual material presented here. However, most companies described here are privately held, and are in the development stage; no guarantee of such accuracy can be given, and none is intended. Please note carefully that many product details provided here may be protected by patent filings, issued patents, or copyrights, and that many company, product, and service names mentioned in this reported are trademarks.

C. FT TECHNOLOGY AND MARKETS (CHAPTER II)

The number of fault-tolerant (FT) system suppliers is increasing rapidly because:

- o There is a strong demand, as amply demonstrated by Tandem.
- o Plenty of venture capital is available.
- o The technological environment is conducive to new FT approaches.

The demand for fault-tolerant computing systems is driven mainly by the large increase in on-line applications, in which the tangible and intangible costs of a failure have risen dramatically.

On-line transaction processing (OLTP) applications, which generally allow on-line data base modification as well as inquiry, are the leading potential market for (FT) systems. Tandem discovered this market in 1974-5 and has successfully engineered a product from existing, ripe technologies, to exploit this market.

OLTP applications include resrvations systems; systems for ticketing and wagering; on-line banking and electronic funds transfer (EFT) systems; brokerage and insurance systems; order entry, inventory, billing, and manufacturing control systems; hospital systems; POS systems; information utilities; and electronic mail systems.

Other application areas in which fault-tolerance is important include communications (CO switching and PABX); military; process control and inustrial automation; word processing; and microcomputer networks sharing a file server. (This report does not discuss communications and military applications).

Process control applications are sensitive to the availability issue because the computer is a critical part of the process; should it fail, considerable loss of product could result.

Word processing systems and microcomputer networks that access a common "file server" (disk controller) are similar in that a failure in the central, shared resource could idle many workers simultaneously; worse still, the loss of data in the shared resource could nullify the combined work of many employees over a prolonged period of time.

The ready availability of venture capital is encouraging newcomers to form fault-tolerant system start-ups.

The technological environment is conducive to new fault-tolerant approaches primarily because of the availability of powerful microprocessors (e.g. Motorola 68000, Intel 432) and dense memory chips. The impact of these is not in price/performance per se, but in the possible new FT designs which are better than Tandem's in one sense or another.

Exhibit I-2 provides a "quick look" comparison of some of the main features of the Tandem system and four other FT system suppliers.

Although the potential markets for FT systems are large, ITOM forecasts that only a small portion of those will actually be realized by 1986, simply because those in the market and those planning to enter it after 1982 cannot grow fast enough. ITOM forecasts the following FT market segment sizes in 1986:

EXHIBIT I-2
REALIZABLE FT MARKETS IN 1986

SEGMENT	POTENTIAL	REALIZABLE	% PENETRATION
	(Billions of 1981 dollars)		
On line transaction proc.	17	3.3	19
Data acquisition, P.C.	3.6	0.24	7
Microcomputer nets	0.6	0.02	3
Word processors	0.9	0.05	5

Source: ITOM International Co.

D. TANDEM (CHAPTER III)

Since 1977, the first full year of shipments, Tandem (Cupertino, CA) grew on the average 100% a year in both revenues and earnings for five years. Even though growth moderated in the last three quarters, ended June, 1982, Tandem is

EXHIBIT I-1

FAULT TOLERANT SYSTEMS COMPARISON

	TANDEM NONSTOP I	TANDEM NONSTOP II	STRATUS 32	SYNAPSE	DOSC FailSafe	AUGUST SYSTEMS Can't Fail 300
First Shipment	5/76	4/81	2/82	10/82	12/81	10/81
Target Market	<--- On Line Transaction Processing --->				Low cost OLTP	Process Ctrl.
Max. # of CPUs per Node	16		32	28 Incl. IOPs	32	3
Processor Technology	Microprogrammed Schottky TTL		68K MPU	68K MPU	Bit Slice DBM Mgr. 8085A2 Workstas.	8086 MPU
Processor MIPS	0.7		0.7	0.7	200 ns.	0.4
Processor Interconnection	Dynabus 10-13 MB/sec		StrataLink 1.4-2.8 MB/s	Shared Memory 32-64 MB/sec	Multibus 200 KB/sec	Read-only P-P Links
Long Haul Networking	yes		yes	planned	no	no
I/O Scheme	1 IOP per CPU Microprogrammed		Z80A-based Controllers	Multiple 68K-based IOPs	Printers etc. at DBM Mgr.	Multibus & Triple Redun. Process I/O
Basic FT Mechanism	Backup processes & Checkpointing		Self-checking Pair & Spare	Auto shut down & Restart	None	Triple-Redun. & Maj. Vote
Disk Protection	<------------------- Disk Mirroring ------------------->					None
Data Base Consistency	yes		yes	yes	yes	No
Entry Level Typical $	$150K		$120K	$300K	$60K	$50K

Source: ITOM International Co.

still one of the all-time success stories of Silicon Valley. Revenues during the 4 quarters ended June, 1982, amounted to about $310 million. The company boasts over 500 customers, and over 2,500 processors shipped.

Tandem has been so successful because:

- o It was able to raise substantial venture capital early in its history.
- o It had the foresight to see the growth in the OLTP market.
- o It engineered a revolutionary product, well suited to the market, out of existing, ripe technologies.
- o Because the design was so radically different, Tandem enjoyed some 7 years of virtually no comparable competition.
- o The design yielded additional benefits, especially graceful growth (modularity) and provided an excellent basis for networking (distributed processing). These have been just as important as fault-tolerance, if not more so, in customers' decisions to buy Tandem.
- o High employee productivity and loyalty, encouraged by a unique working environment and indoctrination.
- o High margins through concentration on end users.
- o High customer loyalty because of quality support.
- o Management flexibility in adjusting to accomodate technological and market changes.

Tandem is now being challenged by a fast-growing list of competitors (Stratus, Synapse, Computer Consoles, Sequoia, Parallel Computer and others) who offer microprocessor based designs. Partly in response to these challenges, the company is broadening its market focus to include the corporate communications network. Tandem's greatest challenge, however, is not competition but the management of growth.

E. STRATUS (CHAPTER IV)

Stratus (Natick, MA) addresses the same OLTP market as Tandem, but with a different, <u>self-checking</u> design based on a multiplicity of microprocessors. In this design, the hardware assumes almost the entire task of creating the fault-tolerant environment. In the Tandem system, much of this mission is accomplished by software, though since 1980 the role of software in assuring basic fault-tolerance has been limited to system software components.

Stratus is very well capitalized, has shipped a number of systems since February, 1982, and has developed a large assortment of essential software more quickly than expected. In particular, Stratus offers a networking capability which appears to be as good as Tandem's.

Of all the "new wave" of Tandem competitors, Stratus is clearly in the lead.

F. SYNAPSE (CHAPTER V)

Synapse (Milpitas, CA) is also going after the OLTP market, but with still another type of microprocessor based design. The basic idea is to obtain fault-tolerance as well as graceful growth by having a pool of self-dispatching, microprocessor-based CPUs, all sharing main memory and the applications load. Synapse calls this the "N+1" design, because by configuring one more than the number of processors required to carry the load, a failure of one processor has no impact on the end user. (The design concept is rather reminiscent of BTI Computer's Variable Resource Architecture).

After its third financing round, concluded in June, 1982, Synapse is very well capitalized. The company already has orders for two systems, and expects to ship the first one around October, 1982.

G. AUGUST SYSTEMS (CHAPTER VI)

August Systems (Salem, OR) has a triple-redundant design with majority voting, also microprocessor based, but specialized for the process control and industrial automation markets.

By being the first to offer a generalized, moderately-priced FT solution in its particular market, August has the potential to reproduced the Tandem success story, although it has been a bit slow to "get going", and its selected market is neither as large nor as rapidly growing as the OLTP market.

H. OTHERS (CHAPTER VII)

Computer Consoles, Inc. (Rochester, NY) plans to enter the OLTP market with another microporcessor based design around October, 1982. The company begins with a good base ($50 million in revenues, national sales and service organization) established in a specialty niche, the telephone industry.

Computer Technology Ltd. (Hemel Hempstead, Hertfordshire, England) offers a dual-processor system with fault-tolerant hardware and software features, based on its standard, microprocessor-based small computer series.

DOSC (Albertson, NY) is attempting to go after the very low end of the OLTP market with a network of microprocessor based workstations, with fault-tolerant features limited to the central data base. In addition, the company offers interesting productivity-oriented software. Corporate viability is the main problem for DOSC currently.

Parallel Computer (Englewood Cliffs, NJ) and Sequoia (Natick, MA) are developing microprocessor-based designs that will present UNIX™-compatible interfaces, so that third-party developed applications software could be used.

Parallel Computers (Santa Cruz, CA) is developing a fault-tolerant design based on the Intel 432 chip set, emphasizing software reliability and productivity features. Syntech (Dallas, TX) is developing a microprocessor-based, networked design tailored especially to gaming applications.

Syntrex (Eatontown, NJ) has a fault-tolerant, microprocessor-based system specialized for word-processing applications.

Others with related, existing or planned products include ATEX, BTI, Formation, High Integrity Systems Ltd., Modcomp, and National Semiconductor.

CHAPTER II

FT TECHNOLOGY AND MARKETS

A. INTRODUCTION

The availability of a computer system can be improved in essentially only two ways:

- o One can enhance the reliability of the hardware and software components and subsystems which the system comprises. This approach is generally termed fault avoidance.
- o One can provide multiple hardware and/or software components and subsystems, so that should a failure occur, system operation may be continued by transferring the functions of the failed portion to another part of the system. This is the essence of fault tolerant (FT) systems.

It is worth pointing out at the outset that, while the notions of reliability, availability, and fault tolerance may appear to be simple, and are frequently bandied about as if they were self-evident, in fact they are neither simple nor self-evident. For example, the recently-constituted IFIP working group on FT systems (WG 10.4), which includes several leading authorities in the field, has so far been unable to agree on the definitions of even such fundamental terms as "error", "fault", and "failure".

One can gain some appreciation of the difficulties involved by recognizing, for instance, that the concept of "error", intuitively defined as "a deviation from correct behavior", is meaningless unless "correct behavior" is fully understood, in the form of a precise definition of what the system is expected to do when it operates "correctly". In commercial computer systems, such specifications are rarely complete, and are often largely intuitive as well. Furthermore, such specifications are dependent on the particular view one takes of the system. For example, the same computing system and its software may appear to be composed of a totally different set of subsystems and interfaces when viewed from the perspective of the applications (end user), system programmer, and the field maintenance engineer.

In this report, such issues are largely ignored. The terms "fault", "failure", and "error" are used loosely. An "intuitive" grasp of the subject of reliability in general, and fault-tolerant systems in particular, is assumed throughout. Interested readers are directed to a number of references in the bibliography section, which address the finer points alluded to above, and other, more theoretical FT aspects.

Fault tolerant systems go under numerous names, some of which have been trade-marked by particular vendors. Examples include:

- NonStop (a Tandem trademark).
- Fail-Safe (DOSC trademark).
- Can't Fail (August Systems trademark).
- Continuous Processing (Used by Stratus but so far not trade-marked).
- PerpetualProcessing (CCI trademark)
- "Survivable" systems.
- "Fail-Soft" systems.
- "High Integrity" systems.
- "High Confidence" systems.
- "Resilient" systems.

Fault-tolerant systems come in a variety of designs and implementations, reflecting the variety of markets and applications for which they are intended. They do, however, share a number of basic assumptions:

- They accept as inevitable the eventual occurrence of a failure, despite the ever increasing reliability of the individual components and subsystems.
- They assume that the probability that two or more identical subsystems will fail simultaneously is very much lower than that of a single subsystem failure.

Thus by providing a sufficient number of identical subsystems, and the appropriate mechanisms to either transfer functions between such subsystems, or use them to correct faults, the probability that any one subsystem's failure will have an impact on the end user can be brought down to an acceptably low level.

It is quite appropriate to frame this discussion in probabilistic terms, because there is no practical way in which a FT system can be made absolutley "fail-safe". By investing more resources (e.g., additional duplicate subsystems) it is possible to increase the depth and/or coverage of fault-tolerance in a system. "Depth" is a measure of the survivability of the system in the face of multiple failures, while "coverage" implies the range of possible failures with which the system is equipped to deal. Unexpected faults (i.e., those not "covered") can nullify, or bypass, the FT mechanisms. For instance, in defining the "subsystems" and their interfaces (i.e. the particular view taken of the system), the class of faults that can be confined to a single subsystem is also being defined; but other faults may occur.

Faults whose effect cannot be limited to a given subsystem, or those that unintentionally propagate beyond the subsystem's boundaries, are examples of such "unexpected" faults. In practical situations, many unexpected faults are the result of errors in the <u>software algorithms</u> (operating system and applications program "bugs"), or of <u>usage errors</u>, i.e. wrong data or procedures supplied or invoked by the system's users. Occasionally, the system's hardware algorithm may be faulty, i.e. contain "design bugs".

Because of the increasingly-acute competition between suppliers of various fault-tolerant systems, certain terms have to be used with caution. For example, some manufacturers object to the use of the term "redundant", because they would like to reserve that description to systems in which some subsystems are essentially unproductive until a failure occurs. Such systems can nominally continue to operate at full capacity despite the failure of one, and possibly more, subsystems. They are occasionally called "fail operational" systems.

By the same token, suppliers whose systems rely on redundancy feel that other approaches, in which multiple identical subsystems share the work load so that one (or possibly more) failed subsystems result in gradual performance degradation, are more appropriately termed "fail-soft" rather than "fault-tolerant". They "soften" the impact of failures on the end user.

The distinction between these two FT approaches may be illustrated as follows. Four-wheel passenger cars carry a spare tire, which is redundant: it does no useful work until a puncture puts one of the working tires out of commission. On the other hand, "eighteen wheeler" trucks typically carry pairs of tires at each end of most axles. Each member of a pair shares in carrying the load. Should one tire fail, the truck may still proceed, supported by the surviving tire, although it may need to reduce its speed until the damage is repaired. It is a "fail-soft" truck, as far as tires go.

These everyday-experience fault-tolerant systems also underline the significance of the mean time to repair (MTTR) in the FT context. Once a subsystem fails, the system loses part or all of its FT characteristics. The longer it takes to repair the failed subsystem (punctured tire) and return it to service, the higher the probability that a subsequent failure will occur in a similar subsystem (the spare or second tire of a pair), resulting in an impact on the end user, or even in a complete system shutdown.

B. A HISTORICAL PERSPECTIVE (1945-1975)

Fault-tolerant techniques were employed in some of the earliest digital computers. In fact, because those computers were constructed from a large number of low-reliability components (e.g., relays), the probability of system failure during the execution of a particular calculation was rather high. To guard against such failures, various techniques were employed.

For example, the relay computer constructed by Bell Laboratories in 1944, which used 9,000 relays and 50 teleprinters, generally did every computation twice and compared the two results; it also employed error correcting codes. The UNIVAC I, built in 1951, which employed 5,000 vacuum tubes and utilized serial sonic delay lines for memory and magnetic tapes for auxiliary storage (both major technological advances then), had two identical ALUs, which continually compared the results of their computations. It also employed error correcting codes on I/O and extensive, internal parity checking.

The advent of solid state devices -- first the transistor, and later integrated circuits -- greatly improved the overall reliability of computer systems because these basic components were far more reliable than the vacuum tubes which they replaced. However, one notable exception in this trend has been the now-ubiquotous dynamic MOS RAM. Memory systems based on such ICs are actually less reliable than the magnetic cores they replaced. The reliability of solid state memory systems has been brought up to match that of the older magnetic core systems only through the use of error correcting codes (ECC).

ECC schemes may be reagrded as merely more sophisticated parity systems. In either case, redundancy is used: a single bit in parity systems, multiple redundant bits in ECC schemes. By increasing the number of redundant bits in an ECC arrangement, it is possible to not only detect errors, even in the check bits themselves, but also to pinpoint which particular bit is in error; this in turn allows error correction. However, parity and ECC schemes are applicable only to subsystems which do not perform any transformations on the data, but rather do pure data transport (e.g. computer busses, I/O channels) or pure storage (e.g. main memory, disks).

The improvement in basic component reliability on the one hand, and the development of error correcting codes on the other, resulted in a gradual loss of interest in fault-tolerance. During the 1960's and early 1970's, interest in such techniques remained limited to a number of specific applications areas:

- Computer-controlled telephone switching systems.
- Military and commercial real-time monitoring and control systems.
- Commercial time sharing systems.

o Airline reservations systems.

Computer-controlled, electronic switching systems began to appear in "central offices" (COs) of the public telephone network in the U.S. and in France around 1965. Because of the nature of the services they render, the computers incorporated in such switching complexes must provide very high availability. A typical requirement is that there should be no more than two hours of system outage (down-time) in 40 years.

To achieve this goal, various techniques are employed in the family of ESS computers, designed for this application by Bell Laboratories. Although details differ in each particular ESS processor (of which the largest ones are currently the 1A and 3B processors), the general scheme is to duplicate all critical components (e.g., control unit, memory system). The running system utilizes one set of subsystems, while the other, duplicate set is in a "hot backup" mode, executing in synchronism with the "on-line" set. Errors are detected either by matching the results produced by both sets (e.g., No. 1A ESS), or by constructing each set from self-checking modules, which are in themselves duplicates which match their results (e.g. No. 3A ESS).

In real time monitoring and control applications, a computer system is integrated into its environment through various sensors, which permit it to monitor the state of phsical devices and processes. If the computer is also entrusted with the task of controlling some devices or processes (a "closed loop" system), it does so via various actuators. Such applications, discussed in more detail in section D.3, include:

o Industrial process control, both continuous and discrete.

o Power plant monitoring, both conventional (fossil fûel) and nuclear.

o Aerospace telemetry and on-board control systems.

o Air traffic control systems.

- Military command and control systems.

To address the high-availability issues inherent in these applications, dual-processor configurations, similar to the one shown in Exhibit II-1 were (and in many cases, still are) employed. The particular system depicted in the exhibit closely resembles the SEL 88 system, manufactured between 1970 and 1974 by Systems Engineering Laboratories (now a Gould subsidiary).

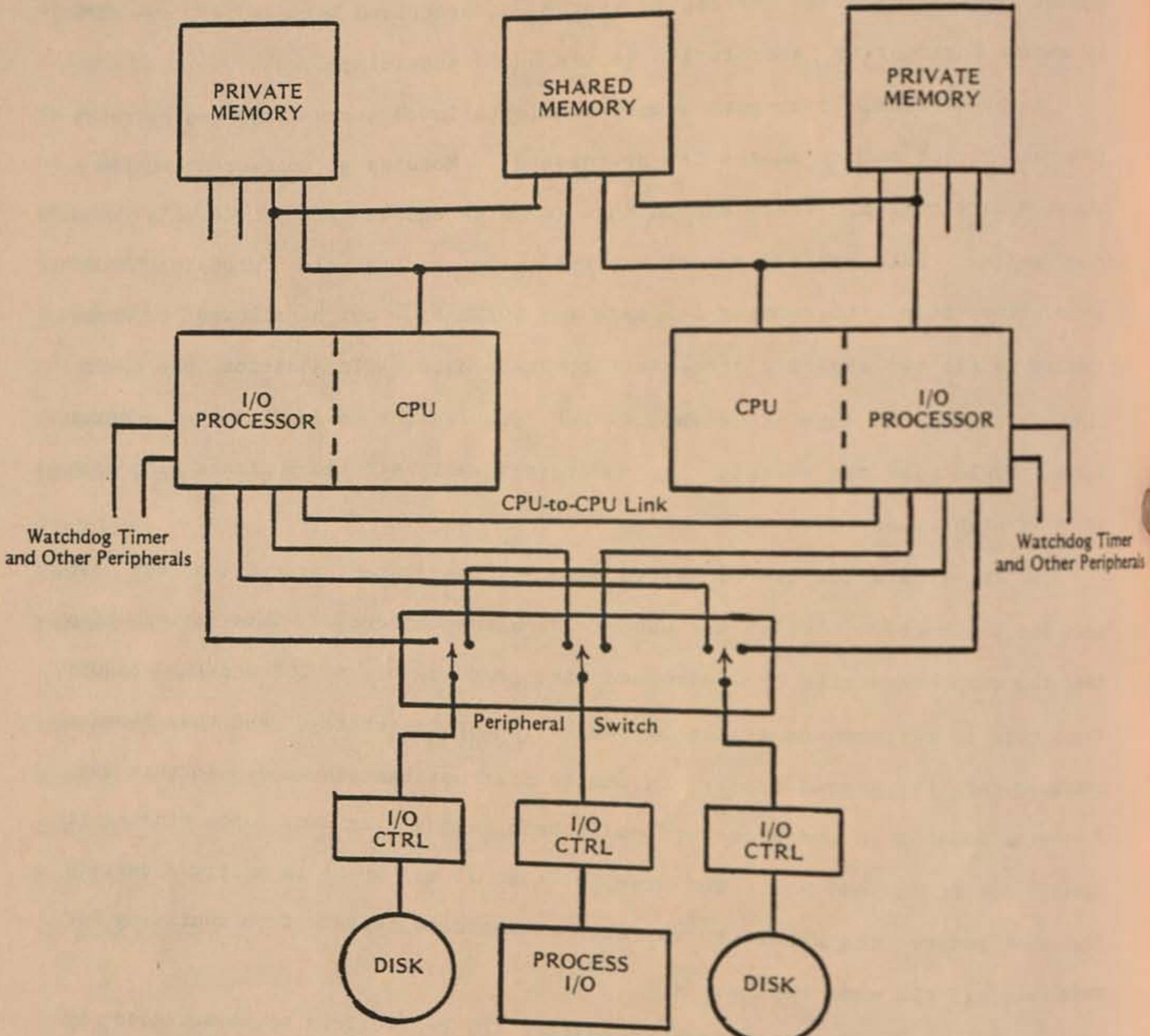
In this system, four-port memory modules allowed access from two pairs of CPUs and direct memory access I/O processors. Modules so connected created a shared memory region, which mapped into the high end of each processor's address space. This shared memory was typically used to hold "global COMMON" areas (the main programming language was FORTRAN), which allowed programs running in the two separate processors to share data. In addition, the operating system copy in each processor, which occupied the low end of the address space, could use the shared, high-address locations to communicate with each other at high speed.

To coordinate the use of shared memory, the system supported a Test Bit and Set instruction, which was used to manage semaphores. This instruction read the word containing the addressed bit, set the bit to ONE and the condition code to reflect the status of the bit prior to setting, and then rewrote the word into the shared memory, in one uninterruptible sequence. In this way, a program running in one processor could both test a flag and, upon finding it clear, set it to indicate, for example, that it was about to modify a certain region of memory; the other CPU was then expected to refrain from modifying (or even reading) the same region.

A special "peripheral switch" permitted I/O controllers to be accessed by either one (but not both) of the I/O processors. Each controller attached to the switch (up to 14 could be accomodated) was actually controlled by a single-pole, double-throw (SPDT) switch, with the peripheral controller at the center

EXHIBIT II-1

SEL 88 DUAL PROCESSOR (c. 1970)



Source: ITOM International Co.

position and the I/O processors at the two "throws". This was made possible because the I/O processor normally communicated with the controllers over coaxial cables in bit-serial fashion; but parallel interfaces can also be similarly switched. Both manual and computer-controlled switching were supported. Typically, the "process I/O" interfaces (analog-digital converters, discrete I/O lines, etc) and one or more disk controller were attached to the peripheral switch.

Each CPU in this system was equipped with a "watchdog timer", which was the main fault-detection mechanism. This timer (actually a down-counter) could be loaded with an initial count by the CPU; it then counted down at a fixed, clock-controlled rate. The operating system or application programs running in each CPU were expected to periodically reload the initial value into their timers. An interrupt signal was sent to the other CPU if the program failed to do so before the watchdog timer counted down to zero.

Assuming that no branch of either the system or user programs took longer to execute than the timer's period, such a situation could only come about because of either a complete CPU failure, or because of a program bug or hardware error leading to an "infinite loop". In any event, the receipt of the watchdog timer interrupt at a given processor signalled that something was very wrong with the other CPU.

Dual or multiple-processor systems, similar to the one just described, with or without the shared memory feature, were available from a number of other suppliers, including DEC, Data General, and Perkin Elmer's Interdata division. Variants of this arrangement are still available from these, and many other manufacturers, including Honeywell and Computer Technology Ltd. (see Chapter VII).

However, systems of this type provide only the illusion of fault-tolerance. In the first place, they incorporate a number of "critical points", the failure of any of which could bring the entire system down. Examples of such critical points include the shared memory, the peripheral switch, and the shared controllers and devices attached to the switch. Such defficiencies are partly the reason why computer-based "closed loop" control systems are not permitted in certain critical applications in the U.S. (e.g., nuclear power plant control).

Even worse is the fact that failed components can neither be removed, nor returned to service, without powering down one or even both processor systems.

Probably the most devastating disadvantage of such systems is that they include practically no software support. It is generally left to the end-user to supply even the most basic mechanisms for inter-processor communications, and control of shared memory and shared peripherals; recovery procedures are entirely within the user's own responsibility.

These, and other defficiencies can be easily traced to the fact that the elements employed in these multi-processor systems were never designed for such an environment, much less for fault-tolerant operation. (Indeed, even SEL's 4-port memories and bit-serial peripheral controllers were -- and still are — highly unusual). By and large, these systems are "force fitted" into the "fault-tolerant" application by incorporating only superficial hardware and software modifications to products that were originally meant to function in a single, stand-alone processor environment.

Variants on this theme have been employed in commercial time sharing systems, and in airline reservations systems. Both environments are particularly sensitive to downtime, not only because of the actual monetary losses resulting from such disruptions, but also because of the large number of users affected, both internal employees and outside customers.

Airline reservations systems, initially based on Univac and IBM computers, were quite unlike other real time systems in several important respects, not least of which was that the hardware manufacturers actually undertook to develop the specialized operating systems, terminal communications protocols, and applications interfaces. This task proved so onerous for Univac, especially at United Airlines, that the company could never recover its original momentum. Only a handful of airlines now run Univac's USAS reservation system.

IBM hardware and the IBM PARS and IPARS software systems became de-facto industry standards in the U.S. and abroad. The underlying software, Airline Control Program (ACP) is now fully interfaced to SNA, IBM's "grand design" in computer networking, and especially to SNA's Multi-Systems Networking Facility (MSNF), which permits user terminals to access applications programs throughout a network of mainframes, even when the application is physically located in a processor to which the terminal has no direct connection. More detail on SNA can be found in the IBM NETWORKING study by ITOM (see Bibliography section).

ACP has been sufficiently successful to merit its being offered as a more-or-less "standard" product for such other on-line applications as on-line banking and credit verification. (More accurately, ACP itself is a PRPQ, i.e. a "special" software product; its SNA interfaces, ACF/ACP and ACP/TPF, are "program products", i.e. standard, licensed software packages).

Unlike real-time monitoring and control systems, which make little use of disk-resident data because disk accesses are too lengthy relative to the required response time, airline reservations system are created expressly for the manipulation of disk-resident data bases. The issues of shared access from a large number of terminals, data base consistency and integrity, and system recovery are therefore of prime importance. ACP, for example, includes facilities for periodic dumping of critical data items, called "keypoints" and "globals", to different disk modules. The concepts of checkpointing, audit trails, record locking and disk mirroring (record duplication), also supported by ACP, originated largely from the requirements of on line transaction processing systems, of which airline reservations systems were early examples.

C. TANDEM ARRIVES ON THE SCENE (1975-1980)

Perhaps the most significant element in the subsequently spectacular success of Tandem was the foresight of its founders in recognizing that on-line transaction processing (OLTP) applications were not limited to just a few, huge systems, like the airline reservations systems, and that the OLTP field would eventually develop into an explosively-growing market.

Another contributing factor to the Tandem success story has been its founders' recognition of the jerry-rigged nature of fault-tolerant systems existing at the time (1974-1975), and their willingness to make a clean break with the past and start afresh.

They correctly perceived that most future OLTP applications could be adequately served by systems comprised of multiple, minicomputer-class processors. Such systems would offer substantially better price-performance factors than the large mainframes employed in such systems as the airline reservations applications.

Tandem and its current products are described in detail elsewhere in this report. Nevertheless, because of the large role played by Tandem in the development of fault-tolerant systems, it is appropriate here to review its original offering, which was conceived an 1974-5 and began shipping in 1976. (The current system, dubbed NonStop™ II, was introduced in April, 1981).

In some respects, the computer designed by the founders of Tandem was a fairly conventional, 16-bit minicomputer. It employed the then-state-of-the art minicomputer hardware technology (a small number of large boards, printed circuit backplane), and took full advantage of the then-relatively-new architectural concepts of dynamic address translation ("virtual memory"), strict separation of code and data, and the Dijkstra-Hansen ideas of processes communicating strictly through messages.

The mild appearance of the various components misled many pundits into discounting the entire effort as "old hat". In fact, the manner in which Tandem put together the mostly-conventional component parts resulted in a revolutionary system, in the sense that nothing like it existed before, at least not as a commercially-available product.

The key elements of Tandem's original system (Exhibit II-2), which was first called simply Tandem 16, and later NonStop™, can be summarized as follows:

- o Failure detection is mainly the responsibility of the hardware; software is in charge of preparing for, and managing recovery.
- o Hardware duplication, achieved through:

  - Multiple, loosely coupled processors, communicating over duplicated inter-processor busses ("Dynabus").

  - All I/O controllers are dual-ported; each attaches to two processors.

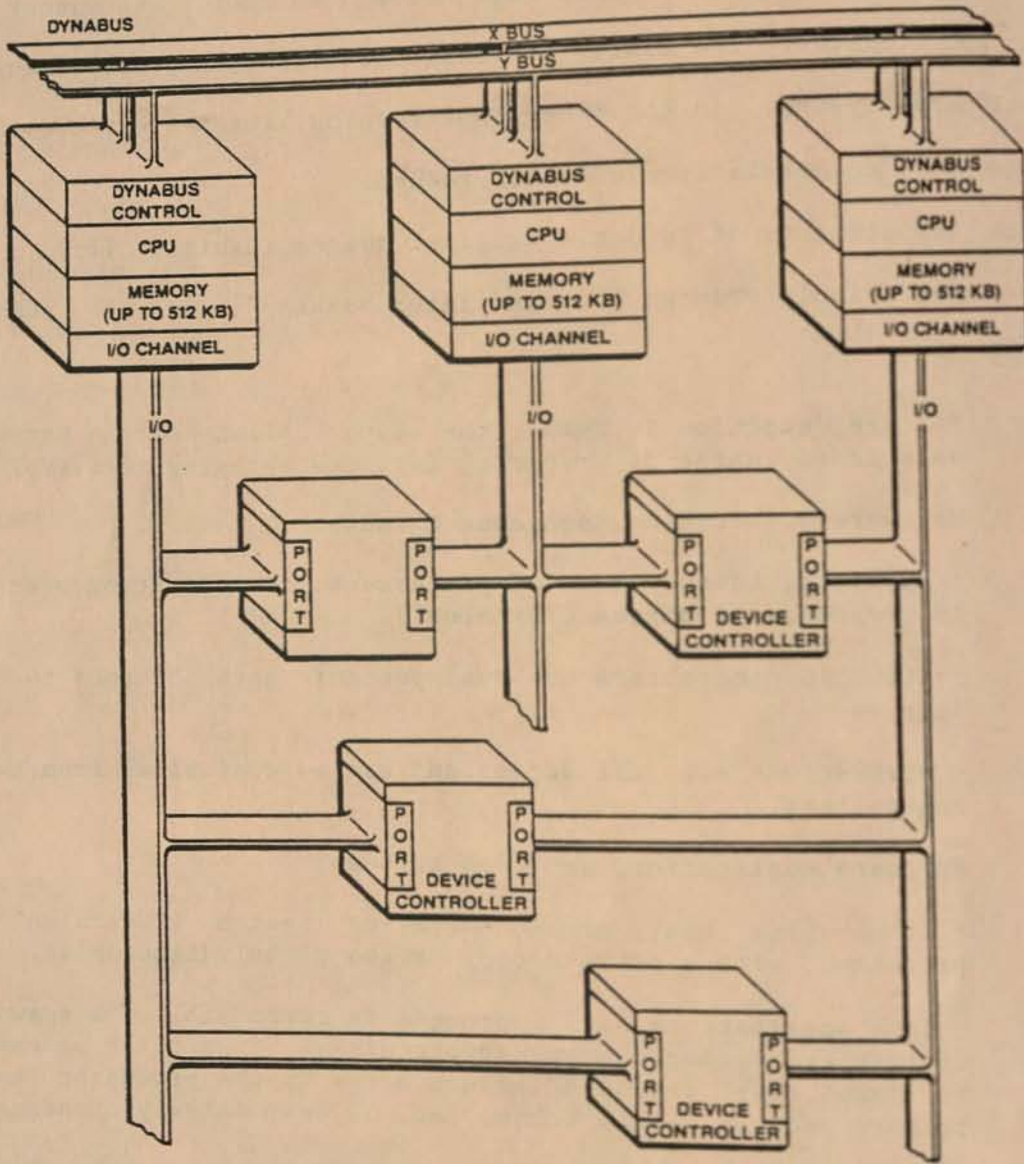
  - Disk drives are dual-access and can be controlled from two separate controllers.
- o Software duplication, achieved through:

  - A separate copy of the operating system ("Guardian") in each processor, with a private copy of the global directories.

  - Each applications or I/O process is responsible for spawning a copy of itself, called the backup processes, in another processor, ready to take over should a failure occur in the processor running the primary process. (This scheme has now been largely abandoned).
- o Checkpointing (now largely abandoned), a mechanism by which primary processes keep their backups informed of the progress of the computation, so that the backup could, if needed, restart the process from a known good state.
- o Mirrored disks, providing data base duplication, to allow for system recovery from disk failures. (There is less reliance on this mechanism now).

EXHIBIT II-2

TANDEM 16 ARCHITECTURE



Source: Tandem

- o On-line repair and recovery, i.e. the ability to remove failed components and return them to service without powering down the running portion of the system.

This design led to some unexpected benefits, which turned out to be at least as important as fault-tolerance in the "buy" decisions for Tandem gear.

By strictly limiting the communications between processes to the operating-system managed <u>message system</u> as opposed to shared memory or other direct means), application programs on the Tandem system are largely insensitive to, and independent of, the number of available processors, and the specific peripheral configuration (e.g. which processors have connections to which disk controller). This is clearly necessary in order that the removal and return to service of a particular processor could be accomplished on-line, without impact on the running applications.

This logical separation between application level programming and the physical configuration of the system also leads to <u>graceful growth</u>, i.e. the ability to add resources to the system with no impact on existing applications. In particular, more processors can be added, to service a growing system load, without the need to make any changes in the existing applications. Only the operating system needs to be regenerated, so that the resource tables in each processor properly reflect the new, higher maximum number of resources.

In practical terms, this means that an installation can begin with a small, low-cost two-processor system, and grow to a much larger system with no conversion effort to speak of. When compared to the more typical alternatives -- i.e., either purchasing a lot of unnecessary power initially, in anticipation of future needs, or swapping systems to obtain a step function in capacity ("upgrading") -- the Tandem "graceful growth" solution looks so attractive that many customers make their buy decision based mainly on this aspect of the system.

Furthermore, the same underlying features that permit graceful growth within the context of a single system can be equally useful in creating a network of geographically-dispersed Tandem nodes. Again, because logical entities (processes) communicate with each other via system-routed messages, they are unconcerned with the physical location of the nodes (processors) in which the communicating processes operate. It is the responsibility of the operating system copies in each processor to determine, by consulting the local copy of the global resource directories, where a particular process resides, and select the appropriate route (local memory, Dynabus, or remote communications link) for messages directed to it. Tandem calls the software component that handles this network routing Expand™.

Although Tandem itself is so far the only major user of Expand, and only a few customers have established significant Expand networks since the software became available in 1979, there is no doubt that the availability of this networking facility is important to prospects in their buy decisions. Many systems start with one node, or a few unconnected nodes; but more often than not, future plans call for a distributed processing network. Furthermore, because the availability of the network as a whole is inversely proportional to the number of nodes, the high availability of the fault-tolerant Tandem nodes becomes even more significant in this environment than in stand-alone situations.

In late 1980, when Tandem introduced its Transaction Monitoring Facility (TMF), it in effect abandoned many of the essential elements of the original system's architecture. In a sense, as discussed in more detail in the Tandem section of this study, TMF is a repudiation of checkpointing, backup processes, and even disk mirroring. This was brought about by the realities of the market place.

Nevertheless, Tandem has been immensely successful while promoting its original product. Since the first full year of shipments (1977), and through September, 1981, it grew at an average rate of about 100% each year, in both revenues and earnings. In fact, it is the huge success of Tandem that is one of the major motivations for the decision by many new suppliers, described elsewhere in this study, to enter the fault-tolerant, on-line transaction processing market.

D. THE FT MARKET TODAY

1. Overview

The immense success of Tandem has demonstrated beyond a doubt that a substantial market exists for high-integrity, on-line transaction processing systems. The market is driven principally by three forces:

- o Demand created by user needs.
- o Financial Environment.
- o Technological developments.

2. User Needs: OLTP Applications

On-line transaction proecssing (OLTP) applications, of which the airline reservations systems were the earliest commercial manifestations, are unlike such other on-line applications as time-sharing and even other types of transaction processing. The main OLTP characteristics may be summarized as follows:

- o A universally-accessible, shared data base.
- o "Bursty", I/O-bound work-load.
- o Data base can be modified, as well as interrogated, on-line.

The mission of time sharing systems is to create the illusion of a separate computer for each user. Each user generally conducts typical cycles of program development (editing), compilation, debugging, and production runs independent of any other user. In sharp contrast, the OLTP system's main mission is to maintain a common, shared data base, accessible by all users.

Furthermore, unlike time sharing and batch systems, in which a substantial component of the work load represents heavy CPU requirements (e.g., compilation, production runs of batch jobs), the OLTP application is characterized by transactions, which are short bursts of activities, generally I/O bound with terminal and disk activity.

On line transaction processing differs even from other types of transaction systems, still quite common today, in which transactions are captured on-line, and are applied to the "master file" off-line, typically at night. In contrast, the OLTP system is created expressly to permit multiple users to apply transactions to -- i.e., interrogate and modify -- the data base "on-line".

The range of applications in which these characteristics are in high demand has been growing dramatically over the past decade or so. Some examples include:

- Reservations systems, now including not only airlines but also car rentals and hotels/motels.
- Ticketing systems (sports events, theaters, concerts, etc.).
- Off-track betting (OTB) and other wagering systems.
- On-line banking systems, supporting either on-line teller terminals, or automated teller machines (ATM).
- Electronic funds transfer (EFT) system, currently linking primarily large banks and financial institutions, but which eventually may expand into the consumer level (cashless society).
- Brokerage applications, including securities, commodities, and real estate trading systems.
- Insurance applications, such as on-line claims processing, customer account maintenance.
- On-line order entry, inventory, billing, and general ledger systems, either integrated or with each phase (e.g. inventory/materials management) as a separate on-line application.
- Manufacturing and factory management applications.

- o Hospital/patient management systems.
- o Credit authorizations systems.
- o Point-of-sale (POS) data capture systems, integrated with inventory and/or billing.
- o Information utilities, such as commercial and corporate on-line data bases, home-oriented videotex data bases.
- o Electronic mail (including potentially voice mail) and message switching systems.

It is worthwhile to examine some of these applications in more detail, and in the context of specific installations. Such examination should help establish a "feel" for the OLTP market. Naturally, because of the undisputed leadership position Tandem occupies among FT system suppliers, the great majority of the actual installations mentioned are Tandem's.

a. Reservations Systems.

Large scale reservations systems, including those serving the airlines, hotel/motel chains, and car rental agencies, are still served mainly by mainframe-based systems. Tandem has been unable to penetrate this market so far. The required CPU power, disk capacity and transfer rates, and the number of terminals supported are beyond the capabilities of the present Tandem architecture. Also, the investment in existing custom software is very great, and a switch to a non-IBM-compatible architecture is economically unattractive to the users.

However, proposals have been made to implement large reservations systems in a distributed fashion. For example, local systems could be set up in major air traffic hubs; data on flight originating at each hub would be kept in the system located in that hub. Access to this data from remote system would be provided via an efficient packet-switched communications network. Should this trend materialize, smaller system - like Tandem's - could be utilized.

b. Ticketing.

Computerized ticketing services provide conveniently located outlets and box offices through which the public can obtain tickets for a variety of unrelated cultural and sports events. By computerizing this operation, it is possible to avoid the inefficiencies inherent in the allocation system, typically employed to furnish each outlet with a quota of actual tickets. High availability is obviously important in this application. The president of Convenient Ticket Company of Detroit put it this way: "when you've got 10,000 people lined up to buy tickets to a rock concert, you can't afford to have the system down". The ability to start with a low cost, two-processor system, and upgrade it by adding processors as the business grew, was another deciding factor in CTC's decision to buy a Tandem system.

c. Wagering.

Computerized off-track-betting (OTB) systems, state lotteries, and the like, have the standard characteristics and requirements of OLTP systems. High availability is important, since system outages irritate the waiting customers, and might result in loss of business. Syntech of Dallas, TX, (discussed elsewhere in this report) has plans for a microprocessor-based fault-tolerant system, dubbed Marathon™, to serve this particular market niche.

d. On Line Banking.

There are several areas of applications within this general category. One that has been implemented with Tandem computers at a number of banks, including Chase Manhattan and Security Pacific, is that of account verification. At Chase, for example, the Tandem two-processor system replaced a manual system, in which operators handled 1,500 inquiries per day using 1.5 million index cards representing 750,000 customers. The Tandem system, which began operating in June, 1978, quickly grew to handle 1.3 million accounts, with roughly 2,500 new accounts being added each week. Other banking applications include support of manned teller stations and automated teller machines (ATMs).

e. Electronic Funds Transfer (EFT).

Banks around the world are implementing international EFT systems at a rapidly growing pace. Such systems reduce dramatically the time needed to "clear" money movements; this, in turn, means that money could be quickly moved to high interest locations. Because of the massive amounts of money typically involved in such transfers, even one day's interest could be worth tens of thousands of dollars. Data integrity and security are essential in these applications, for obvious reasons. Because of international time zone differences, 24-hours-a-day operation is highly desirable. First Chicago and Crocker are two banks that have Tandem systems installed in international EFT applications. These systems typically must be interfaced to existing EFT networks, including the Fedwire, SWIFT, and CHIPS.

An interesting EFT application outside of banking is the Remote Meter Resetting System, operated by Pitney Bowes. The system allows postage meter customers to obtain, via a toll-free phone call to the voice-response equipped Tandem system, a code which permits them to reload the meter on site, while the corresponding funds are drawn from a pre-deposited, trustee bank account. Eventually, meters could be equipped with a communications interface and could be set on-line.

A related application just developing involves "smart cards". These plastic credit-card like units carry an embedded microprocessor and a substantial amount of memory. One potential usage of these cards is very much like a postage meter: they could be loaded with some amount of money, drawn from the customer's account, and then could be used to purchase goods, especially from automatic vending systems dispensing, say, bus or airline tickets. The computer system supporting the smart cards in both the withdrawal and purchase transactions would clearly need to operate 24 hours a day and provide a high degree of data integrity and security.

f. Brokerage Applications.

Computerized systems have been used increasingly in recent years to support a variety of trading activities, including stocks, bonds, commodities, options, financial futures, surplus electronic parts and real estate. Because such systems perform the essence of the business, high availability and data integrity are crucial requirements. The Securities Industry Automation Corp. (SIAC), a joint venture of the New York and American stock exchanges, utilizes Tandem systems in six different applications, of which perhaps the most widely known is the Inter-market Trading System (ITS). ITS electronically links six major stock exchanges and facilitates placing a buy or sell order at the exchange offering the best price.

g. Insurance.

A large number of applications in the insurance industry have been computerized over the years, including claims processing and customer's account maintenance. An interesting example of a large-scale claims processing system is the one launched by the Blue Cross and Blue Shield associations in 1980. The system, based on eight geographically dispersed Tandem nodes comprising of 21 processors, links 96 regional sites throughout the U.S.

h. Order Entry, Inventory, Billing.

These "bread and butter" business applications have been going "on line" at an accelerated rate, resulting in better response to customer needs, better internal controls and reporting, and reductions in inventories. Because such on-line systems are at the heart of the businesses they serve, they must provide high availability and data integrity. An interesting system of this type has been implemented by the cosmetics supplier Jovan around two Tandem computers employing a total of six processors. Jovan markets some 700 products to some 42,000 customers, ranging from small local shops to national department store chains. The volume of orders fluctuates widely (1,000-2,500 orders a day) and peaks at holiday seasons, especially before Christmas. Because the company is experiencing rapid growth, the ability to upgrade the system's capacity without a major switchover was a key consideration in Jovan's decision to buy Tandem.

i. Manufacturing Applications.

Inventory management, work-in-process tracking, and materials requirements planning (MRP), are just a few examples of the many manufacturing and factory management applications that have gone on-line in the past decade or so. High availability is essential to minimize the drastic adverse impact of system outages on the business; graceful growth is essential, as in any on-line application, to permit capacity increase without shutting down operations for a prolonged switchover period.

Porsche, the car maker, has two Tandem systems in this environment. Even though Porsche's output is intentionally limited to just 135 cars a day, its production plant includes some 1,000 workstations which handle some 13,000 different parts. Parts distribution control, quality control tracking, production orders and shipping papers are handled by the computerized system.

Motorola has several Tandem systems installed to support wafer fabrication at several plants in the U.S. and abroad. Merely tracking the millions of devices as they undergo a complex sequence of delicate processes is a monumental task in itself. Additonal complexity is introduced by the volatility of the device and process specifications (about 500 change notices a month). The systems support specifications maintenance, inventory tracking, process data collection and maintenance to track process yields and pinpoint trouble areas, and furnace management.

j. Hospital Applications.

Computerization of administrative and clinical hospital functions has become the main element in the attempt to provide high quality care while holding the line on spiraling costs. Keeping track of patient records, from admission through discharge, is important for both clinical reasons (e.g. which treatments and medications have been administered) and for correct and speedy billing. In addition, the Tandem 4-processor system at the 1,400-bed University of Alberta Hospital also performs materials management and laboratory support functions. Patient monitoring in intensive care units, although a legitimate hospital application, has the characteristics of a process control & monitoring application.

k. POS Applications.

Point-of-sale applications, along with the closely related credit authorization, are currently served primarily by systems which capture the transactions (sales records) on line, to be shipped later for off-line application to the data base. As the trend to bring more of these applications truly on-line continues, the high-availability already required of POS systems will become even more important. National Semiconductor's Systems Division, which supplies the Datachecker line of POS systems, is believed to be readying a fault-tolerant version of the supporting computer.

l. Information Utilities.

Over the past decade or so, a whole range of computerized systems have evolved, whose primary function is to provide rapid access to specific items of data within large data bases. Examples include such public data bases as those provided by the New York Times, Wall Street Journal, The Source, Dialog subsidiary of Lockheed, and many others. These systems are intended primarily for inquiry transactions, and hence do not require the mechanisms for supporting orderly concurrent updates; also, they handle primarily textual material, so the need for data consistency and integrity is not as high as in other OLTP systems. Nevertheless, these systems, like OLTP systems, are characterized by a "bursty" load of typically short transactions, and require the same high availability.

A particularly interesting example, with potential mass-market appeal, is videotex. The term originated in Europe, and covers both interactive and one-way versions, the latter being known as teletext. A two-way videotex system consists of a computerized data base accessible to consumers via specially-modified TV sets connected to the phone line. The data base consists of information of interest to the home consumer (and possibly small business): weather and traffic reports, sports results, airline schedules, entertainment schedules, games, etc. The British Prestel system is so far the only fully-operational, nationwide, commercial videotex service.

However, numerous videotex experiments and tests are taking place around the world. In the U.S. and Canada, where cable TV is a major factor (it is practically non-existent in Europe and Japan), cable-based videotex systems are of special interest. The Qube™ system by Warner-Amex (Columbus, Ohio) and Indax™ system by Cox Cable Communications (Omaha, Nebraska, and in planning for San Diego, CA) are examples of cable-based videotex services, with such added special features as home catalog-shopping, bill paying, and bank account status display. The Indax system relies on a Tandem computer, both for high availability and for its ability to accomodate graceful growth as the number of customers grows. Bank-at-home services, relying on either the consumer's TV set, or a personal computer, are also being tested and are generally grouped under the videotx umbrella. Such services may eventually be made more versatile with the use of "smart cards" mentioned earlier.

One example of a specialized information utility is the computerized systems which support the "information" operators in the telephone industry. Computer Consoles, Inc. (Rochester, NY; see elsewhere in this report) is the leading supplier of such "directory assistance" systems in the U.S.

It's interesting that the most visible (and controversial) aspect of the French videotx program is the "annuaire electronique". This is a computerized directory assistance system, accessible directly to subscribers via low-cost CRT terminals. The French PTT planned to furnish subscribers with these $100-target-cost terminals at no charge, to subsidize French industry, although nominally the justification for the giveaway was the savings in directory printing and distribution costs, and the reduction in the number of "information" operators. The socialist Mitterand government, which is committed to full employment, is less enthusiastic about this project.

m. Electronic Mail.

Both public and private electronic mail (EMS) systems have been implemented in either centralized or distributed fashion. In centralized systems, messages from all locations are entered into a central data base, where they are available for distribution to, or on-demand interrogation by, the addressees. In distributed systems, messages are distributed directly to wait-queues at the destination nodes. Although such systems generally do not involve the common data base ingredient of a typical OLTP application, they do require high availability. Both Tymnet and GTE/Telenet, the packet-switched public data networks, and others, offer electronic mail services which interface to the postal service system to permit message delivery to essentially any location in the U.S. The GTE/Telenet offering, dubbed Telemail, is based on a Tandem system.

3. Other Applications

On-line transaction processing applications are just one class of systems which are particularly sensitive to the availability and data integrity issues, and hence are receptive to the fault-tolerant equipment idea. Other such applications, some of which were mentioned earlier, include:

- o Commercial time-sharing systems.
- o Computer-controlled telephone switching systems.
- o Process monitoring & control and similar real-time systems, both commercial and military.
- o Shared-disk and/or shared-logic word-processing systems.

a. Time Sharing

Time sharing systems, as discussed earlier, generally do not involve shared data bases; nevertheless, they do require high availability. In the past, it was taken for granted that because of the nature of their workload (e.g. compilations and assemblies, large scientific batch jobs, etc.), T/S systems were not amenable to implementation by systems other than large mainframes with high-powered CPU and high-speed I/O channels. Today, with the increasing popularity of distributed processing on the one hand, and microprocessor-based systems on the other, the need for large-scale, centralized T/S systems is less certain.

b. Communications and Military

High availability, and to a lesser extent, data integrity are key issues in computer systems supporting telephone switching systems, both private (PABX) and public (central office). These applications are not covered in this study for a number of reasons. First, the field is specialized and, in the U.S., is addressed mainly by AT&T, although the structural changes now taking place in the telecommunications industry (following some landmark FCC decisions and especially the consent decree agreed to by DOJ and AT&T in January, 1982) may result in the capture of a bigger slice of the market by such independent suppliers as Northern Telecom and ROLM. More to the point, it is nearly impossible to obtain data on the value of the computer systems embedded in these switching systems.

For much the same reasons, military systems are also not treated in this report.

c. Process Control and Industrial Automation

In prcoess control and monitoring applications, the computer is interfaced to a physical process through various sensors and actuators. Through the sensors, which convert such properties as temperature or rate-of-flow to machine-readable electrical signals, the program monitors the status of the process, which may be either continuous or discrete. The program logs and analyzes the collected data, reformats it for human-readable display in various forms, and issues warnings when out-of-tolerance conditions are detected. If the system is a "closed loop" type, the program may also compute the optimum settings for various controls (valves, relays, etc.) and implement these settings through electrical and electronic actuators.

Such processes demand high availability because computer outages can result in substantial loss of output or product spoilage.

The control of telephone switching systems mentioned above may be regarded as an example of a discrete process control system. Also, military command and control systems have many of the characteristics of process monitoring and control applications. However, the mainstream of such applications consists of the following categories:

- o Industrial process control and monitoring:

  - Continuous processes (e.g. petroleum refining, chemicals production, food processing, paper manufacturing).

  - Discrete processes (e.g. parts machining, mail sorting, bottling and packaging, semiconductor wafer manufacturing).

- o Nuclear and fossil-fuel power plant monitoring.

- o Environmental control systems (controlling energy use in industrial plants, high rise office buildings, schools, hospitals, etc.)

- o Air traffic control systems.
- o Patient monitoring systems in intensive care units.
- o Ground-based telemetry systems and on-board control systems for aircraft and spacecraft.

August Systems (Salem, OR) is addressing several of these control and monitoring applications with a microprocessor-based system which employs triple-redundant hardware and majority-voting mechanisms. August is discussed in more detail elsewhere in this report.

Interestingly enough, a Tandem system is employed in an energy management and plant security application at United Airlines Maintenance Operations Center in San Francisco.

d. Word Processing

Another potential applications is that of shared-logic and/or shared-disk word processing systems. Such systems are riding a wave of popularity, due to the high degree of interest in office automation. By sharing a central processor ("shared logic") or a large central disk ("shared disk"), such systems have been able to offer cost-effective word processing power to multiple workstations. While the economics of shared resource arrangements are less certain now, as a result of the proliferation micrprocessor-based, stand-alone workstations, the size of the office automation market is such that both shared and stand-alone systems are likely to coexist and even flourish for perhaps the next ten years or more.

Shared systems in general require high availability. Word-processing systems are especially sensitive to system failures, not only because of the disruption to present operations, but principally because the loss of a stored document could represent the loss of the combined efforts of many workers over a prolonged period of time. Syntrex (Eatontown, NJ), which is discussed in more detail elsewhere in this study, is addressing the shared-disk WP application with with its mirrord-disk Gemini system.

e. Microcomputer Networks

Local networks of microcomputer-based workstations increasingly make use of a shared "file server" (disk controller). This is being done at the low end (e.g. in schools) to eliminate the need for disks at each workstation; at the higher end are systems like those offered by Apollo and others. In such arrangements, the availability of the shared file server is of increasing concern as the number of stations sharing it increases. DOSC (Albertson, NY; see elsewhere in this report) offers a system composed of a network of microprocessor based workstation with a fault-tolerant, redundant disk controller and mirrored disks.

f. Database Machines

One other application worth mentioning is the "back-end data base system". The general concept is to service the data base needs of a number of computer systems with a single "back end" machine (the term is taken from the common view of a system which regards the terminal communications hardware as "front end", while the disks are in the "back" of the system). The major flaw in the concept is that, because current data base implementations are intimately interfaced with the operating system's I/O structure, significant performance loss would result by attempting to move the data base management system "outboard". However, in implementing new data bases, especially relational ones, which are highly desirable from the user's point of view but which are inefficient in resource utilization and access speed, a "back end" machine makes sense. Britton-Lee has been addressing this market with their IDM line, and Intel recently entered this market with their iDBP system. While neither company as yet offers much in fault-tolerant features in these systems, it is clear that such features are key to the success of the concept, especially in the large mainframe environment.

E. FINANCIAL ENVIRONMENT

The immense success of Tandem, as well as the recognition that the potential size of the on-line transaction processing market is huge, are providing a powerful incentive for newcomers to enter the field. Aiding and abetting this process is the ready availability of venture capital.

Considering today's buyers' market in venture capital, it is easy to forget how scarce venture financing was in 1974-5, when Tandem got started. Not only was venture capital hard to get; but especially in high-technology areas, and specifically in computers, such financing was practically non-existent. Tandem's subsequent achievements are even more remarkable in light of this fact.

Today, however, the situation is drastically different. Venture capital is not only plentiful, but it is especially seeking high-technology startups, and most especially computer start-ups. The Economic Recovery Tax Act of 1981 is responsible for this state of affairs to some extent; but probably the key element in drawing venture capital away from other investment alternatives is the R&D limited partnership mechanism.

Under this mechanism, a group of investors forms a limited partnership, which in turn commissions some company (a start up or an established company) to do some hardware and/or software development work that (hopefully) would lead to a profitable product, such as a new computer. The company gets the cash, while the partnership gets the ownership of the technology that would be developed. While waiting for the product, the partnership gets immediate tax writeoffs, equal to the amount invested, which are passed on to the individual investors. When the product is ready, the partnership either sells the rights to it outright, or licenses the marketing of the product in exchange for royalties. Income from such sale or royalties is treated as capital gains. In this way, the investor gets "the best of both worlds": substantial tax write-offs initially, equal to the initial investment, plus the opportunity to participate in later profits, taxed at the low, capital gains rate.

The effect is to encourage newcomers to enter markets for computer products. A dozen or so have entered, or are planning to enter, markets for fault tolerant systems. They are described elsewhere in this report. The expectation is that, as long as the financial climate remains positive, more new entrants will materialize.

F. TECHNOLOGICAL DEVELOPMENTS

In some ways, the technological environment today is rather similar to what it was in 1974, when Tandem got its start. Now, as then, a number of advanced technologies reached maturity and wide availability.

Back in 1974, Tandem melded together minicomputer hardware technology, along with such architectural concepts as the separation of code and data, dynamic address translation, and the Dijkstra-Hansen ideas of processes communicating strictly through messages.

Minicomputer technology (large boards, printed circuit backplane, tri-state logic facilitating the bus system) endowed the Tandem product with far better price/performance than the mainframes employed at the time in on-line transaction processing systems.

Tandem's willingness to employ new architectural concepts, rather than try to modify an existing architecture, resulted in a "clean", consistent design, which, in addition to providing a measure of fault-tolerance, also had several important side benefits.

First, for nearly seven years, no one else was prepared to make the substantial investment involved in such a sharp break with the past. Thus Tandem had the luxury of operating virtually without comparable competition until quite recently.

Second, the Tandem fault-tolerant design also permits graceful growth. and geographically-distributed networking. These have been just as important as fault-tolerance, if not more so, in customers' decisions to buy Tandem.

1. The Microprocessor Challenge

Today, the key technological factor that is driving new entries into the FT field is the maturity and wide availability of microprocessors, especially the 16/32 bit "superchips".

Examples of such superchips include the Intel 8086 and X86 family; the Motorola 68000; the Zilog Z8001 and Z8003; and the recently-announced National Semiconductor NS16000 and Texas Instruments' TMS99000 families.

These superchips differ from the current generation of 8-bit micros in three important respects.

First, they have at least 16 pins over which they can exchange data with the "outside world", which includes the memory system. This is important, because most instructions and data items, even in an 8-bit micro, are actually 16-bits long. By this criterion, incidentally, the Intel 8088 chip, which is often lumped together with the 8086, is not truly a "superchip".

Second, unlike the 8-bit micros, which are typically limited to a 32-64KB address range, the superchips are characterized by very large address spaces. The Motorola 68000 and the National 16000, for example, use 24-bit addressing, and can linearly address a 16 MB space, just as the IBM System/370 and 43XX mainframes do. Other superchips (e.g., Intel 8086, Zilog Z8001) maintain a large addressing range with segmentations schemes, which allow a program to switch, with relative ease, among a large number of small segments. Segmentation allows a measure of upward compatibility with earlier, 8-bit micros.

A large, linear address space is important not only because it makes life much easier for the assembly language programmer, but mainly because it makes practical large programs, such as those typically produced by high-level language compilers. Support for high-level languages is a key element in widening the appeal of a computer system.

Finally, the superchips are fast. While the Zilog Z80B, the fastest 8-bit micro today, runs at 6 MHz, most superchips are available in 8 and 10 MHz versions, with 12 MHz samples expected this year. Performance is not always linearly related to clock rate; but within the same family, it is generally true that faster clock rates mean better performance. Superchip performance is also enhanced by the addition of a "slave processor", such as the Intel 8087, which executes floating point, decimal, trigonometric and transcendental arithmetic.

Like the "hybrid" 16/32 bit minicomputers of a decade ago, some superchips -- notably the 68000 and 16000 -- are architected internally as 32 bit machines. They have 32-bit wide registers and internal data paths, and can perform some operations on 32-bit long data items. This is important, first to allow efficient manipulation of 24-bit (or longer) addresses, and secondly, because floating point items are typically 32-bit long. Although floating point arithmetic is executed outside the microprocessor (for instance, in the "slave" processor), it is still essential that the main processor be able to handle such data items.

Ironically, the new technological environment created by these high-performance, low-cost (typically around $50 in Q100) microprocessors is posing a threat to Tandem in a number of ways:

- o Microprocessors make self-checking designs practical.
- o 32-bit microprocessors offer a greater address range.

- o Some microprocessor-based systems offer popular UNIX™ interfaces that can accomodate third-party developed software.
- o Local networking of microprocessor-based workstations offers a viable alternative to the Tandem approach.

2. Self-Checking Designs

It is now possible to create new fault-tolerant designs, which are just as "clean" and consistent as Tandem's, but which, because they rely on microprocessors, are either lower in cost, or else bring fault-tolerance to more elementary levels than is possible in a system like Tandem's. A good illustration is the Stratus design, which employs eighteen 68000 and other microprocessors in its minimum system. What is significant about the Stratus system is not the proliferation of microprocessors, but that they are used to create a self-checking design.

In the Stratus design, each subsystem, which is generally confined to a single PC board, checks its own operation by duplicating its critical internal elements, and continuously comparing the outputs of each pair. When a mismatch occurs, the subsystem declares itself faulty, and its functions are continued, uninterrupted, by an identical, duplexed subsystem, which normally runs in tight lockstep with the original subsystem. This type of system is sometimes called a "pair and spare" system.

In contrast with Tandem's approach, this design eliminates the need for backup processes and checkpointing, along with the associated overhead. Instead, the hardware redundancy, within each self-checking subsystem, and among duplexed subsystems, is entrusted with creating the fault-tolerant environment.

Such self-checking designs would have been far too costly to be practical with Tandem's minicomputer-based technology, but are quite cost effective when based on low-cost microprocessors.

3. Large Address Space

Microprocessor based systems, especially those utilizing the 16/32 bit "superchips", are putting pressure on Tandem in another way. The large address space offered by these microprocessors is far greater than that of the Tandem processor, the latter being a fairly conventional 16-bit design allowing programs a maximum of 256KB: 128KB for code (instructions) and 128KB for data.

Tandem has already "bumped" against the addressing limitation when it ran out of space for its evolving operating system, Guardian™ To alleviate this problem, Tandem came up with its NonStop II™ system, in April, 1981. However, the address range increase in the NonStop II is available only to the operating system.

User programs, as well as the various compilers, are still limited to the dual 128KB range. It is technically possible to offer the extended addressing capability to compilers and user programs; in fact, a debate about the advisability of such a move is now raging within Tandem. However, this solution would not only violate some of the basic premises of the Tandem design, but would also be far less "clean" than the linear 16 MB address space inherent in such microprocessors as the 68000 and 16000.

4. <u>Standardized Software - UNIX</u>

Software is another, surprising advantage that some microprocessor-based designs have relative to Tandem. The significant amount of proprietary software developed by Tandem over the past eight years is generally regarded as a major competitive advantage. Newcomers will have to spend the same amount of time, and make the same massive investment, in order to catch up, by which time Tandem would have moved to an even higher software plateau, Tandem reasons. Some of the newcomers, however, are refusing to play the game by Tandem's rules.

Instead, such new FT competitors as Parallel Computer (Englewood Cliffs, NJ) and Sequoia (Natick, MA) plan to take advantage of the expected rise in popularity of such standardized operating system as UNIX™. They are evolving designs which will support fault tolerant operation internally, while offering UNIX-compatible user interfaces, including the UNIX file system and the Shell command interpreter. This is made possible by the fact that both UNIX and the "C" compiler have been "ported" to such microprocessors as the 68000 and others.

This would allow the newcomers and their potential customers to take full advantage of the developing market in third-party supplied software. Although the UNIX third-party market is currently very limited (certainly when compared to CP/M's), some prognosticators are very bullish; one has even predicted a $9 billion market in UNIX-based systems by 1985. While this particular prediction is clearly unattainable, there is, nevertheless, an unmistakable "bandwagon effect" building around UNIX. Third party supplied software will develop as the number of UNIX installations increases; by taking advantage of such software, the newcomers can bypass the software hurdle that Tandem hopes will keep them behind.

5. Local Area Networks

Local networking of microprocessor based workstations represents still another way in which microprocessors are putting pressure on Tandem. Local networks are schemes by which a single communications channel -- typically a coaxial cable -- is shared among multiple workstations and computers. These arrangements are now being offered by a rapidly growing number of suppliers, including Apollo Computer (Chelmsford, MA), Convergent Technologies (Santa Clara, CA), and Prolink (Boulder, CO), among others. The main purpose of such systems is to endow low-cost workstations with the ability to share "expensive" resources (expensive relative to the cost of the workstations). Typical shared resources in these systems are large capacity disks and the databases they contain, and high-performance laser printers.

By distributing the workload among multiple workstations, such system offer a higher degree of immunity to failure; generally, the failure of any one particular workstation does not bring the whole system down. However, a failure in the shared resource, especially in the data base, is especially serious (though even then some workstations may continue to process local data).

DOSC (Albertson, NY) capitalizes on the idea of locally-networked, microprocessor-based workstations sharing the use of a data base. No special fault-tolerant features are offered in the workstations; but the data base is protected by a fully-redundant data base controller, operating a pair of disks in a fully-mirrored configuration. In this way, DOSC is able to offer a very low cost system, which nevertheless possesses significant fault-tolerance where it counts the most -- in the data base.

6. "Micromainframes"

Beyond the "superchips", a new class of even more powerful MPUs is beginning to emerge. For example, true 32-bit versions of the Motorola 68000 and National 16000 have already been announced. These chips, which will become available in late 1983, derive additional capabilities from combining their internal 32-bit architecture with a 32-bit wide external data bus. Thus they will be able to read and write the memory system 32 bits at a time. Naturally, more pins will be required. The Motorola part, for instance, will have 100 pins.

Over the past several years, Hewlett Packard engineers have described some of the characteristics of a 32-bit NMOS chip, which is said to contain the equivalent of some 450,000 transistors implemented in 1 micron geometry. (This is well beyond current packing densities, which are implemented typically in 3-5 micron geometries). This CPU is driven by an 18 MHz (4 phase) clock. It is supported by a 128K bit memory chip and other parts, all implemented with the same high-density technology. It is unlikely that HP will offer these parts to the general market in conventional IC packaging; but the company may employ them in its own future designs.

Bell Laboratories' engineers have also occasionally released details of a 32-bit CMOS chip, dubbed BELLMAC® 32. There have been indications that Bell Labs is preparing to market this MPU outside the Bell system. Recent relaxations in the regulatory environment increase the likelihood of this development.

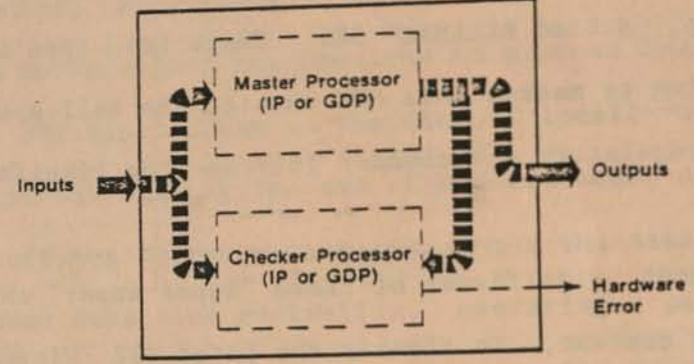
But the most significant of these "super-super" chips, in the fault-tolerant systems context, is clearly the Intel 432 MicroMainframe™. Despite the fact that its external data bus is only 16-bit wide, the architecture of this 3-chip MPU set has a distinct large mainframe flavor, exemplified, for example, by the very large (2 gigabytes) address space. In addition, the 432 offers several features that are of special interest in fault-tolerant systems applications.

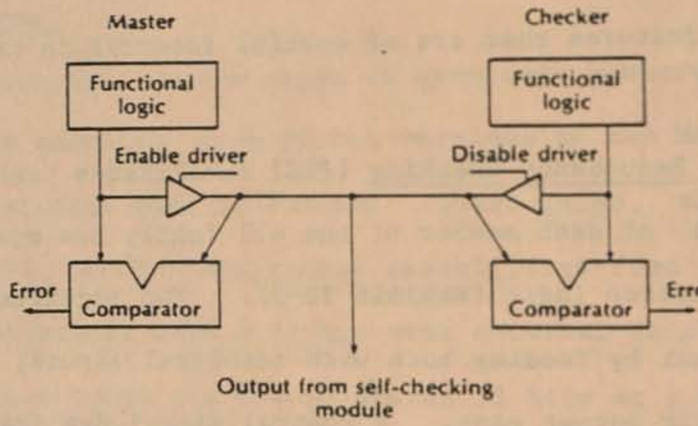
<u>Functional Redundancy Checking</u> (FRC) facilitates self-checking designs. The output pins of each member of the 432 family are equipped with special gating and comparison logic (Exhibit II-3). Two identical chips may form a self-checking unit by feeding both with identical inputs, and tying together their corresponding output pins. A control signal designates one of the chips as a "master" and the other as a "checker". This has the effect of enabling the comparison circuits on the output pins of the checker chip, so that it can compare the output signals produced by itself to those provided by the master chip. Should a discrepancy be discovered on any of the pins being compared, an error signal is generated.

This is precisely the type of self checking design developed by Stratus with conventional circuits. Its task would have clearly been far simpler had the FRC capability been available as a standard feature of off-the-shelf ICs.

EXHIBIT II-3

432 FUNCTIONAL REDUNDANCY CHECKING





Source: Intel

The FRC feature need not be restricted to hard-wired component pairs. With the appropriate gating and control logic, it is possible to create designs in which any number of "masters" could be periodically connected to a single checker, or in which a number of masters could check each other's operation by temporarily switching into the role of checkers. Parallel Computers (Santa Cruz, CA) is apparently evolving a 432-based fault-tolerant design using the latter concept.

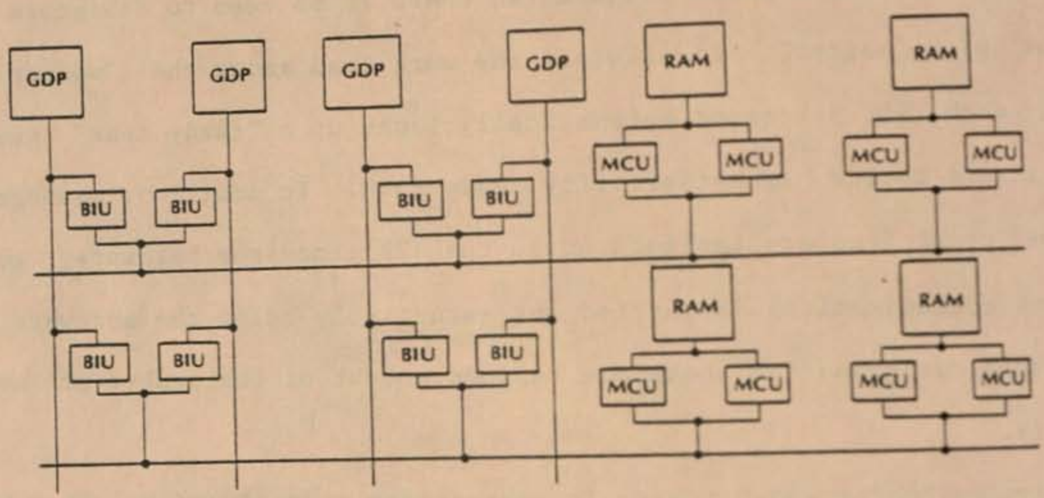
Another important 432 feature is self dispatching. This means that, in a system employing multiple 432 processors, there is no need to designate any one of these as a "master", to allocate the work load among the "worker bees". Instead, each 432 processor automatically looks up a "ready task" queue and assigns itself to the highest priority ready task. In addition, message communications primitives are implemented in the 432 processor hardware, so interprocessor communications is carried out essentially below the software level. Applications programs can therefore be independent of the number of available processors.

Self-dispatching and hardware interprocessor communications are important, because they facilitate the implementation of systems which feature graceful growth. As pointed out earlier, graceful growth is one of the most attractive features of the Tandem system. It has a strong appeal, quite independently from any fault-tolerance considerations, in installations which expect substantial increase in their work-loads, but are unable to afford the required computing capacity initially, or are loath to go through a number of "upgrades". Exhibit II-4 shows how 432s can be arranged in a self-checking multiprocessor configuration.

Finally, the object-oriented, capability-based architecture of the 432 is especially conducive to the development of fault tolerant software. This comes

EXHIBIT II-4

432 SELF-CHECKING MULTIPROCESSOR



Source: Intel

about mainly because such architectures limit each program's access according to a "need to know" principle. Exhibit II-5 depicts how this is accomplished.

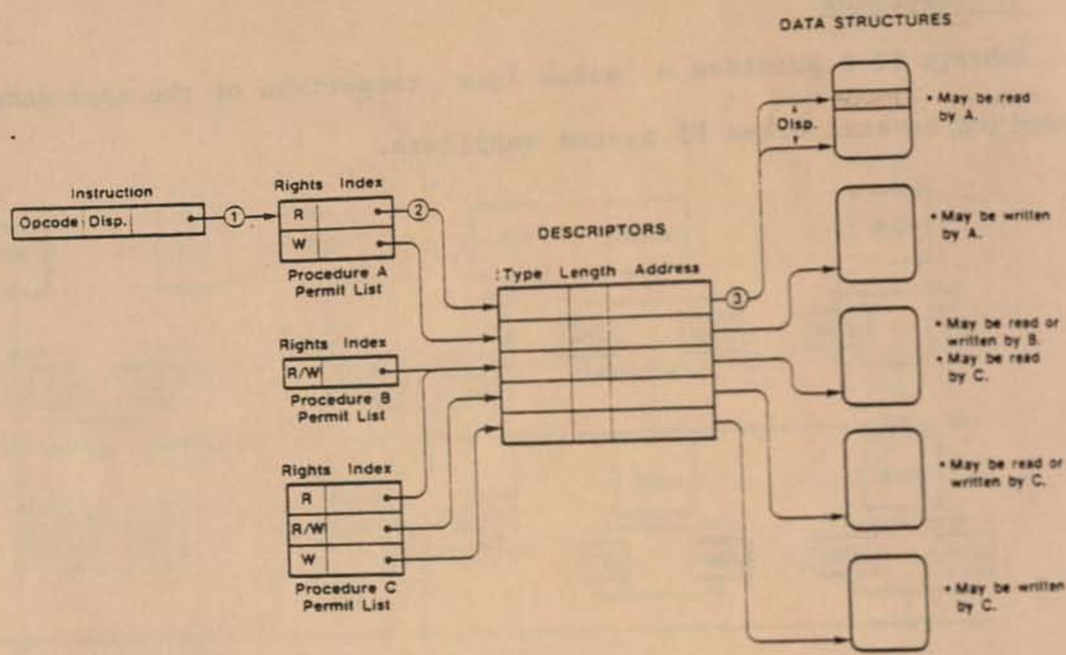
While wide acceptance of the 432 is still some time away, such advanced MPUs will clearly make it easier than ever before to design robust, low-cost fault-tolerant systems, which would compare well with the current Tandem approach.

7. Comparison

Exhibit II-6 provides a "quick look" comparison of the approaches taken by Tandem and several other FT system suppliers.

EXHIBIT II-5

432 PROTECTED ADDRESSING



(1) Processor reads permit specified in instruction and checks rights.
(2) Processor reads descriptor indexed by permit, checks type, and compares length to displacement in instruction.
(3) Processor adds displacement to data structure address and fetches operand.

Source: Intel

EXHIBIT II-6

FAULT TOLERANT SYSTEMS COMPARISON

	TANDEM NONSTOP I	TANDEM NONSTOP II	STRATUS 32	SYNAPSE	DOSC FailSafe	AUGUST SYSTEMS Can't Fail 300
First Shipment	5/76	4/81	2/82	10/82	12/81	10/81
Target Market	<--- On Line Transaction Processing --->				Low cost OLTP	Process Ctrl.
Max. # of CPUs per Node	16		32	28 Incl. IOPs	32	3
Processor Technology	Microprogrammed Schottky TTL		68K MPU	68K MPU	Bit Slice DBM Mgr. 8085A2 Workstas.	8086 MPU
Processor MIPS	0.7		0.7	0.7	200 ns.	0.4
Processor Interconnection	Dynabus 10-13 MB/sec		StrataLink 1.4-2.8 MB/s	Shared Memory 32-64 MB/sec	Multibus 200 KB/sec	Read-only P-P Links
Long Haul Networking	yes		yes	planned	no	no
I/O Scheme	1 IOP per CPU Microprogrammed		Z80A-based Controllers	Multiple 68K-based IOPs	Printers etc. at DBM Mgr.	Multibus & Triple Redun. Process I/O
Basic FT Mechanism	Backup processes & Checkpointing		Self-checking Pair & Spare	Auto shut down & Restart	None	Triple-Redun. & Maj. Vote
Disk Protection	<------------ Disk Mirroring ------------>					None
Data Base Consistency	yes		yes	yes	yes	No
Entry Level Typical $	$150K		$120K	$300K	$60K	$50K

Source: ITOM International Co.

G. MARKET FORECASTS

Past attempts to forecast the markets for fault tolerant systems have generally failed. This is so because traditional forecasts attempt to define the applications areas first, and then define the dollar value of computer systems being shipped into such applications. This method creates two insurmountable difficulties, namely:

- o There are no reliable data on current shipment levels categorized by fault-tolerant applications.
- o The market size is intimately related to the incremental cost of the fault-tolerant features, and such data is even harder to ascertain than the shipment levels.

In this study, a totally different approach is taken. This approach leads to a market model that is based on verifiable current data, and which projects future trends based on a few, simple assumptions, which are clearly stated. The result is a forecast that is firmly rooted in reality, with projections that are based on clearly understood assumptions that can be easily modified to accomodate other assumptions or to conform with data available to readers of this report.

The development of the market model takes the following steps:

- o Define market segments for which current shipment levels are well known.
- o Make assumptions about the expected average growth rate of each segment, to obtain the segment's estimated size in 1986.
- o Within each market segment, define application area(s) which are sensitive to the fault-tolerance issue.
- o Estimate the percentage of total shipments that these FT-sensitive applications represent within each segment, now and in 1986. This yields the estimated <u>potential</u> market for fault-tolerant systems.
- o Define the suppliers of fault-tolerant systems that are currently shipping, and that are known to be readying products for introduction by the end of 1983.
- o Estimate the attainable growth rate of each, and sum up the resulting 1986 numbers by segments. This yields the <u>realizable</u> market.

1. Segments.

Excellent data is available from a number of sources on computer shipments categorized by the following four classifications:

- o Mainframes (over $250K).
- o Minicomputers ($15K-$250K).
- o Microcomputers (less than $15K).
- o Word Processors.

The base data for these four categories are the 1981 figures from The Gartner Group, whose kind permission to use this data is hereby gratefully acknowledged. These figures are shown in Exhibit II-7.

This exhibit also shows the estimated average annual growth rate (AAGR) for each category over the five year period 1981-6, and the resulting shipment levels in 1986. These AAGRs are estimated by ITOM.

EXHIBIT II-7
MARKET SEGMENTS

SEGMENT	1981 SHIPMENTS(1) ($ Billions)	1981-6 AAGR(2)	1986 SHIPMENTS(2) (1981 $ Billions)
Mainframes	16.5	6.5%	22.6
Minicomputers	10.0	12.5%	18.0
Microcomputers	1.7	30. %	6.3
Word processors	2.0	17. %	4.4

(1) Based on data by The Gartner Group, Stamford, CT. Excludes peripherals, software, services, and datacomm equipment.
(2) Source: ITOM International Co.

Mainframes, other than IBM's, are already exhibiting typical symptoms of a nearly-saturated market; namely, growth rates of only about twice the GNP, and increased sensitivity to economic downturns. IBM is the exception, growing at about 15-20% overall. However, when IBM's results are combined with those of the other mainframe suppliers, an AAGR of 6.5% over the next five years is probably quite realistic.

Minicomputers are doing much better than mainframes, but the days of 40% growth are over for good. Minicomputer shipments have been impacted not only by the current economic conditions, but, over the longer run many minicomputer applications are being captured by microcomputers, especially the "supermicros" (i.e. those based on 16/32 bit MPUs). A conservative AAGR of 12.5% over 1981-6 is estimated.

By far the "hottest" action is in the microcomputer segment, which is currently growing at better than 40%. However, this rate will not be sustainable through 1986. A more moderate average of 30% is assumed.

Word processors are also past their peak, not because demand is slacking, but because general purpose microcomputers offer comparable WP capabilities, along with respectable DP facilities, at prices which are comparable to, or lower than, stand-alone word-processors.

2. FT Applications.

The applications for fault-tolerant systems have been discussed at some length earlier in this chapter. It remains only to classify them relative to the four market segments, and to estimate the percent of shipments that go into these applications. Exhibit II-8 summarizes this information.

On line transaction processing is clearly the prime application for fault-tolerant systems. It is classified within the mainframe segment despite the fact that Tandem, the current leading FT supplier, services these applications with what is essentially a minicomputer, and the newcomers are microprocessor based. The reason for this classification is not only historical (mainframe-based airline reservations systems were the earliest OLTP applications), but mainly because OLTP and other on-line applications are currently being served primarily by mainframes. ITOM estimates that some 50% of all the mainframes shipped in 1981 were intended to carry some on-line load, either initially or eventually. By 1986, the percentage of mainframes shipped into such environments will grow to 75%.

EXHIBIT II-8
POTENTIAL FAULT TOLERANT APPLICATIONS

SEGMENT	FT APPLICATIONS	ESTIMATED % OF TOTAL SHIPMENTS GOING TO FT-SENSITIVE APPLICATIONS	
		1981	1986
Mainframes	On-line transaction processing, other on-line applications	50%	75%
Minicomputers	Data acquisition, process control & monitoring, industrial automation, communications	5%	20%
Microcomputers	Shared-disk, LAN-based systems	2%	10%
Word processors	Shared disk, shared logic systems	50%	20%

Source: ITOM International Co.

Data acquisition, process monitoring & control, factory automation and communications applications are served primarily by minicomputers. ITOM estimates that, of the total minicomputer shipments, about 5% went to FT sensitive applications like those just listed. The percentage is low relative to the total minicomputer shipments into these applications because not all such applications are necessarily sensitive to the fault-tolerance issue. By 1986, ITOM estimates that the percentage of minicomputers shipped into FT-sensitive applications will grow to 20% of the total shipments.

In the microcomputer segment, the FT-sensitive applications revolve around shared-resource arrangements, especially shared-disk, which are now increasing rapidly in popularity through local area network (LAN) interconnection. Corvus, for example, is doing a land-office business in selling its disks, along with either multiplexers or a single-channel LAN, to allow multiple microcomputers to share this "expensive" resource. The primary buyers of the Corvus, and similar offerings are schools and similar customers who are interested in buying "stripped down" micros sans the local disks, for example.

However, it is clear that, as LANs increase their penetration of the office environment, there will be a heavier emphasis on fault-tolerance features at the shared resource (data base). ITOM estimates that only 2% of microcomputers shipped in 1981 went into FT-sensitive applications, but that this number will grow to 10% by 1986.

In word processors, a distinction has to be made between stand-alone and shared-resource systems. Stand-alone, which range from electronic typewriters all the way to dual-page display systems with local disks and printer, are generally not sensitive to FT-features, i.e. users of such stand-alone stations are looking for low cost and are not willing to underwrite the incremental cost involved in providing fault-tolerance.

Shared resource systems range from arrangements in which a cluster of low-cost terminals share a dedicated minicomputer ("shared logic") and/or a central disk controller ("shared disk"), to word-processing terminals attached to a mainframe and running specilaized WP software on that mainframe. These shared-resource systems are far more sensitive to the availability and data integrity issues, for two reasons. First, the failure of the shared resource idles a large number of workers; and secondly, the loss of a document in the central data base could represent the loss of the labor of many workers over extended periods of time.

ITOM estimates that some 50% of all word processor shipments in 1981 fell within the "shared resource" category. However, for 1986, ITOM projects a dramatic reduction in such shipments, to only 20% of the total. The main reason for this drop is that the rapidly-dropping prices of stand-alone, microprocessor-based word processors are undermining the economic justification of shared-resource arrangements, which, because of their inherent "political" (ownership) complications, are already unattractive to many organizations.

Market projections in this report exclude the communications and military segments, even though these are believed to be quite substantial. The main difficulty in the communications segment is separating the value of the computer equipment from the rest of the system, which currently is limited to central office (CO) switchgear, but may soon include computerized PABXs. The same difficulty applies to weapons system, where, in addition, shipment data is often classified.

Exhibit II-9 combines the market segment sizes, developed in Exhibit II-6, with the percentages of FT-sensitive applications developed in Exhibit II-7.

EXHIBIT II-9
SIZE OF POTENTIAL FT APPLICATIONS
(In billions of 1981 dollars)

SEGMENT	FT APPLICATION	ESTIMATED MARKET SIZE 1981	1986
Mainframes	On line transaction processing, other on-line	8.2	16.9
Minicomputers	Data acquistion, process control & monitoring, industrial automation, data comm.	0.5	3.6
Microcomputers	Shared-disk, LAN-based systems	0.03	0.6
Word processors	Shared disk, shared logic systems	1.	0.9
	TOTAL	9.7	22.

Source: ITOM International Co.

These numbers represent the <u>potential</u> market and not necessarily the <u>realizable</u> market for fault-tolerant systems. In fact, it is clear that the firms who are now (or soon will be) supplying such systems, will not be able to grow fast enough to realize these markets. The majority of the market will, in fact, be served by conventional systems, arranged perhaps in a variety of backup and redundancy configurations.

Market Participants. The current line up of present and potential FT system suppliers is about as shown in Exhibit II-10.

The criterion used in constructing this list was that the product offered must have been designed expressly for fault-tolerant operation, rather than be based on general-purpose products "force-fitted" into a pseudo-FT configuration.

EXHIBIT II-10
FAULT-TOLERANT SYSTEM SUPPLIERS

On Line Transaction Processing	FCS
Tandem (Cupertino, CA)	(1976)
Stratus (Natick, MA)	(3/82)
Computer Consoles (Rochester, NY)	(4Q82 est.)
Synapse (Milpitas, CA)	(4Q82 est.)
Parallel Computer (Englewood Cliffs, NJ)	(3Q83 est.)
Sequoia (Natick, MA)	(4/83 est.)
Data Acquisition, Process Control	
August Systems (Salem, OR)	(11/81)
Shared Resource Microcomputer Networks	
DOSC (Albertson, NY)	(12/81)
Syntech (Dallas, TX)	(N/A)
Shared Disk Word Processor	
Syntrex (Eatontown, NJ)	(1982)

Source: ITOM International Co.

Of these companies, only Tandem has established a clear record that can be extrapolated with some confidence. During the first full five years of shipments, Tandem grew at an average rate of 100% a year, in both revenues and earnings. During the next two quarters, ending in December, 1981, and March, 1982, Tandem grew at approximately 80% (relative to year-before results) in terms of revenues, and slightly less in terms of earnings. Lower-than-expected results for the quarter ending June, 1982, (which have not been released as this is being written), will apparently reflect a 50% revenue growth and 20% earnings growth.

Should Tandem be able to recover to an annual growth rate of 60%, then it could reach $2.5 billion in calendar 1986, beginning with the $242 million the company recorded in calendar 1981.

Computer Consoles has been operating in a specialized niche of the on-line transaction processing market, supplying directory assistance systems to telephone companies. Although its present product is based on standard minicomputers, substantial hardware and software elements have been added, so the product may be regarded as bona fide fault-tolerant. In 1981, CCI reported some $50 million in revenues, of which the lion's share was from on-line transaction processing systems. For market forecast estimates, we assume that CCI's revenues from present and future FT systems will grow at 50% a year through 1986; this should put its 1986 revenues at about $380 million.

For Stratus, Synapse, Sequoia, and Parallel Computer (NJ) we assume a very optimistic five-year growth curve of $2 million, $10 million, $40 million, $80 million, and $160 million. For Stratus, we assume the curve to begin in 1982, while for the other three, in 1983. Thus their total revenues in 1986 would amount to 3x80 + 160 = $400 million.

This is, of course, a very optimistic scenario, assuming that all entrants will be so spectacularly successful. By the same token others may enter the market, and they have been ignored. On balance, the projection seems reasonable.

Adding together the contributions of Tandem, CCI, and the other four, a total of $3.28 billion is obtained. This represents the realizable FT market in the on-line transaction processing segment.

In the process control segment, we assume for August the same dramatic $2/10/40/80/160 million growth curve, beginning in 1982. Assuming that one other company enters the market in 1983 (perhaps National Semiconductor) and follows the same curve, we have 160 + 80 = $240 million in 1986.

In microcomputers, we assume that DOSC, Syntech, and perhaps others might capture between them some $20 million in 1986.

In word processing, we assume Syntrex will grow from $11 million in 1981 to $120 million in 1986; of these revenues, we assume that $30 million will come from sales of Gemini and follow-on fault-tolerant systems. Other suppliers my capture an additional $20 million.

4. Realizable 1986 FT Markets

Exhibit II-11 summarizes the results of these calculations.

EXHIBIT II-11
REALIZABLE FT MARKETS IN 1986

SEGMENT	POTENTIAL (Billions of 1981 dollars)	REALIZABLE	% PENETRATION
On line transaction proc.	17	3.3	19
Data acquisition, P.C.	3.6	0.24	7
Microcomputer nets	0.6	0.02	3
Word processors	0.9	0.05	5

Source: ITOM International Co.

The conclusion is evident: present and potential FT suppliers will be able to capture only a small portion of the potential FT market in any segment. The 1986 market will remain wide open.

CHAPTER III

TANDEM

A. A SUCCESS STORY UNFOLDS

Until very recently, Tandem was, without a doubt, one of the great success stories of Silicon Valley, and indeed the U.S. business scene. Even the beating its stock took in mid July, 1982, serves to underline the magnitude of the company's success. The stock lost some six points within a week not because of any significant downturn in the company's business or earnings picture, but simply because the company announced that its results for the June quarter are likely to reflect a growth of "only" 50% in revenues and 20% in earnings, relative to year-ago comparable period!

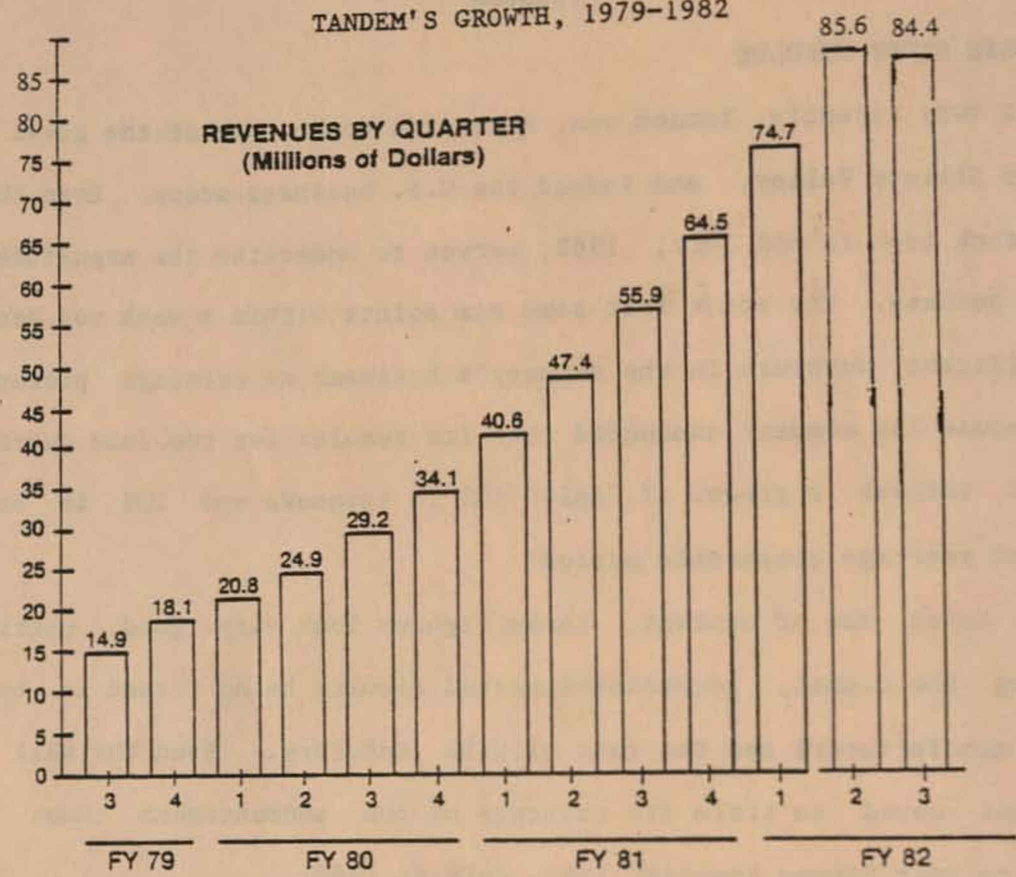
When taken out of context, these figures look very good, particularly considering the dismal, recession-impacted results being turned in by other computer manufacturers and the rest of U.S. industry. Even The Wall Street Journal was moved to title its coverage of the announcement thus: "Tandem Computers to Post Strong Results" (WSJ, July 8, 1982).

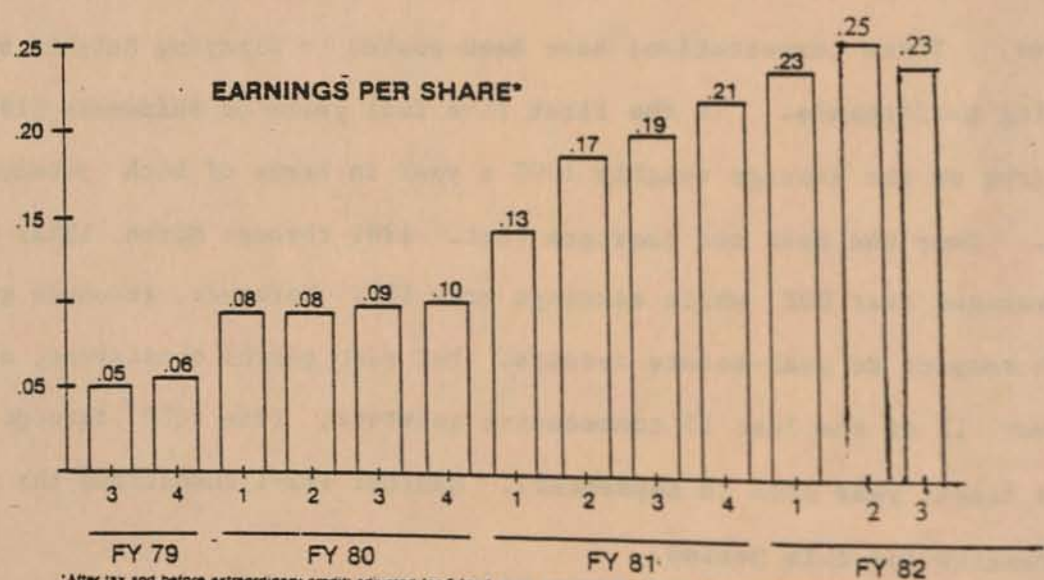
These "strong" anticipated results, however, are significantly below expectations. These expectations have been pushed to dizzying heights by years of sizzling performance. In the first five full years of shipments (1977-81), Tandem grew on the average roughly 100% a year in terms of both revenues and earnings. Over the next two quarters (Oct. 1981 through March, 1982) revenue growth averaged over 80%, while earnings grew 55%. Moreover, revenues grew not only with respect to year-before results, but also posted consistent, absolute gains over 12 of the last 13 consecutive quarters, from 3Q79 through 3Q82. (Tandem's fiscal year ends in September). Exhibit III-1 summarizes the revenue and EPS results for this period.

Dramatic success has been the hallmark of the company ever since its founding. The Tandem idea was conceived in early 1973 by Jim Treybig (pronoun-

EXHIBIT III-1

TANDEM'S GROWTH, 1979-1982





*After tax and before extraordinary credit; adjusted for 2 for 1 stock split 6/30/80 and 3 for 1 stock split 6/30/81.

Source: Tandem

ced try-big), a Texan with a Stanford MBA, who was then a minicomputer marketing manager at Hewlett Packard. Following a management shuffle at HP, Treybig left and took his idea to Thomas J. Perkins, another former HP executive who, together with Fairchild cofounder Eugene Kleiner, ran a successful venture capital firm in San Francisco.

This early venture capital connection later proved to be Tandem's first major success: that of being able to attract sufficient funding at a time when such funding was nearly non-existent, especially to computer start-ups.

Kleiner and Perkins liked the idea, but felt it needed additional work. They hired Treybig to work on Tandem and other projects, which he did for about 18 months. In mid 1974, Kleiner and Perkins put up $50,000 in seed money and let Treybig work on Tandem full-time. He then recruited three other HP executives: Michael D. Green, who had worked on HP's first time-sharing software, became Tandem's vice president for software development; James A. Katzman, previously a key member of the HP 3000 design team, became Tandem's engineering vice president; and John C. Loustanou, a HP accounting executive, became Tandem's first financial vice president. These four executives are officially considered to be Tandem's founders. All but Loustanou are still with the company; T.J. Perkins is still Tandem's chairman; and Treybig is still a limited partner in Kleiner, Perkins.

Katzman and Green put sufficient "flesh" on the design to convince Kleiner, Perkins to ante up an additional $1 million. The company was formally incorporated in November, 1974. In December, 1975, just prior to the official announcement of the Tandem 16, the company managed another coup by raising a second round of financing, amounting to about $2 million. Joining Kleiner, Perkins (who contributed another half a million) in that round were other leading venture capitalists, including E.M. Warburg, Pincus, and Data Science Ventures. First customer ship took place in May, 1976. The company became profitable in its 1977 fiscal year; in December of that year, it went public. Its stock is traded over-the-counter under the symbol TNDM.

Ever since, Tandem has been performing spectacularly, rapidly increasing its revenues, its earnings, the productivity of its employees, the number of its customers and the number of processors shipped, as summarized in Exhibit III-2.

EXHIBIT III-2

TANDEM'S PERFORMANCE, FY 1977-1982

	1977	1978	1979	1980	1981	1982(1)
Revenues ($ millions)	7.7	24.3	56.	109.	208.4	244.7
Net Earnings ($ millions)	0.3	3.4	4.9	10.7	26.6	27.7
Employee Productivity (Sales in $K/employee)	74.	83.4	87.9	98.4	101.2	NA
Number of Customers (Cumulative)	30	73	160	290	460	NA
Number of Installed Processors (Cumulative)	81	257	646	1299	2509	NA

(1) 9 months ending June 30, 1982
Source: Tandem

B. TANDEM TODAY

1. Management

A recent Fortune magazine article, dubbed "Management by Mystique at Tandem Computers" (Fortune, June 28, 1982), drew this response from Tandem's chairman T.J. Perkins: "[The article] does both the company and your readers a great disservice. Chief Executive Jim Treybig is presented as some kind of Silicon Valley Jim Jones, guiding (or misguiding) spellbound employees into a wild future. The great breadth and strength of the management team is ignored.

The careful product engineering, attention to manufacturing, skill in marketing, and all the other aspects of a most successful business are ignored".

Nevertheless, the Tandem management structure and style are certainly unusual, largely informal and highly decentralized. Treybig's "open door" office policy, for instance, even extends to a "sign-up-for-yourself" appointment calendar. Official organization charts are pretty much nonexistent, and both titles and the scope of duties of some executives, notably in marketing, manufacturing, and software development seem a bit overlapping.

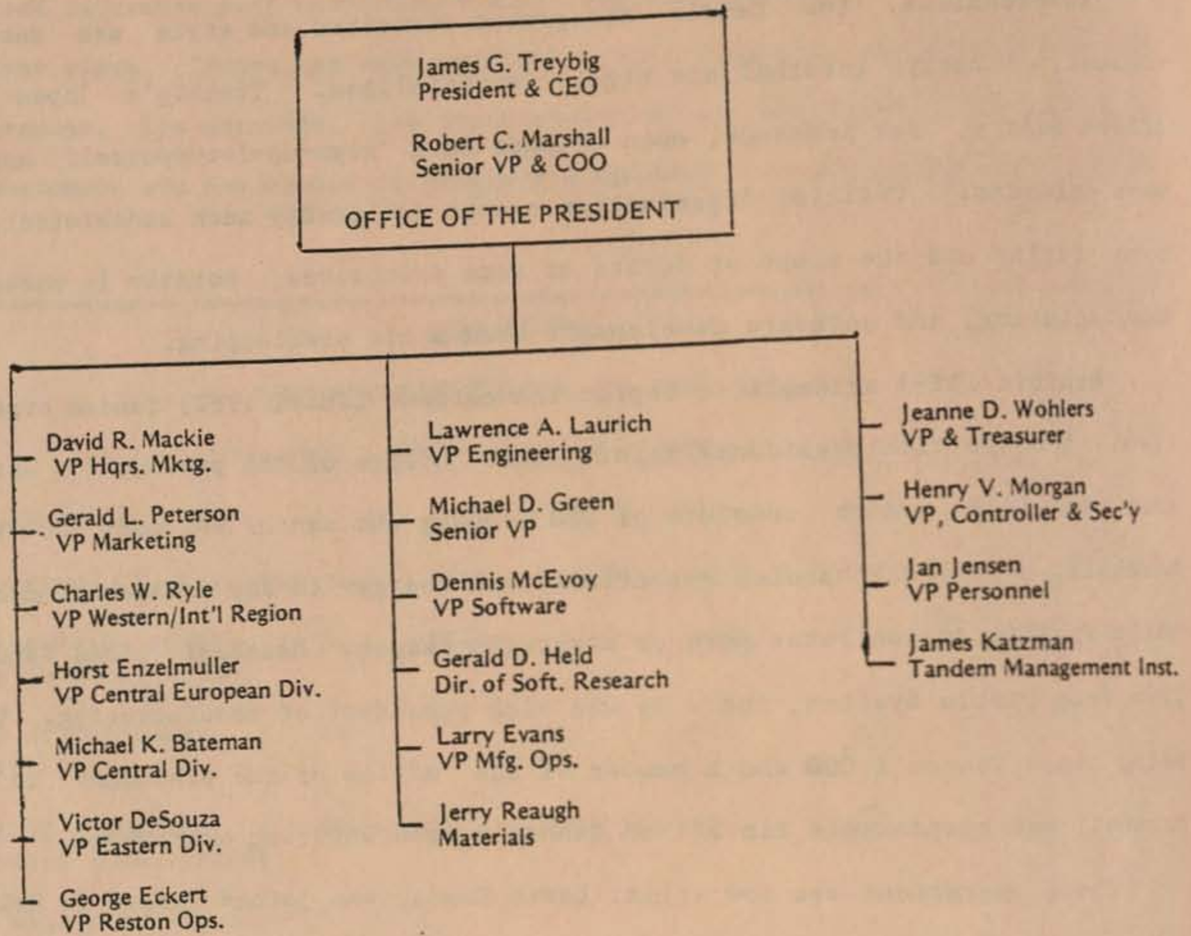
Exhibit III-3 attempts to depict the current (July, 1982) Tandem organization. Some 16 vice presidents report to an "office of the president", established in 1979, which consists of CEO Treybig and senior VP and COO Robert Marshall. Marshall handles essentially all the day-to-day management details, while Treybig concentrates more on strategic issues. Marshall joined Tandem in 1975 from Diablo Systems, where he was vice president of manufacturing. Before being named Tandem's COO and a member of the "office of the president" in 1979, Marshall was responsible for all of Tandem's manufacturing operations.

These operations are now split. Larry Evans, who joined Tandem in February 1982 as vice president of manufacturing operations, runs the organization which produces the Tandem systems on a "build to order" basis. Materials and subassemblies are procured, "to forecasts", by Jerry Reaugh's materials organization. Approximately 60% of the labor involved in the company's products in FY 1981 was provided by subcontractors, primarily in the form of PC boards, power supplies, and cables purchased from outside sources. Tandem's manufacturing contributes mainly integration and testing. The system integration and test facility in Reston, VA (one of three such facilities, the others being in Santa Clara and in West Germany), is under vice president George Eckert.

Marketing responsibilities are divided between two headquarters executives and four autonomous regional divisions. Headquarters marketing duties are

EXHIBIT III-3

TANDEM'S ORGANIZATION



Source: ITOM International Co.

shared between vice presidents David R. Mackie and Gerald L. Peterson. Mackie joined Tandem in 1975 from Hewlett Packard, where he held various product development and marketing posts. At Tandem, he was first manager of technical support, rising to vice president of product and technical support in 1977, and assuming his headquarters marketing vp post in 1979. Peterson joined Tandem in 1980 from Hewlett Packard, where he was a marketing manager in the small business systems operation. At Tandem, Peterson was first marketing director, reporting to Mackie. He was named vp of marketing in 1982. Peterson is responsible for sales policies, industry marketing, major accounts program, and software education, while Mackie has product management and business development functions.

The regional division concept, introduced in 1979, allocates sales, support, and customer engineering responsibilities to four divisions, each headed by a vice president. The Western/International division is headed by Charles Ryle; the Central Division is under Michael Bateman; Victor DeSouza heads the Eastern Division; while the Central European Division is under Horst Enzelmuller.

Hardware development functions are under vp of engineering Lawrence A. Laurich, who joined Tandem in 1978 from an 11-year stint with IBM. Software development responsibilities are split between senior vp Michael Green, one of the founders, and Dennis McEvoy, who joined Tandem in 1974 and was part of the team that developed the Guardian™ operating system. McEvoy was named vice president in 1980, and "corporate vice president" in February, 1982.

James Katzman, one of the founders, headed the Western/International division for a while. He is now in charge of the Tandem Management Institute, an internal training organization whose mission is to impart management skills to Tandem employees as they are promoted to management assignments. The company tries hard to promote internally rather than hire externally, and the institute was established to support this policy.

Perhaps the most visible aspect of Tandem's management philosophy is the unstructured, informal working environment. This "people oriented" environment is replete with an array of amenities, including a swimming pool, jogging trail, basketball court, other athletic facilities, and the famed, company-underwritten Friday afternoon "beer busts".

Tandem employees enjoy a 3-week annual vacation, rather than the more conventional two-week leave; and, in addition, they earn a fully-paid, six-week "sabbatical" upon completing their fourth year with the company.

Employees are indoctrinated with the Tandem spirit by studying a thick "Understanding Our Philosophy" binder in compulsory educational sessions. These sessions go beyond the conventional "do and don't" exposition: they attempt to make each employee understand the essence of Tandem's 5-year business plan, which calls for revenues of $1.1 billion in 1985, and how individual performances affect the company's goals. To give all this a stronger personal meaning, Tandem encourages employees to share in the company's success by granting stock options to every worker, in addition to the more conventional 15%-company-financed stock purchase plan.

These measures are evidently effective. Despite the long leaves and weekly "beer busts", Tandem boasts a high and increasing employee productivity, as measured in terms of sales per employee. For the six quarters ending March, 1982, productivity stood at about $100K per worker, well above IBM's 1981 figure of $82K, (although not quite as dramatic as the corresponding Apple figure of $148K). Moreover, employee turnover is at a very low 7%, compared to the more typical 15-20% experienced by most other Silicon Valley firms. Keeping employee productivity high and turnover low are important to the company, if it is to achieve the ambitious revenue goals it has set for itself.

2. Resources

Tandem has been able to maintain strong balance sheets, ending its FY 1981 with a current ratio of 5.4 to 1. The company was capitalized at nearly $205 million at that time (Sep. '81), of which long-term borrowings represented less than 1%. That number is expected to grow to finance expansion.

The company spends over 8% of its gross revenues on product development activities. In FY 1981, the amount spent on such activities was over $17.8 million.

Employment as of late April, 1982 stood at 3,349, up from 2,730 at the end of FY 1981, at which time nearly half (48%) were in marketing and customer support, while only 7% were in direct sales. Exhibit III-4 provides the complete employment breakdown. The support-to-sales ratio is about 4:1, with two system analysts and two field service engineers for each salesman in the field.

EXHIBIT III-4

TANDEM'S EMPLOYMENT BY FUNCTION, END OF FY 1981

Marketing & Customer Support	48%
Manufacturing	25%
Research & Development	14%
Direct Sales	7%
General & Administrative	6%
	100%

Source: Tandem

The company's Cupertino, CA headquarters and main manufacturing plant are housed in a leased, four-building complex totaling 440,000 sq. ft. of floor space. Approximately 45% of that space is allocated to manufacturing, while the remainder is occupied by marketing, support, R&D, and administrative functions. Several other facilities are located in Santa Clara county (the heart of "Silicon Valley"), including a 55,000 sq. ft. R&D and software education plant in Sunnyvale, CA, and in McLean, VA. A subassembly and PCB manufacturing plant in Watsonville, CA, about 45 miles south of San Jose, is expected to grow to 86,000 sq. ft. by November, 1982. The 17 acre tract for this plant is the first land purchased by Tandem.

A major facility for system integration and test is being constructed in Reston, VA. It is expected to provide 220,000 sq. ft. of floor space. A similar, though smaller facility is located in Neufahrn, West Germany (near Munich). In Austin, TX, where the 6530 terminal is now being manufactured in a 63,000 sq. ft. rented facility, the company is building a 190,000 sq. ft. "terminal products development and manufacturing" plant, expected to be complete in mid-1983.

In July, 1982, Tandem had 75 sales, service and education centers world wide, of which 54 were in the U.S., with rest distributed in Canada, Western Europe, United Kingdom, Hong Kong, and Japan. Tandem equipment is being sold through distributors in Australia, Finland, Greece, Mexico, and Venezuela.

3. Markets

More than two-thirds of the company's systems are sold to end users, who either develop their own applications programs, or subcontract that task to firms specializing in custom work. The remaining systems are sold mainly to vertical markets system integrators (e.g., American Totalisator), with a small percentage going to OEMs.

Banking and other financial institutions are the primary users of Tandem equipment to date. Manufacturing and hospitals are also significant users. A breakdown of system usage by industry segments is depicted in Exhibit III-5. The "other" category includes distributors, wagering, postal, university, retail, library services, printing and publishing, legal, broadcasting, utility, local government, and energy.

EXHIBIT III-5

USE OF TANDEM SYSTEMS BY INDUSTRY SEGMENT

Banking	18%
Manufacturing	17%
Software	10.5%
Hospital	9%
Federal Government	7%
Communications	7%
Service Bureau	6%
Transportation & Travel	5%
Other	20.5
	100.

Source: ITOM International Co.'s estimates, based on Tandem's data

Repeat business is common, and customers' satisfaction is high, as confirmed by both the level of shipments going to existing accounts, and by independent surveys. Although the average installed system has just 2.8 processors (CPUs), those that have been in service for a year or more average 4-5 CPUs. About half of all annual CPU shipments recently went to existing installations.

C. TANDEM 16 - THE FIRST NONSTOP™

1. System Overview

The general principles underlying Tandem's original design were outlined in Chapter II, where a block diagram of the Tandem 16 is also given (the term NonStop, although frequently mentioned in Tandem's publications at the time, was then used in its generic, rather than trade-mark, sense).

To recoup briefly, the basic hardware concept is a system of multiple, minicomputer like processors, interconnected by duplicated, high-speed parallel buses, supporting redundantly-powered, dual-ported I/O controllers. Although the following description is limited to the original NonStop system, most details apply as well to the newest version, the NonStop II™, which will be described separately later.

The basic elements of the system are the processor modules, the Dynabus™, the dual-ported I/O controllers, and the DC power distribution system.

The system is physically packaged in floor standing racks, whose general organization is shown in Exhibit III-6.

Each processor module consists of up to 8 large (16"x18") PC boards. The 16-bit CPU, a multiplexer I/O channel, memory control and Dynabus control occupy two boards, each containing about 300 chips. The remaining six slots can be used by memory boards. These were originally implemented with 800 ns core memories requiring two slots for a total of either 32K or 128K of 17-bit words (one parity bit per word). Later memories, using 500 ns 4K and 16K dynamic MOS RAMs held, respectively, 48K and 192K 22-bit words (16 data + 6 ECC) per board, thereby allowing a maximum of over 1 MB per processor (though physical addressing was limited to 1 MB). A battery backup system provides short-term non-volatility for the semiconductor memory system.

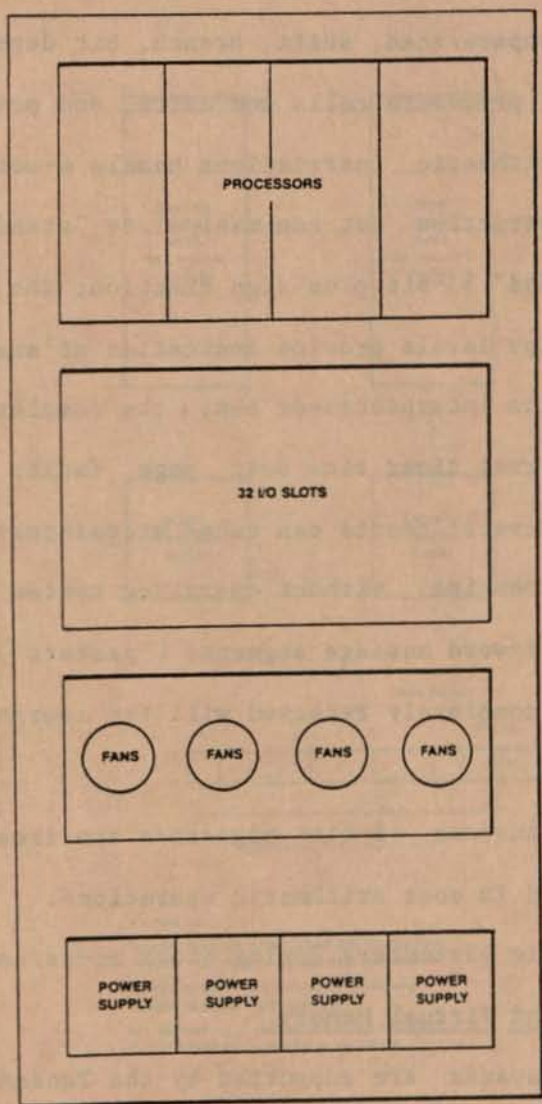
Even though the processor card cage has 32 slots, power and cooling considerations limit each rack to a maximum of 4 processor modules; the maximum 16-processor configuration requires 4 racks.

2. CPU

The stack-oriented CPU, implemented with Schottky TTL logic, is driven by a microprogram which resides in a 32-bit wide ROM-based control store. The control architecture allows addressing of up 4K control words, organized in 512-word sectors. The Tandem 16 instruction set occupies 1K words, while the

EXHIBIT III-6

TANDEM SYSTEM PHYSICAL ORGANIZATION



Source: Tandem

decimal and floating point arithmetic requires 512 words more.

The two-stage pipelined microengine has a cycle time of 100 ns. All microinstructions take two cycles to execute; but, because of the pipelining, one completes every cycle. The basic macroinstruction set consist of 173 instructions, each 16 bits wide. These include arithmetic, logic, data movement, block move/compare/scan, shift, branch, bit deposit, stack manipulation, interprocessor SEND, procedure calls and exits, and privileged control instructions. Decimal arithmetic instructions handle 4-word operands, while the floating point instruction set can manipulate "standard" 22-bit plus sign fractions or "extended" 55-bit plus sign fraction; the exponent is 9 bits long.

Sixteen interrupt levels provide indication of such events as the receipt of a message from the interprocessor bus; the completion of an I/O operation; memory error; interval timer time out; page fault; privileged instruction violation; etc. Several events can cause microinterrupts, which are fielded entirely by the microengine, without operating system involvement. An example is the receipt of 16-word message segments ("packets") over the Dynabus; only when the message is completely received will the operating system be alerted by an interrupt.

Eight general-purpose 16-bit registers are treated as a "wraparound" stack, which is used in most arithmetic operations. These registers are also used to hold updatable parameters during block moves/compares/scans.

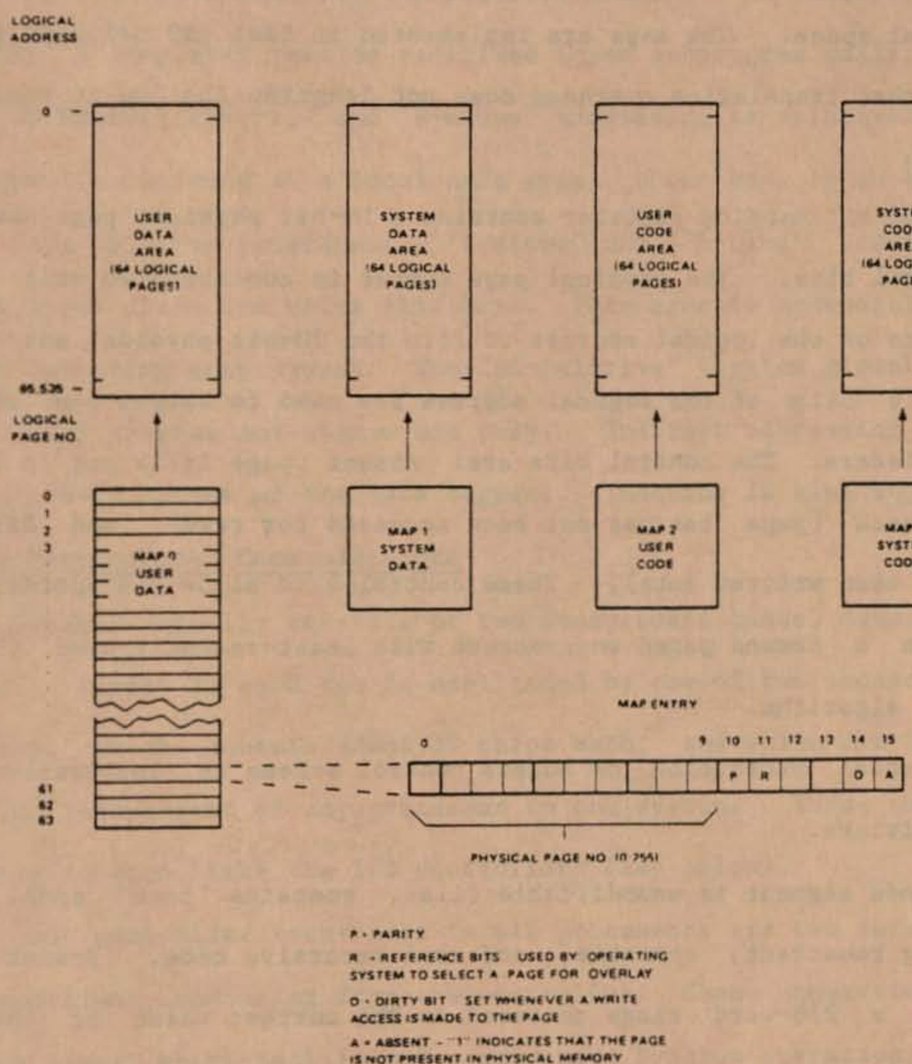
3. Addressing and Virtual Memory

Four address spaces are supported by the Tandem system, as shown in Exhibit III-7: user code, user data, system code, and system data. Each is 64KW (128KB) long. One of these virtual spaces is automatically selected by the processor, depending on whether the memory reference is for data or for an instruction fetch, and on whether the processor is in the system or user mode.

Dynamic address translation, supporting demand paging operation, is emp-

EXHIBIT III-7

TANDEM 16 LOGICAL MEMORY ADDRESS SPACE



Source: Tandem

loyed. Physical memory addresses are 20 bits long, allowing a maximum of 1 million words (2 MB) per processor. Four physical translation tables (hardware maps) are provided, one for each virtual space, to translate logical addresses issued by the running program into physical memory addresses. Each map contains 64 mapping registers, one for each 1K word (2KB) page in the correspon-ding virtual space. The maps are implemented in fast (50 ns) bipolar static RAMs, so that translation overhead does not lengthen the 500 ns basic memory access time.

Each 16-bit mapping register contains a 10-bit physical page number, and three control bits. The physical page number is concatenated with the low-order 10 bits of the logical address to form the 20-bit physical address. The high-order 6 bits of the logical address are used to select one of the 64 mapping registers. The control bits are: Absent (page is/is not in main memory); Reference (page has/has not been accessed for read); and Dirty (page has/has not been written into). These control bits allow the operating system to maintain a demand paged environment with least-recently-used (LRU) page replacemnet algorithm.

No special protection or access control scheme is implemented in the mapping registers.

The code segment is unmodifiable (i.e., contains "pure" code), thereby facilitating reentrant, sharable, and even recursive code. Branch addresses are within a 256-word range centered on the current value of the program counter. Procedures are classified as either non-privileged or privileged, the latter being callable from procedures currently executing as privileged. "Callable" procedures, a third class, can be called from non-privileged procedures, but execute in the privileged mode, making operating system services accessible to non-privileged users.

The data segment can be referenced in a variety of ways, depending on the structure of the address portion of the instruction word, as shown in Exhibit III-8. One extreme of this data space holds a global data area (to be shared by all subprograms of a particular task); addressing relative to the base of this global area is called "G-relative". The other extreme holds a memory stack (not to be confused with the register stack). The base of the stack, kept in the "S" register, may be redefined (upon subprogram calls, for example, as shown in Exhibit III-9), and "S-minus" addressing is relative to this base. Between the two extremes is a local data area, whose base is in the "L" register and can also be redefined. "L-minus" and "L-plus" addressing allows accessing items above and below this base. This area is accessible only to the currently executing subprogram. The "SG-relative" (system global) is reserved for privileged program and system use only. Indirect addressing allows access to the full 64KW extent of the data segment. Indexing is also supported.

4. Interprocessor Communications

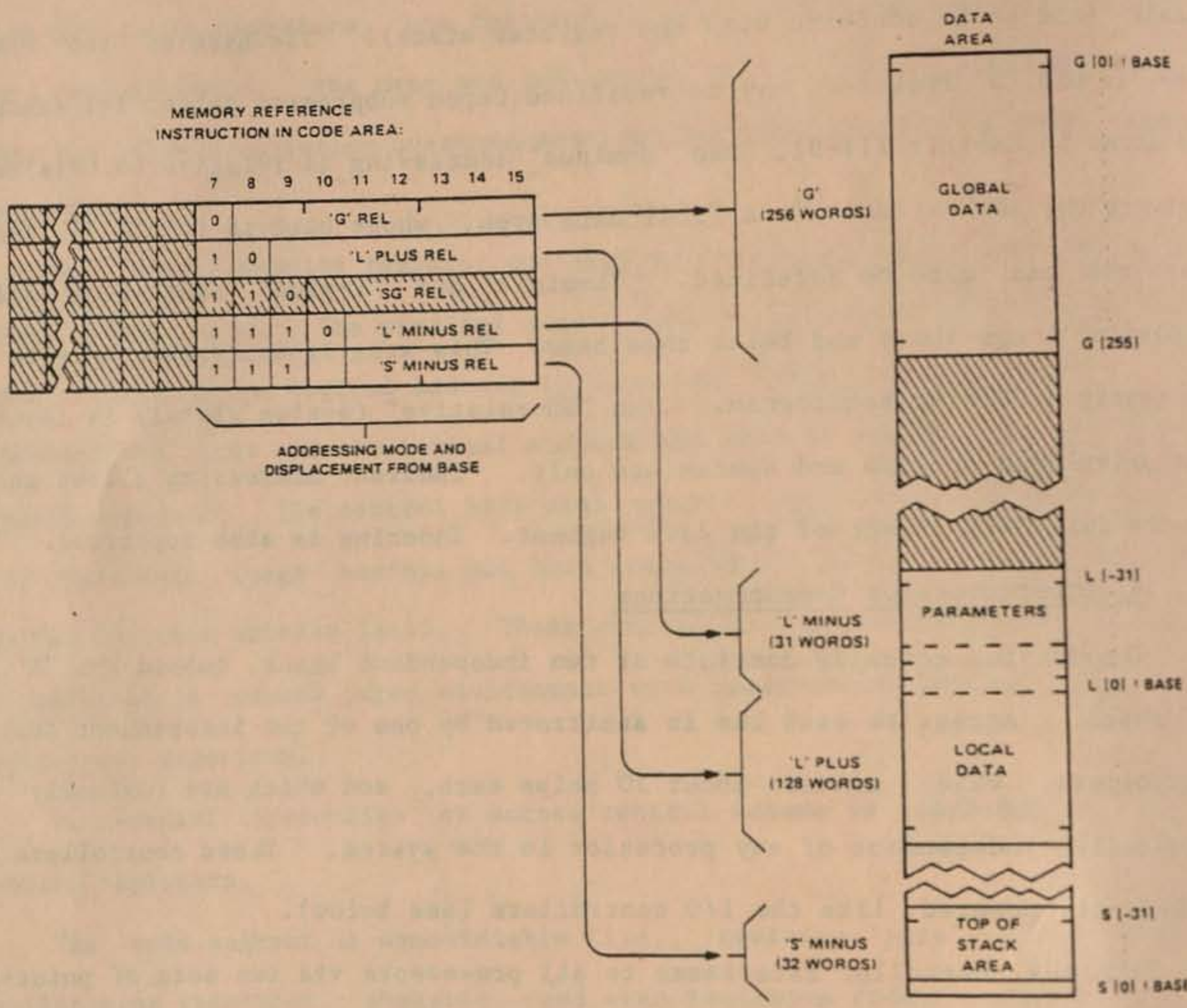
The Dynabus actually consists of two independent buses, dubbed the "X" and "Y" buses. Access to each bus is arbitrated by one of two independent central controllers, which contain about 30 chips each, and which are logically and physically independent of any processor in the system. These controllers are redundantly powered, like the I/O controllers (see below).

Each bus controller interfaces to all processors via two sets of point-to-point connections, radiating from the controller. These connections distribute the clock signal which facilitates synchronous Dynabus operation, as well as the signal which grants bus access. Access is granted in round-robin, time multiplexed fashion.

The clock rate is 150 ns for configurations of up to 8 processors, and 200 ns for larger configurations. Since the X and Y buses are 16 bits wide, these translate into 13.3 MByte/sec and 10 Mbyte/sec bus transfer rates for the

EXHIBIT III-8

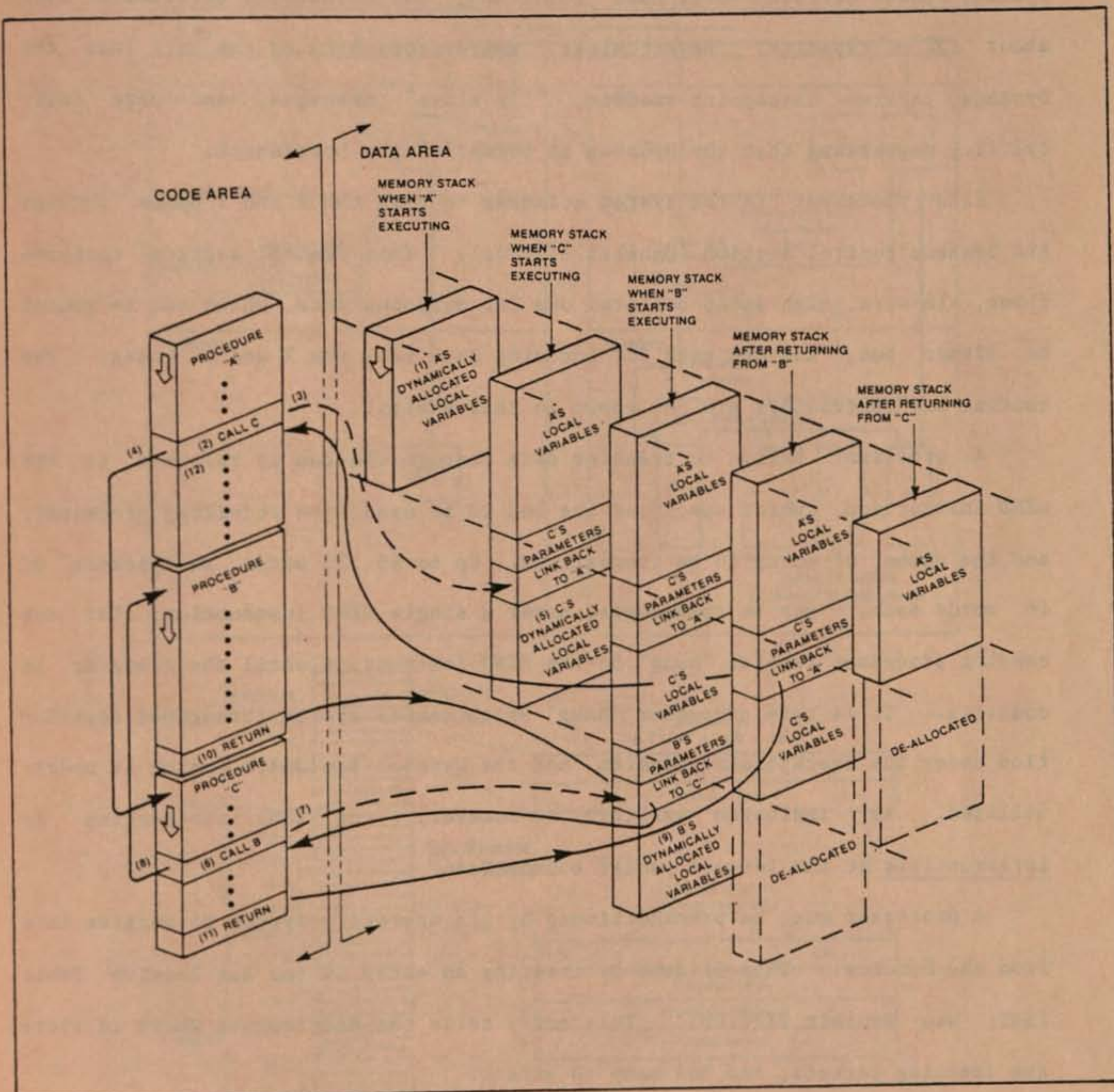
TANDEM 16 DATA SPACE ADDRESSING



Source: Tandem

EXHIBIT III-9

MEMORY STACK OPERATION



Source: Tandem

smaller and larger processor configurations, respectively.

Performance measurements at Tandem have suggested that in a 10-processor system, under certain "worst case" condition, the Dynabus is utilized at only about 15% of capacity. Nevertheless, competitors harp on the fact that the Dynabus carries checkpoint traffic, "I'm alive" messages, and page fault traffic, suggesting that the Dynabus is potentially a bottleneck.

Each processor in the system attaches to both the X and Y buses through the Dynabus control section (Exhibit III-10a). This control section contains three, 16-word, high-speed buffers: one for outgoing data, which can be routed to either bus, and one each for incoming data from the X and Y buses. The central bus controllers are not shown in this exhibit.

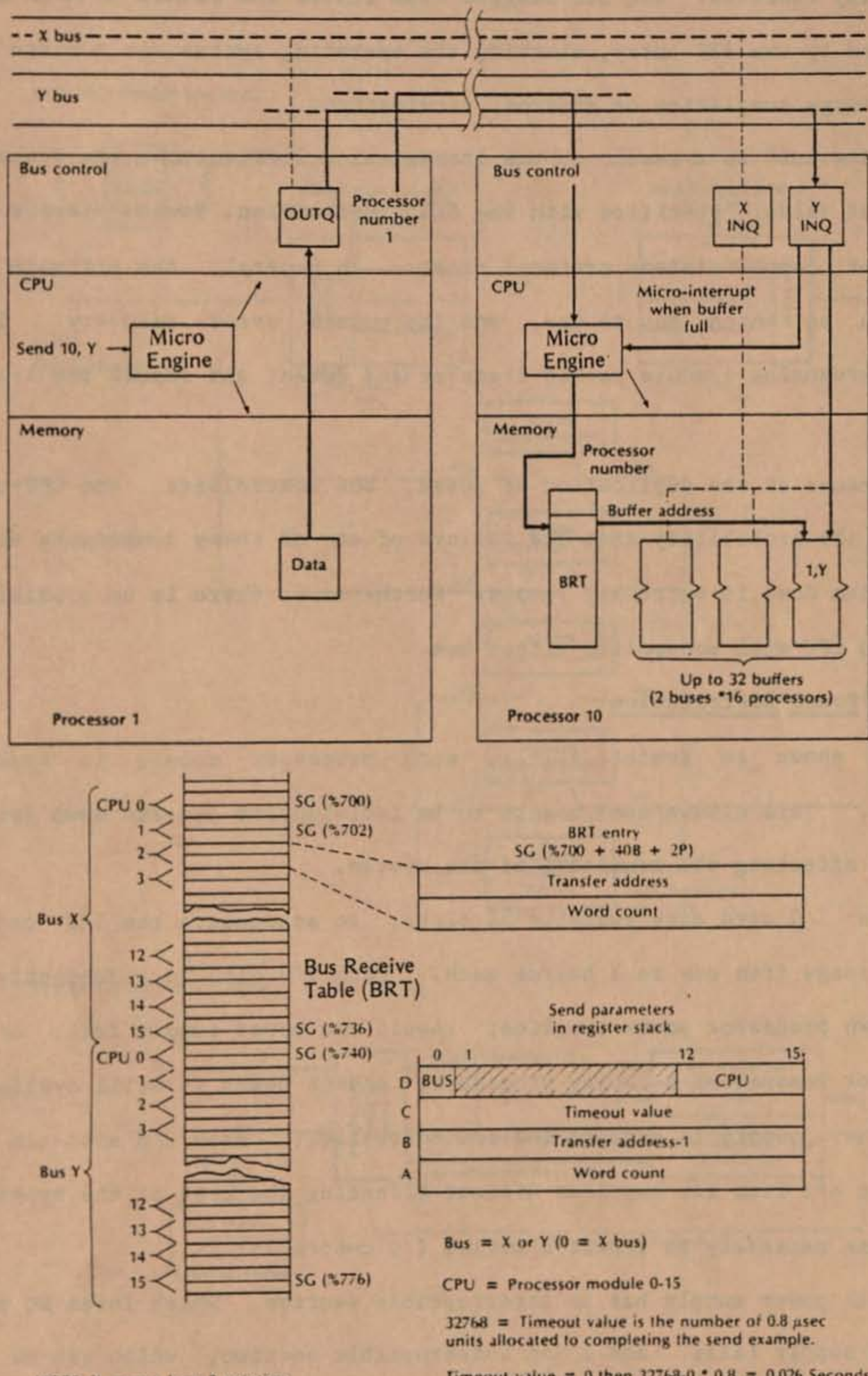
A processor begins to transfer data through the bus in response to the SEND instruction, which specifies the bus to be used, the receiving processor, and the number of words to be transmitted. Up to 65,535 words, in "packets" of 16 words each, may be transmitted under a single SEND instruction; but the sending processor remains "hung" in the SEND instruction until the transfer is complete. It is this processor "hang" which causes system throughput degradation under the checkpointing system, not the Dynabus bandwidth (which is underutilized, as indicated earlier). However, the SEND instruction is <u>interruptible</u> at the 16-word packet boundaries.

A processor must be preconditioned by its operating system to receive data from the Dynabus. This is done by creating an entry in the Bus Receive Table (BRT; see Exhibit III-10b). This entry tells the microengine where to store the incoming packets, and how many to expect.

Each packet consists of 14 data words, a packet sequence number word, and an LRC check word. The sender puts the packet in the output buffer and requests a bus transfer from the controller. Upon being granted bus access, it transmits the packet. The receiving processor stores it away in the receiving

EXHIBIT III-10

DYNABUS CONTROL



Source: Tandem

buffer, alerting the microengine with a microinterrupt when the packet has been completely received. The microengine then stores the packet in main memory, as indicated by the BRT entry, alerting the operating system via a macro interrupt upon message completion or abnormal termination.

"Hang ups" as a result of bus transmission difficulties are broken through a timeout value, specified with the SEND instruction. Several levels of inter-processor communications protocol exist. In general, the software makes the decision on which bus to use, and implements error recovery. The hardware/microengine execute packet transfer and detect and report bus transmission errors.

Because of the duplication of buses, bus controllers, and CPU-controller links, the probability that the failure of any of these components will bring the system down is extremely remote. Furthermore, there is no possibility that a failed CPU will monopolize either bus.

5. Power Distribution

As shown in Exhibit III-11, each processor module is independently powered. This allows each module to be individually powered down for repairs, without affecting the remainder of the system.

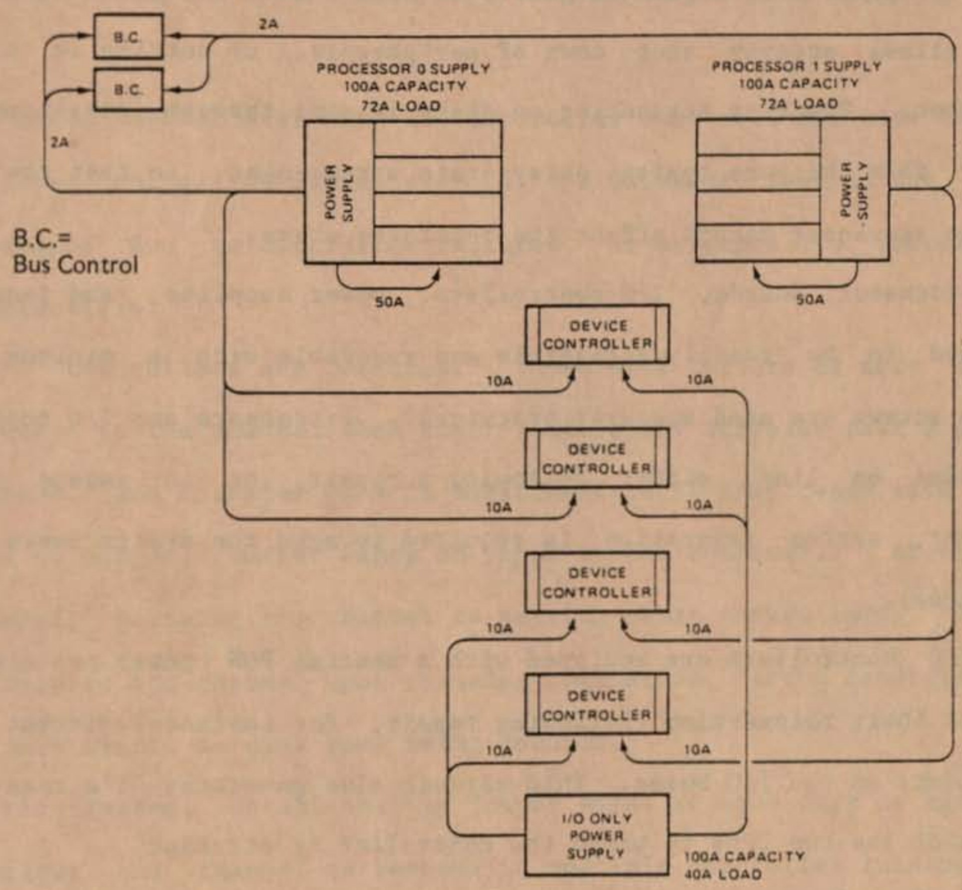
The I/O card cage contains 32 slots, to accomodate the I/O controllers, which range from one to 3 boards each. Each I/O slot is redundantly powered from two processor power supplies; should one power supply fail, or be shut down for removal of a faulty processor, enough power is still available from the other supply to support the I/O controller. Each I/O slot can also be switched off from its supplies without affecting the rest of the system, should it become necessary to repair a failed I/O controller.

Each power supply has an interruptible section, which loses DC power when the AC supply fails, and a non-interruptible section, which can be equipped with a battery backup system, and which is used to power the memory system.

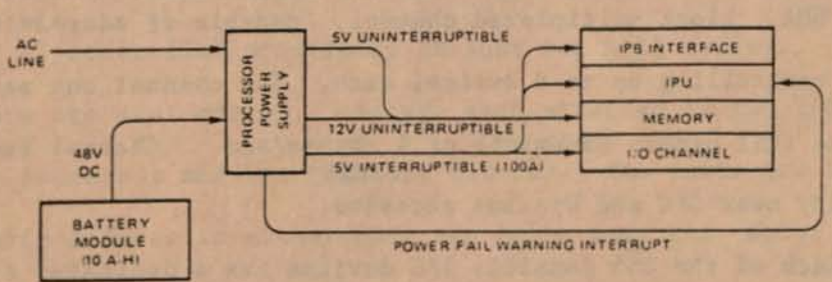
EXHIBIT III-11

POWER DISTRIBUTION - NONSTOP II

MULTIPLE POWER SOURCES



POWER FAILURE RECOVERY



Source: Tandem

Memory can be kept alive from 1.5 to 4 hours, depending on the type and amount of memory.

Storage capacitors provide some 30 msec of "ride-through" AC power line loss. A power-fail signal is generated when 5 msec of regulated power remain; this allows orderly shut down of peripherals, or cutting in of a backup generator. Power up sequencing on disks is done through independent circuits, rather than the more typical daisy-chain arrangement, so that the failure of any one sequencer cannot affect the remaining disks.

Processor boards, I/O controllers, power supplies, and fans have been designed to be readily accessible and removable with a minimum of tools. (Thumb screws are used wherever practical). Processors and I/O controllers may be added on line, either following a repair, or to expand the system. (However, system generation is required to make the system aware of the new resources).

I/O controllers are equipped with a special PON (power on) circuit which permits their reinsertion (following repair, for instance) without generating transients on the I/O buses. This circuit also generates "I'm ready" interrupt to one of the two CPUs to which the controller is attached.

6. Input/Output

The I/O channel incorporated in each processor module is a microprogrammed, DMA, block multiplexed channel, capable of addressing up to 32 control units controlling up to 8 devices each. The channel can maintain data transfer at the full memory bandwidth of 4 Mbytes/sec. Channel access to memory takes priority over CPU and Dynabus accesses.

Each of the 256 possible I/O devices has a dedicated two-word entry in the IOC (I/O Control) table in the system data space. This entry contains the logical address of the I/O buffer within the system data space with which the transfer is to take place, and a 12-bit byte count; thus the maximum block that can be transferred in one I/O operation is 4KB. The channel moves the IOC entry into its active registers at the start of a transfer. When the byte count is decremented to zero, or upon abnormal termination, the channel alerts the operating system via an I/O interrupt. Command and data chaining are not supported.

The channel communicates with the controller over a 16-bit wide I/O bus, with associated control and status signals. A watchdog timer in the channel prevents hangups due to controller failures, or attempts to address non-existent controllers.

All I/O controllers are buffered. Those with buffers of more than 32 bytes reconnect to the channel when their buffers are stressed past a programmable threshold, and transfer data in burst mode until they reach zero stress (buffer full on output, buffer empty on input to the computer). At that time they disconnect, allowing the channel to service other controllers. The controller interrupts the channel upon transfer completion, error condition, or a variety of such events as disk pack being mounted.

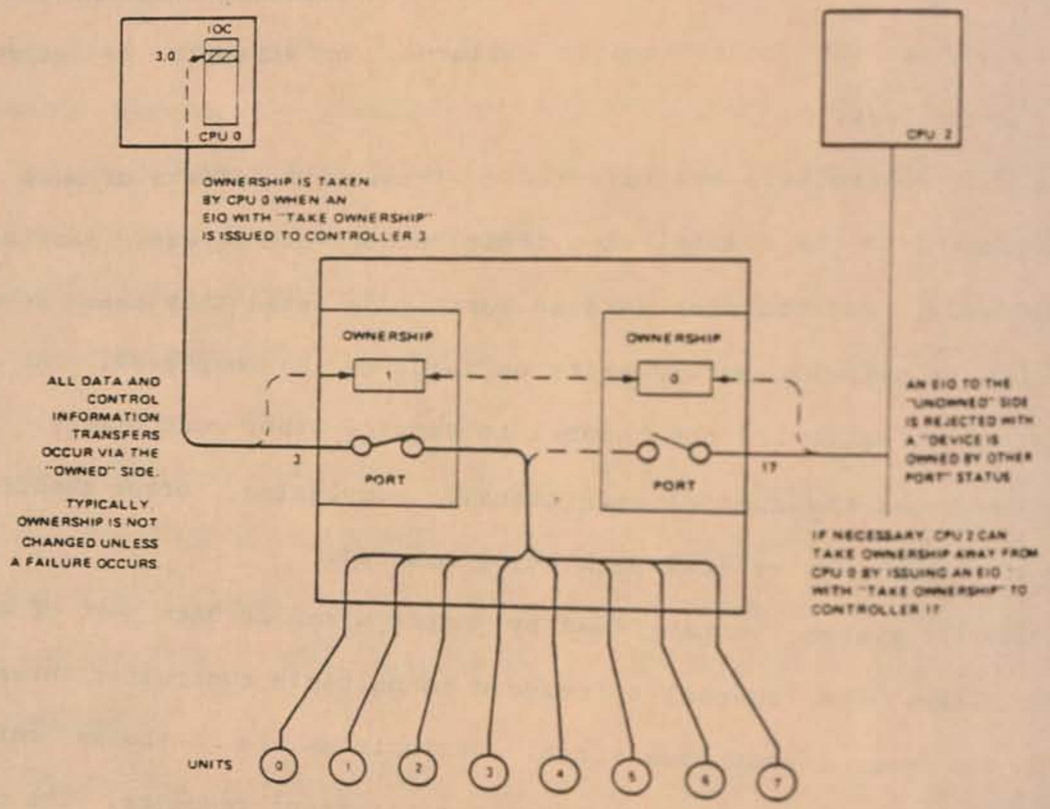
A priority system, established by jumper wires at each port of each controller, allows the channel to respond to multiple controller interrupts by honoring the most urgent ones first. Priorities are actually enforced by having the channel poll the controllers for interrupt requests. The channel is able to resolve all 32 controller priorities in just two poll cycles.

All controllers are dual ported, and are each attached to two I/O channels, i.e. to two processor modules (Exhibit III-12). The ports are independent in that no chip failure in either port can bring down the other. Each port has a 5-bit, configurable "controller number".

In normal operation, a controller is "owned" by one of the two processors it is attached to. Ownership is determined by the status of a control bit,

EXHIBIT III-12

CONTROLLER OWNERSHIP CIRCUITRY



Source: Tandem

internal to the controller. In the exhibit, CPU 0 (left) owns the controller through port #3. The other port (#17) will return "device owned by other side" status if processor 2 attempts to access this controller.

However, ownership can be changed, should port 3 fail, by having the operating system in CPU 2 issue a "take ownership" I/O command to port 17. The port is sensitive to this command even while inactive. A processor can also issue a DISABLE PORT command if it determines that the common section of the controller, rather than the port, is malfunctioning. This command will disconnect the port logically, but will not force ownership automatically on the other port.

Buffer address, byte count, and direction of transfer are kept in the channel, rather than the I/O controller, to eliminate the possibility that a controller failure would bring down both processors to which it is attached. This can happen, for instance, if the controller kept the byte count, and that register stopped decrementing on input. The controller would then continue to write data into memory, eventually wiping out the operating system in that processor. The other processor, upon taking ownership of the controller, would suffer the same fate shortly thereafter.

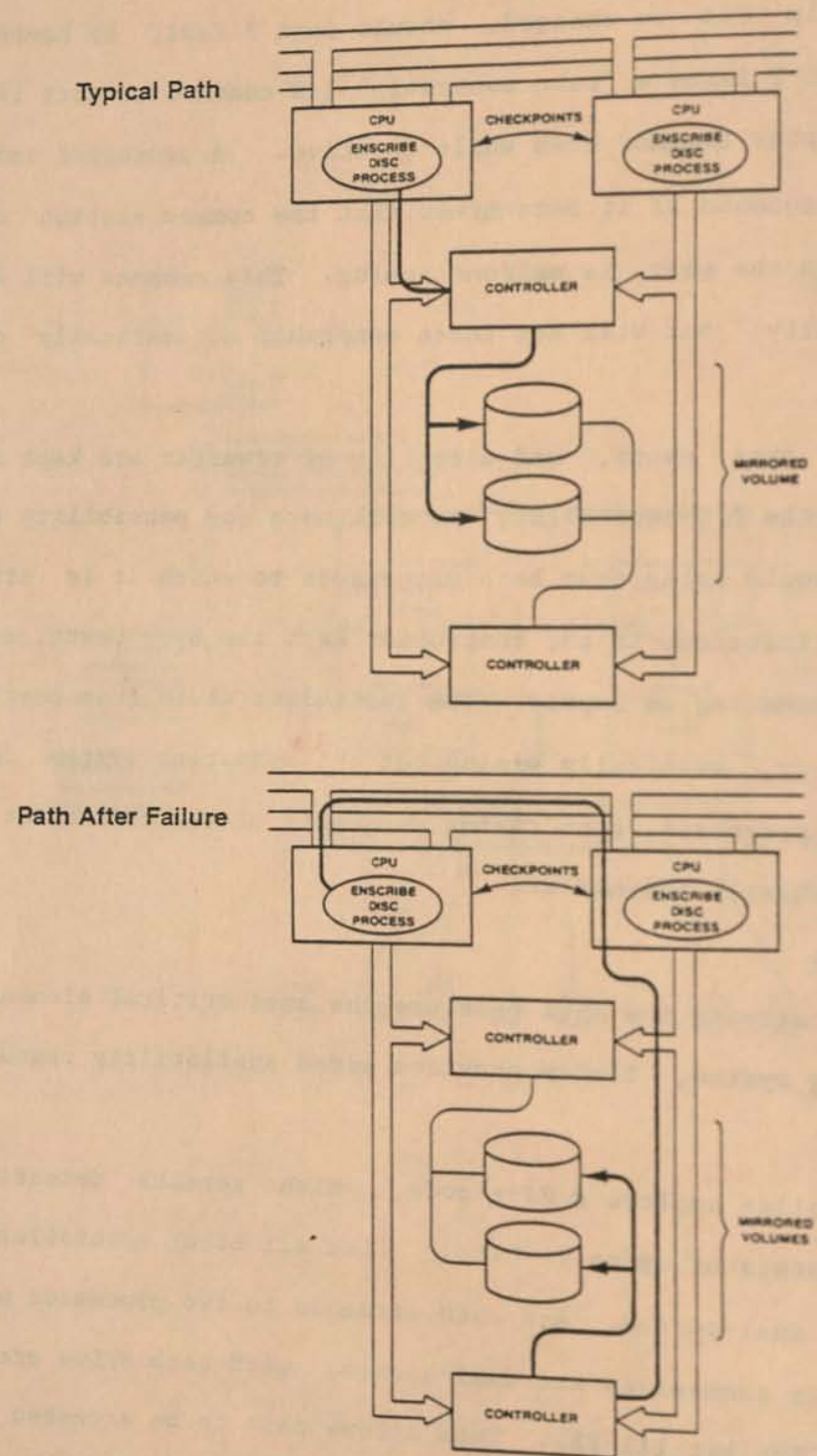
7. Mirrored Disks

Since the disks carrying the data base are the most critical elements of a transaction processing system, Tandem provides added availability features for its disk systems.

The disk controller employs a Fire code, which permits detection and correction of error bursts of up to 11 bits. Like all other controllers, the disk controllers are dual-ported, and each attaches to two processor modules. In addition, the disks themselves are dual-access, with each drive accessible from two controllers (Exhibit III-13). This allows data to be accessed despite the failure of a controller, processor, or power supply. However, should the

EXHIBIT III-13

MULTI-ACCESS DISKS



Source: Tandem

disk drive itself, or its power supply, fail, data will be lost.

To protect against this possibility, the user may declare any disk volume (encompassing one or more spindles) to be "mirrored". In response, the system will automatically maintain a "mirror image" of the original volume on another set of spindles. Each time the user executes a write to the designated volume, the system will write the same data to the "mirror image" volume as well. This is facilitated by the 4KB buffer in the disk controller: the data can be reused out of the controller, rather than by executing a second I/O operation out of the channel.

Read accesses are satisfied from either volume. The disk whose head is nearest the desired data is selected. Normally, the system assigns to each volume of a mirrored pair the responsibility for satisfying read accesses from either the outer or inner half of the disk, reversing these roles every 10 minutes or so (to enhance early detection of write errors).

Should one drive of a mirrored pair fail, the surviving disk continues to support all access requests. When the repaired drive is returned to service, a copy utility is initiated by the operator. This program restores the repaired disk to mirror condition by copying to it the content of the surviving disk. Copying proceeds in operator-specified segments. During a segment copy, write access to the affected tracks is temporarily blocked. As soon as the segment is copied, mirrored operation (both read and write) relative to that segment is resumed.

D. NONSTOP II™

1. Introduction

Like a number of minicomputer companies ten years earlier, by 1981 Tandem -- and some of its customers -- were chafing against the limits of its 16-bit processor architecture, especially in terms of its limited addressing capabilities. Typically, the first program to feel the pinch is the operating system, since it usually is the largest program written for a given system. To alleviate this problem, as well as to introduce a number of enhancements, Tandem unveiled the NonStop II™ system in April, 1981. The major differences between the NonStop II and the previous Tandem systems are summarized in Exhibit III-14 and further outlined in the following sections.

EXHIBIT III-14

MAIN DIFFERENCES BETWEEN NONSTOP II™ AND EARLIER TANDEM SYSTEMS

FEATURE	TANDEM 16	NONSTOP II
Maximum size and type of control store (32 bit wide)	4 KW ROM	8 KW WCS 1 KW ROM
Main memory technology Memory speed	16 Kbit 500 ns	64 Kbit 400 ns
Instruction Repertoire (including optional decimal and FLP arithmetic)	248	285
I/O Channel max. burst rate	4 Mbytes/sec	5 Mbytes/sec
Logical addressing	4 64KW (128KB) address spaces	6 64KW (128KB) address spaces
Extended logical addressing	None	30 bits long, 8,192 segments of 64KW each per processor (1 billion bytes)
Physical memory addressing	20 bits (1 million words)	23 bits (8 million words)
Hardware maps (64x16 bits ea.)	4	16
Disk controller buffer	4 KB	64 KB
OSP (operations & support processor)	No	Optional

Source: ITOM International Co., based on Tandem data

2. Extended Addressing

To solve the limited address space problem, while maintaining compatibility with existing systems, Tandem evolved the classical "extended addressing" solution, of which numerous variants have been previously implemented by other minicomputer manufacturers facing the same dilemma.

First, the addressible range of real memory has been increased from 1 million words to 8 million words, by using 13-bit (rather than 10-bit) physical page numbers in the page tables. (The physical page number is concatenated with the 10-bit word address from the logical address to form the real address).

Next, the number of "standard" address spaces has been increased from 4 to 6. The two new spaces -- the user library code segment and the system code extension segment -- are indicated by a new bit in the "environment register" (program status word). This bit has been added to the two existing ones to allow selection between user and system segment for this added space. This doubles the operating system's code space. The additional user code space is termed "library" to designate its main intended usage.

Finally, an "extended addressing" mode has been added, utilizing addresses occupying two 16-bit words. Extended addressing allows read and write (but not execute, nor branch-to) access to a total of 8,192 segments of up to 64KW (128KB) each, totaling 1 billion bytes. Some 16 new instructions, utilizing extended addressing to load, store, move/compare/scan, and checksum compute, have been added to the repertoire.

Extended addressing is available to both operating system and users; but, while the system -- the main intended user -- accesses the extended segments in absolute fashion, user's extended access is always relative to a base register, set by the system at the time it dispatches control to that user. A companion limit register defines the upper limit accessible by this user. This is the classical "base and limit" register scheme, employed in the mid-1960's by CDC and Univac large mainframes, among others, here applied in the virtual environment.

The effect of the NonStop II extended addressing is to create, for each processor, a segmented address space, comprising of 4 "standard" code segments, 2 "standard" data segments, and 8186 "extended" data segments. The first six segments within this space actually correspond to the six "standard" segments, i.e. those accessible normally through maps 0-5. Of the remaining 8186-segment address space, which is accessible only through the extended addressing capability, each user is assigned a contiguous block, defined by system-controlled base and limit values.

Large logical address spaces suffer from a major drawback: too many mapping registers are required to hold the translation information. The classical solution, introduced by IBM in 1972 with the first virtual memory versions of the System/370, is to store the translation tables in main memory.

Tandem implements the same solution. A main memory resident "Segment Table" contains a two-word entry for each defined segment. The entry includes a pointer to the beginning of the page table, which may have up to 64 one-word entries. These entries in turn contains the physical page number for each of up to 64 pages in this segment. Note that, should all 8192 segments be defined and contain 64-page segments, the amount of memory needed to hold the segment table and the page tables would be well over 1 MB.

Main-memory resident segment and page tables require several additional memory cycles for each memory reference; even more in Tandem's case, because each page entry for a segment in extended memory is two words long. The IBM solution was to use a "translation lookaside buffer" or TLB, a high-speed cache, to store translation data for a few of the most recently accessed pages.

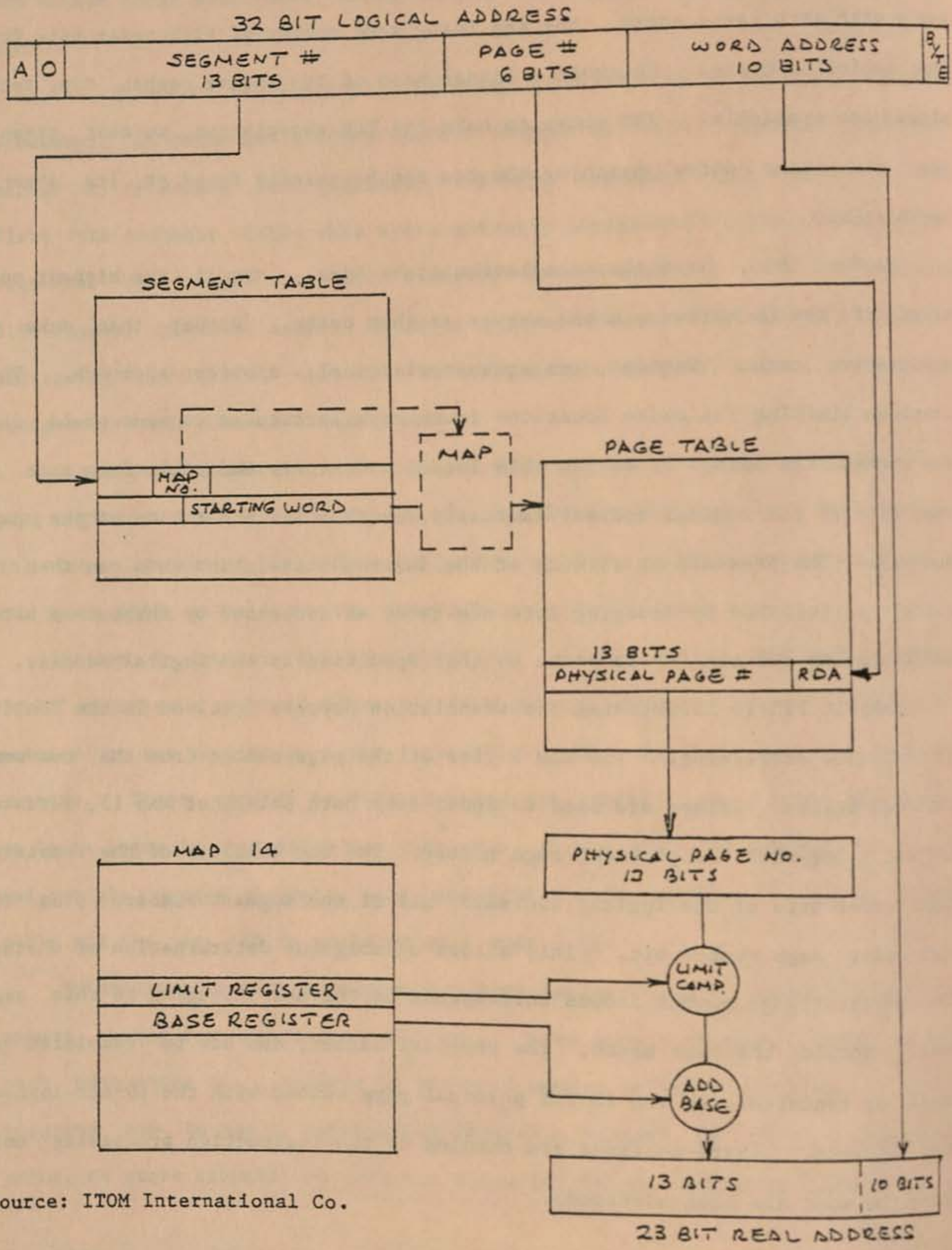
Since the TLB cannot contain all of the translation tables, it is necessary to provide a mechanism to establish whether the translation data for the presently-issued logical address is in the cache. This is done by storing a "tag" along with each cache entry, the tag being some number of high order bits from the logical address. To avoid a linear scan of the entire cache, two techniques are available. IBM chose to make the TLB associative, so that, given a tag, the cache entry matching the tag can be quickly found or its absence established.

Tandem, too, uses the translation cache idea. Map 15 (the highest numbered of the 16 hardware maps) serves as that cache. Rather than make an associative cache, Tandem uses another classical, simpler approach. This involves limiting the cache locations in which a particular segment could find the translation data, by making this location directly deducible from some of the bits of the logical address (actually the five low order bits of the page number). The presence or absence of the desired translation data can then be quickly established by indexing into the cache as indicated by these five bits, and comparing the tag in the cache to that specified in the logical address.

Exhibit III-15 illustrates the translation process involved in the NonStop II extended addressing. The low 5 bits of the page number from the two-word extended logical address are used to index into both halves of Map 15, fetching the tag along with the physical page number. The tag consists of the remaining high order bits of the logical address: all of the segment number, plus the high-order page number bit. This allows unambiguous determination of whether the physical page number indeed corresponds to the one belonging to this segment. Should the tags match, the physical address can now be completed as usual, by concatenating the 13-bit physical page number with the 10-bit logical word address. (Byte accesses are handled by the instruction processing unit after the word has been accessed).

EXHIBIT III-15

NONSTOP II REAL ADDRESS FORMATION



Source: ITOM International Co.

However, should the tags not match, or the examined cache location be empty, the full translation process must be excuted. This involves indexing into the main-memory resident segment table through the segment number from the extended logical address. No translation is involved in reaching the segment table; this table resides in a fixed, contiguous main memory area.

The two-word segment table entry specifies where the page table for this segment is to be found. It could be in one of the 16 hardware maps, or it could still be in main memory. If the latter, the page table origin, pointed to in the segment table entry, is first located through the appropriate map; the corresponding page table is then indexed into by adding the page number from the logical address to the page table origin. The physical page number can now be accessed. It, along with its tag, will be stored in the appropriate cache location, displacing the present cache entry (if not empty) back to its appropriate page table. At the same time, the physical page number is used in the standard way to form the 23-bit real memory address.

If the logical address was issued by a user program, it is first checked against the limit value, and, if within the limit, it is then relocated by adding the base value. Both base and limit values are kept in Map 14.

3. Other Enhancements

A number of other enhancements in the NonStop II were indicated earlier in Exhibit III-14.

The control store size has been increased to 9KW, possibly accompanied by a segmented addressing scheme to allow the microcode to make use of the added space. Writeable control store (WCS), rather then ROM, is now mainly used. This allows future microcode enhancements to be implemented in microcode without requiring a retrofit of all the installed machines. User customization through the WCS is not permitted by Tandem. Instructions to read and write the WCS have been added. Current control store utilization is as follows:

Basic instruction set	2,738
Optional instructions	1,520
Diagnostics (DSP)	1,388
Accelerator	1,292
Spare	2,278
TOTAL	9,216

By using 64 Kbit memory chips of 400 ns access time (rather than 500 ns, 16 Kbit ones), memory boards holding 2 MB each (introduced in April, 1982) have been made possible. In addition, the faster memories allow a 25% faster I/O channel transfer rate of 5 MB/sec, rather than 4 MB/sec.

In addition to the extended addressing and WCS instructions, other instructions have been added for a new total of 285.

The number of hardware maps has been increased from 4 to 16. The first 6 are used to hold the translation tables for the new "standard" 6 segments. Maps 6 through 13 are used as general purpose buffers for I/O and other purposes. Map 14 is used by the system, while Map 15 serves as the extended addressing translation cache, as described earlier.

Buffer size in the disk controller has been increased from 4 KB to 64 KB, to improve the efficiency of disk I/O.

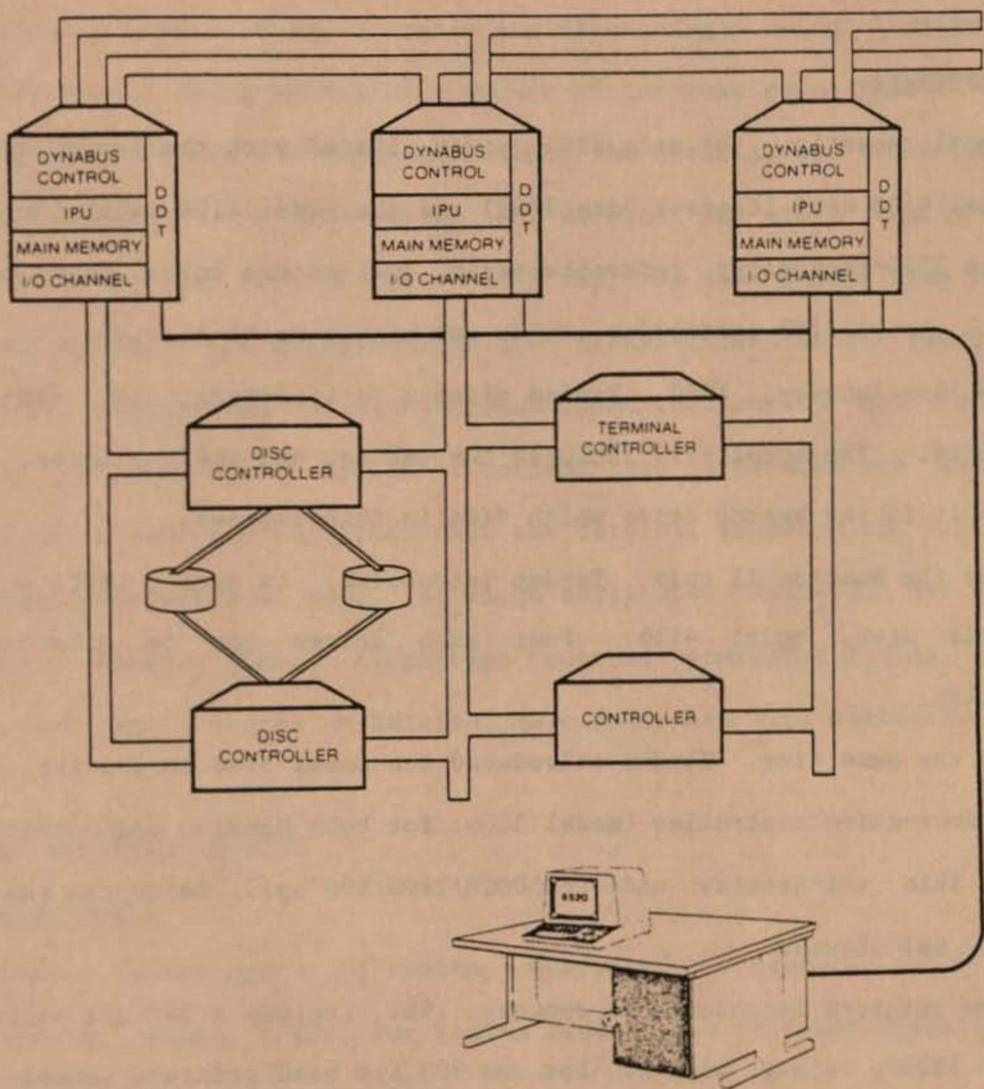
4. Operations and Service Processor

The Operations and Service Processor (OSP) is a major new feature of the NonStop II. Housed in a separate desk, as shown in Exhibit III-16, this Z80-based processor, with its CRT/keyboard terminal, 64KB RAM and two 5.25" floppy disks can assume the functions of a system control console. In addition, it supports both local and remote system diagnostics and maintenance activities.

The OSP communicates with the DDT processors, residing on the CPU board containing the I/O channel and the control store ("CCD board"), over a daisy-chained, serial link. These DDT processors are capable of monitoring status of the Dynabus interfaces, I/O channel processor, memory, and CPU. They can be used to put the CPU into a single-step mode, and monitor the contents of all

EXHIBIT III-16

OPERATIONS AND SUPPORT PROCESSOR (OSP)



Source: Tandem

registers before and after each step.

The OSP includes a built-in modem, which can be used to transfer system control to a remote terminal, or to another, remote OSP. This facilitates remote trouble shooting, and could potentially be used to control remote, unattended Tandem systems. The OSP can communicate with up to 16 NonStop II CPUs.

E. PERIPHERALS

Until recently, the main disk drives offered with the Tandem systems were the model 4105 64MB (Control Data 9762) and the model 4104 240MB (Ampex 9300). Both are 3330-technology, removable-media, dual-access units, meant to run with the dual ported 3103 controller, which can handle up to 8 drives.

In late January, 1982, Tandem added a Fujitsu-made, 14" non-removable, 128MB unit. The model 4110 includes the cabinet and the top drive, while the model 4111 is the second drive which fits in this cabinet.

For the NonStop II only, Tandem introduced, in April, 1982, a 540MB non-removable disk, model 4116. Four such drives can be attached to the controller.

At the same time, Tandem introduced the model 5106 tape drive, along with a new four-drive controller (model 3206) for both NonStop and NonStop II systems. This tri-density unit (6250GCR/1600/800 bpi) augments the existing 800/1600 bpi drives.

New printers introduced in January, 1982, include a 340 cps matrix printer (model 5520), along with 600 lpm and 900 lpm band printers (models 5513 and 5514, respectively), all from Dataproducts.

User terminals were originally Lear Siegler ADM3 "glass teletypes", Lear Siegler page-mode ASCII display terminals, and DECwriter II printing terminals. In 1980, Tandem switched to the model 6520, a microprocessor-driven, "smart"

Zentec terminal, customized to Tandem specifications.

In February, 1982, Tandem introduced a new 15" display terminal, the model 6530, designed and produced at Tandem's newly-established terminal products facility in Austin, TX. The Z80A-based terminal supports local editing functions, and incorporates multilingual character sets, and such ergonomic features as non-glare, tilt-and-swivel screen and detachable, low-profile keyboard with palm rest. These features are increasingly being legislated as mandatory EDP system requirements in a number of European countries.

In addition, in the conversational mode, the terminal can store 300 lines of 80 characters each. In block mode, the terminal can store locally up to 8 pages (25x80) of display information. This improves data access time for the operator, and enhances the efficiency of data transfer between the terminal and the computer. Synchronous or asynchronous communications in half- or full-duplex mode is supported. RS232C or current-loop interfaces are available. The promotional literature suggested that the terminal supports the X.25 standard in the conversational mode, although early spec sheets did not mention this feature. Reverse video, brightness control, protected fields, built-in diagnostics and parity checks on internal data paths are also featured.

F. GUARDIAN™ OPERATING SYSTEM

1. Design Goals

The present Tandem operating system, Guardian™, introduced in 1977. An earlier attempt, dubbed T/TOS (for Tandem Transaction-oriented Operating System) was offered for a short time only.

The design goals for Guardian were (a) to support fault-tolerant system operation, in which the failure of any one subsystem has no impact on the end user, and (b) to support the extensible hardware architecture while striving to isolate the end user from configuration details. These can be stated more explicitly as follows:

- o The operating system should remain operational after any single detected subsystem or communications link (e.g. Dynabus) failure.
- o The operating system should allow any module or link to be repaired and returned to service on line.
- o The operating system itself should not negate the increased hardware availability by introducing software bugs.
- o The operating system should support all possible hardware configurations, ranging from a minimal two-processor system to a fully expanded 16-processor node.
- o The operating system should strive to isolate applications programs from configuration details, so that, for instance, the loss or recovery of processors should not require changes in users' programs.

The following sections describe how these goals were met in the initial operating system. Major conceptual extensions introduced later, especially the Expand™ networking capability and the Transaction Monitoring Facility, are described separately.

2. Processes

The key ideas for the system, borrowed primarily from the work of Dijkstra and Brinch Hansen, revolve around the concept of a collection of processes communicating strictly through messages.

A process is the sequence of events resulting from invoking a body of executable code and its associated data segment(s). Executable code residing on disk could be turned into many processes by loading it into different processors, or into a single processor at different points in time.

Under Guardian, a user or system process is initially created in a specific processor and may not execute in another processor. Each process carries a specific execution priority (assigned by the user or by default). Processor time is allocated on the basis of these priorities.

Semaphores (similar to Dijkstra's P and V) are used to synchronize usage of serially-reusable resources within a processor. Event flags are used to signify such low-level events as power on or message receipt from the Dynabus; a process may WAIT upon one or more events, and is AWAKEned when one such event occurs. Event signals for a process are queued so they are not lost if the process is not WAITing for them. Events are primarily local to a given processor, although the "message received" event is caused by another processor.

A process blocks (suspends) itself when WAITing for an event, freeing the processor to serve the next highest priority ready process. A watch-dog timer can be invoked upon each blocking, to assure that the process is informed if the WAITed-on event does not occur as expected.

Each process in the system has a unique identifier, consisting of the processor number and either a system-generated time-stamp or a user-assigned character string, so that it can be referenced on a system-wide basis. The monitor (see below) rejects duplicate user-assigned names. A node number is added to the process identifier when the system consists of multiple nodes; a node is the two-to-16 processor Tandem system. Each processor can support up to 256 processes. Whenever a new process is created anywhere in the system, its name is made known to all processors via the message system (see below).

Each processor essentially contains a "copy" of the Guardian operating system, consisting mainly of such resource tables as the logical device table (LDT), and of such system processes as the monitor process, which is responsible for process scheduling, the message system, and fault-recovery management; and the memory manager, which is responsible for supporting the demand paging environment.

3. Messages

Processes communicate with each other strictly by exchanging messages through a well-defined protocol. This applies to both user-to-user communica-

tions, as well as to all I/O requests, which are handled as user-to-s
process messages. Communications through shared memory is strictly prohi
since it defeats the main purpose of the message system, which is to p
fault propagation, isolate processes from configuration details, and all
line resource removal and return. Similarly, processes cannot manipula
devices directly; they can only send messages to the I/O driver process r
sible for the device.

The message system is maintained by Guardian, and is not di
accessible to the non-privileged application programs. Instead, such pr
invoke specified operating system entry points, which in turn are al
invoke the privileged message system primitives. This assures tha
operating system is fully in control of the message system, and can the
implement error recovery procedures upon detecting message failures.

Based on its knowledge of the location of the destination process
system will select the appropriate message route. Messages between pro
in the same processor are exchanged through memory buffers; messages b
processes residing in different processors are exchanged over the Dynabus
in the networking expansion to be discussed later, over communications li

Each process has a message queue, where messages sent to it by all
processes are kept. Incoming messages can be queued in either FIFO or
priority order, at the discretion of the receiving process.

A message consists of a request for service and a reply by the
process. This terminology derives from a model of the most frequent ty
message exchange, in which the requesting process is an applications p
while the destination process is an I/O driver or another type of
program (which may be user-implemented). However, the same message p
applies to application-to-application and primary-to-backup (see below)

nications.

If a process wishes to create a new process, for example, it calls the system procedure NEWPROCESS, which in turn sends a message to the monitor process in the processor in which the new process is to be created. The sender WAITs while that monitor process retrieves the message from its queue, creates the new process, and responds with a reply, containing either the new process identifier or an error indication; at which time the sender is AWAKEned. Note that a reply (positive acknowledgement) is required for each logical request, a key provision in the support of fault-tolerant operations.

Each processor maintains a Bus Receive Table (BRT) for incoming data from each other processor. The bus protocol, implemented mainly in the micrcode, involves packetizing messages into 16-word packets. Each packet carries the sender's and receiver's processor number, a packet sequence number, 13 data words, and a checksum. The receiver copies the packet into the memory buffer pointed to in the relevant BRT entry, and, if the packet is error free, acknowledges its receipt, and updates the BRT entry. An acknowledgement is an unsequenced, "datagram" type packet; it can also be "piggybacked" onto some control packet that is part of another request.

Errors are not acknowledged, but are detected by the sender upon failing to get an acknowledgement within one second of transmission. Error recovery is the sender's responsibility.

4. Process-Pairs

The concept of process-pair was devised initially to provide the resiliency necessary to recover from processor failures, and was applicable to user as well as system processes. With the introduction of TMF (described later), the reliance on the process-pair mechanism at the applications level has been eliminated, though the concept remains in effect for such system processors as I/O drivers.

System-wide access to I/O facilities is provided by identifying each such facility with a unique logical identifier, e.g. $DISC1. Actual servicing of the I/O controller and the requests directed to it is the reponsibility of a system-level process-pair. These two processes, which are created at system initialization, must each run in one of the two processors attached to each port of the dual-ported controller (see hardware discussion above).

One of these processes is initially designated as "primary". It has the active port, and messages requesting service from this logical I/O device are routed by the system to this primary member of the process-pair. As part of its normal operation, the primary process keeps its counterpart, which is known as the "backup" process, informed by sending it messages containing copies of the service requests, and other status information. These messages, called "checkpoints", assure that the backup process has the data it needs to take over control of the device should there be a failure of the primary port, I/O channel, or processor. The backup process is quiescent as long as its primary counterpart functions properly; the only activity by the backup process is to accumulate the checkpoint data.

A logical device table (LDT), of which a copy exists at each processor, allows the monitor process to determine the destination processor for I/O requests. This is normally the processor in which the primary I/O process is running. Should the primary process fail, the message can be resent to the backup. Although this can be done automatically, the user has the option of handling recovery from such situations; for example, a primary server failure while printing checks must not be allowed to result in the printing of a duplicate check by the backup process. Similar considerations apply to disk file updates, although that end of operation is now largely handled by TMF and ENCOMPASS, the data base system.

Another system process-pair is the "operator", which is responsible for formatting and printing error and status messages on the designated system console terminal.

5. System Processes

The system monitor, already mentioned, is a process in each processor responsible for such functions as process creation and deletion, time-of-day setting, and initialization or recovery from failure, the last two being treated in the same way. The monitor is also responsible for sending, every second, "I'm alive" datagram packets (no response required) to every other processor in the system, and for checking, every two seconds, that such datagrams have been received from all configured processors. Failure to receive the "I'm alive" message causes the monitor to mark, in its tables, the culprit processor as being "down", after checking first that its own Dynabus circuitry is functioning correctly.

System initialization, which conceptually is not differentiated from a recovery following a fault, begins by "cold starting" the processor attached to the primary disk port from the disk. The disk contains an absolute memory image of the resident code and tables, with all system processes set at their initial states. (Multiple images can be kept to allow cold start despite a processor or a disk being down).

With one processor loaded, the command line interpreter process is created, through which the operator can command the loading of other processors. The initialization microcode in each processor comes up in a state in which it listens to the Dynabus for messages. This is true in the NonStop II as well, where this initial microcode resides in the non-volatile 1K ROM. The individual processor reload can also be invoked upon its return to service following a failure.

Once a processor is up, it broadcasts this message to all other "live" processors, so they can update their resource tables. A power-fail detect with automatic restart is provided within each processor.

G. OTHER SOFTWARE - OVERVIEW

Beside Guardian™, the principal standard software products currently offered by Tandem are as follows:

- Expand™ networking extensions.
- Encompass™ data base management system, consisting of:
  - Data Definition Language (DDL)
  - Data Dictionary
  - Enscribe™ file & record management system
  - Enform™ report generator
  - Pathway™ communications monitor and screen formatter
  - Transaction Monitoring Facility (TMF), a data base integrity and automatic recovery system
  - Enable™ applications generator.
- Programming languages, with extensions to support checkpointing and interprocessor communications:
  - Cobol (ANSI '74)
  - Fortran (ANSI '78)
  - Transaction Applications Language (TAL), a block-structured system language patterned after Algol, with some PL/1 and Cobol like features.
  - MUMPS, an interactive system which originated in hospital and educational environments on DEC equipment.
- Communications and other software packages:
  - Exchange™, a remote job entry (RJE) package supporting IBM 2780 and 3780 bisync protocols
  - TIL (Tandem to IBM Link)
  - THL (Tandem Hyper Link), supports Network Systems Corp.'s HYPERchannel™ high-speed local area network,
  - Axcess™ on-line terminal communications interface (similar to a communications access method in IBM lingo), supporting X.25 and three terminal types: dumb ASCII (e.g. Lear Siegler ADM3), Tandem 6520 (Zentec), and the new Tandem 6530 (see peripherals discussion above). AM3270 and TR3271 below are part of Axcess.
  - AM3270, allows 3270 terminals to attach to a Tandem system; also supports "pass-through" so these terminals can communicate with application programs running on the IBM host.
  - TR3271, a package which emulates an IBM 3271 cluster controller on the Tandem system; allows Tandem terminals and application programs to appear to the IBM mainframe to be 3270 terminals.

- XRAY™, a performance monitoring and measurement package.
- Transfer™, a generalized electronic mail system.
- Infosat™, an interface to a satellite data communications earth station.

Some of the more significant of these software products are discussed in more detail in the following sections.

H. EXPAND™

Announced in October, 1978, and first delivered in 1979, the networking extension to Guardian, dubbed Expand™, is a collection of software components which make it possible to connect a number of geographically dispersed Tandem nodes into a coherent system. A node in this context is a single Tandem system, containing 2-16 processors. Nominally, up to 255 such nodes may participate in the Expand network.

The relative ease with which Expand was implemented (it took only two man-years) is due primarily to the fact that the underlying mechanisms are already in place in the basic Tandem hardware and the Guardian operating system. In fact, a Tandem system can be looked upon as a local network of independent processors. The message system isolates applications processes from the configuration details of this network; and, since the message system is under the exclusive control of the operating system, the extensions to include remotely-located processors in this network are relatively straight-forward.

The major element of Expand is the Network Control Process, which operates as a process pair (i.e. with a primary and a backup copy running in separate processors). The responsibilities of the NCP include the maintenance of the Network Routing Table, logging of network topolgy changes, and responding to certain requests from remote nodes. Only one such process-pair exists in each node of an Expand network.

The actual handling of the communications links between nodes is done by

I/O drivers called Network Line Handlers. In the case of X.25, there is a single X.25 access process, which manages the link to the packet-switched network, while each virtual circuit is maintained by a separate line handler. Line handlers are also responsible for maintaining "end-to-end" logical paths, over which messages can be exchanged between nodes that have no direct communications links, by forwarding the message through one or more intermediate nodes. All line handlers and the X.25 access processor run as process-pairs in the processors attached to the dual-ported communications controllers.

The Network Routing Table is built and maintained in each network node by the local Network Control Process. This table describes the topology of the network, which enables the local monitor process in each processor to direct messages to the correct line handler, depending on the final destination. Line handlers in intermediate nodes also use the NRT to determine the proper next leg when forwarding a message.

Changes in the network topology, such as links going down or being returned to service, are broadcast by the two nodes at the ends of this link to all "neighbor" nodes, i.e. those to which direct links exist. These changes are recorded in the Network Routing Table in each node.

Routing decisions are made on the basis of speed. If there are several possible paths between two nodes, the fastest path is chosen. Thus a path consisting of a 2,400 baud leg and a 56K baud leg would be chosen in preference to one consisting of two 2,400 baud legs.

A number of utilities for logging and displaying network performance are provided as part of the Expand package.

Naming convention for processes and I/O devices are extended in Expand so that these entities can be uniquely identified throughout the network. This is done by adding the node number to the local identifier. Therefore a user at any one node can access files, processes, and I/O devices in remote nodes as readily as if they were local, with the exception of response time, which is limited by the speed of the available communications facilities. It should be noted that the 10-13 MB/sec Dynabus is immeasurably faster than even such "wide band" communications line as a 56Kbps one, which translates to around 7 Kbyte/sec.

A recent enhancement to Expand permits it to handle multiple links between nodes for increased throughput and resiliency. Introduced in August, 1981, this enhancement allows Expand to send packets belonging to the same message simultaneously over the available multiple links; at the destination node, using the packet sequence numbers, the message is delivered to the destination processor in the correct order, even though, due to link speed differences, packets might arrive out-of-order.

I. DATA BASE MANAGEMENT SYSTEM

1. Overview

Encompass™ is the name Tandem has given to its data base management offering. The system evolved gradually, beginning with the low-level file manager Enscribe™ supported by the terminal control process Envoy™ and the screen formatter Entry™.

In 1980, Tandem added a data definition language (DDL) and data dictionary (DC), which allow users to view the Enscribe-created and maintained data files as a relational data base; and the Transaction Monitoring Facility (TMF), which provides support for data base integrity and recoverability. Enscribe, Pathway, TMF, and DDL/DC are now collectively known as Encompass; the Enform™ report generator, introduced in 1979, and Enable™ applications generator, introduced in 1981, may also be considered as parts of the Encompass package.

Encompass exhibits a number of desirable attributes, partly due to the features of the underlying Tandem hardware and software architecture, and partly because of the features of Enscribe. Relational user views can be maintained without sacrificing accessibility and performance. A strong distributed data base flavor is provided. And data base consistency and integrity are assured by largely-automated mechanisms.

2. Enscribe™

Enscribe creates and maintains structured (blocked) files. The block format is depicted in Exhibit III-17. Three distinct file organizations are supported:

- o Entry sequenced (sequential).
- o Relative.
- o Key sequenced (indexed).

Records in entry-sequenced files are stored sequentially, as they are created. They may be accessed sequentially, or through alternate key fields, of which there may be as many as 255. A key field can be defined as any set of contiguous bytes within the record. Sequential file records may have variable lengths.

Relative files support fixed-length records only. Records are accessed and written by record number, which is the most efficient way (one disk seek); but they may also be accessed through alternate key fields.

Key sequenced (indexed) files (Exhibit III-18) are implemented as B*-trees whose index and data block sizes can be varied. Records are stored in order of the primary key, and may be retrieved by primary or alternate keys. Alternate keys are implemented as a separate indexed file (or files) by concatenating the alternate key value with the primary key value for each record of the file. Enscribe automatically maintains the alternate key files for all three file types to reflect the activities against the main file. Alternate key files may be placed on any disk, thus enabling concurrent processing of accesses by

EXHIBIT III-17

ENSCRIBE FILE FORMAT

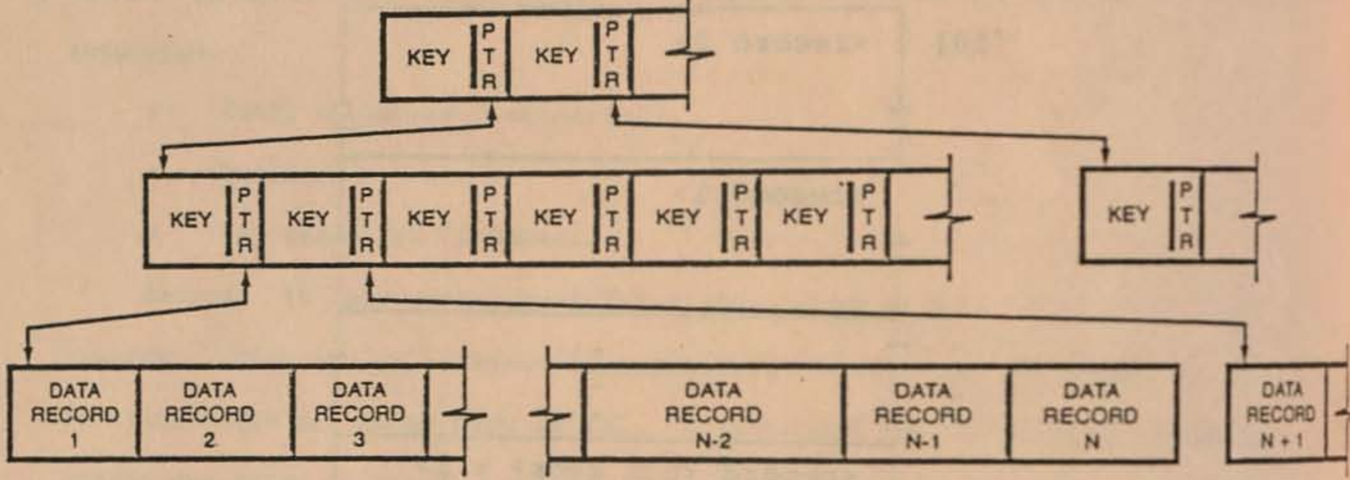
<rba> -->

word [0]	<next block at same level>	! doubleword
[2]	<next block on free list>	! doubleword
[4]	<num recs>	! one word
[5]	<level>	! one word
	unused (zeros)	! four words
[10]	<record 0>	
	<record 1>	
	. . .	
	<record <num recs> - 1>	
	free space	
	byte <offset> from [0] to free space	! one word
	byte <offset> from [0] to records <numrecs> - 1	! one word
	. .	
	byte <offset> from [0] to record 1	! one word
[<block size> - 1]	byte <offset> from [0] to record 0	! one word

Source: Tandem

EXHIBIT III-18

KEY SEQUENCED FILES



Data records stored in order of primary key.
# of index levels dependent upon user.
# of records/block & size dependent upon user.
Data compression available for keys + data.
Lowest level of index held on same cylinder as data.

Source: Tandem

primary and alternate keys. Data and index compression is optional.

Three types of keyed access are supported by Enscribe: exact, approximate, and generic. An exact access will locate the record with an exactly matching key. "Approximate" access will return all records with key values equal to or greater than the search key. "Generic" access returns all records in which a specified portion of the key matches the search key.

Enscribe maintains, in main memory buffers, the most recently accessed data or index blocks. The amount of such buffering is user specified. Read requests are satisfied from main memory whenever possible. Furthermore, the lowest-level index blocks can be loaded on the same cylinder as the corresponding data blocks. This saves a disk head move. When combined with main memory buffering, this feature permits rapid keyed access. For example, a record in a file with two index levels (generally sufficient for even large files) can be accessed with just one disk seek and two disk latencies: the first level index is accessed in main memory; the second level requires one seek and one latency; and the data block can be accessed in one more latency.

Another useful facility supported by Enscribe is file partitioning, under which a logical file may be segmented into up to 16 sub-files, based on a range of primary key values; each sub-file can be stored on a separate disk drive. The alternate key files may also be similarly partitioned. Overall system performance can be enhanced by this artifice, since it allows more concurrent accesses to heavily-used files.

Partitioning can also be used for other purposes:

- To manage files that are too large to fit on a single disk drive.
- To reduce the number of required index levels.
- To distribute sub-files among nodes of a network.

Of course, Enscribe supports disk mirroring to protect against the failure of a disk drive. Disk mirroring is described earlier, in the Tandem hardware section. In addition to enhanced availability, the Tandem scheme of disk mirroring actually contributes to enhanced performance via the "split seek" option. Under this option, Enscribe treats each disk drive as two areas: inner and outer. Each drive of a mirrored pair is assigned responsibility for one such area. Enscribe routes read requests to the drive responsible for the area in which the record is located. This minimizes required head moves. Furthermore, two read requests could be satisfied concurrently. To allow early detection of write errors, the responsibility areas of the mirrored pair are reversed every 10 minutes or so.

Write requests counter the intent of this scheme; but Tandem experience has shown that, in the majority of its systems, write accesses constitute only 20% of the total. Furthermore, where the members of a mirrored pair are attached to separate controllers, the mirrored writes can be executed concurrently.

3. DDL/DC

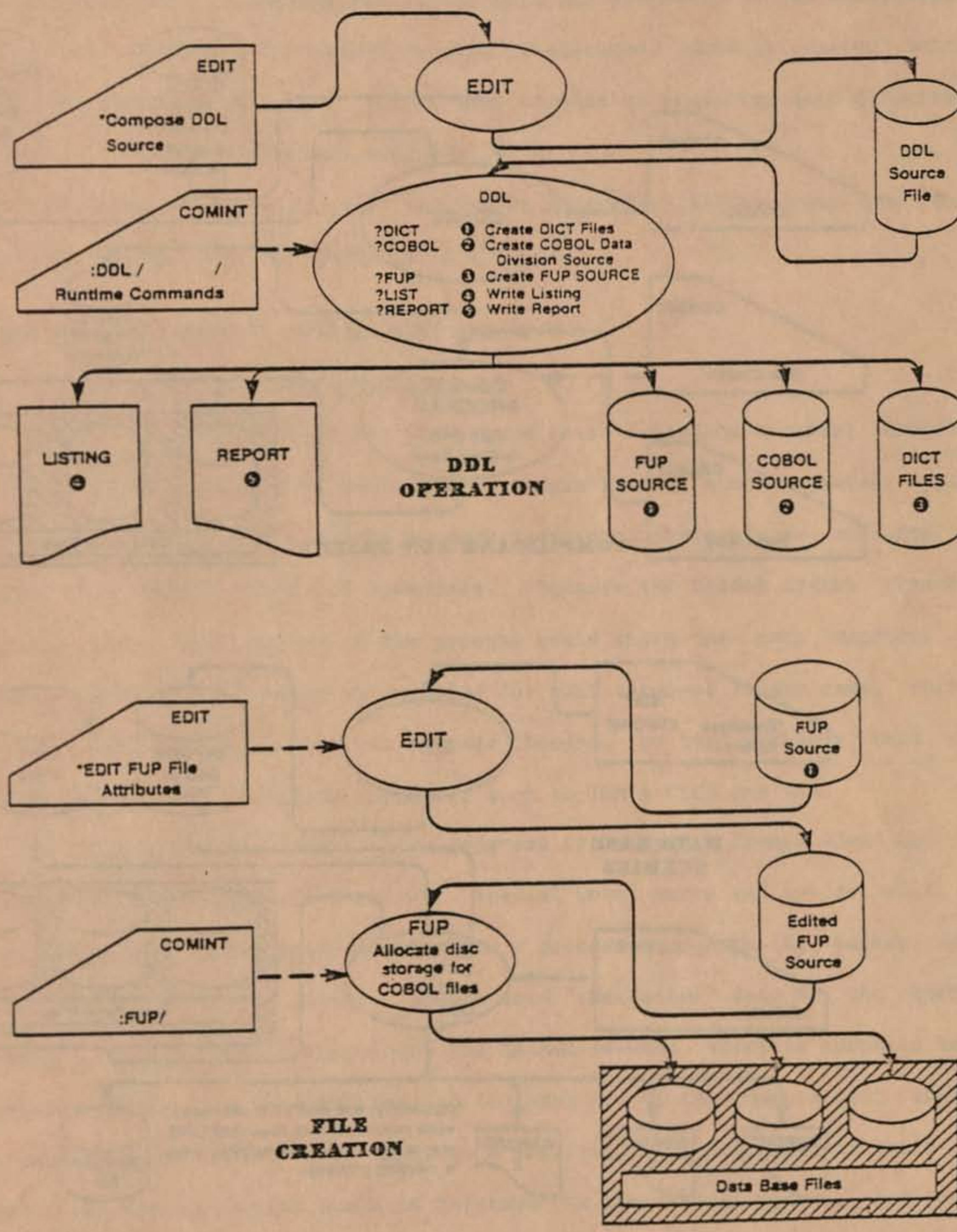
The Data Definition Language (DDL) and the Data Dictionary (DC) are critical elements in the Tandem DBMS. The DDL permits users to create relational views of the database; while the data dictionary, a small, 7-file relational data base in itself, is a global depository for the data definitions produced by the DDL. These data definitions, collectively known as the "schema", describe record structure, file types, and access methods. Exhibit III-19a, b, c, and d describe graphically how DDL/DC are used.

DDL source statements, which can be created as a file via the EDIT (editor), or entered on-line via the COMINT (command interpreter), are processed by the DDL compiler to produce a number of files and reports (a).

The file creation statements can be futher edited and/or augmented through COMINT. The File Utility Processor (FUP), a components of Enscribe, processes

EXHIBIT III-19

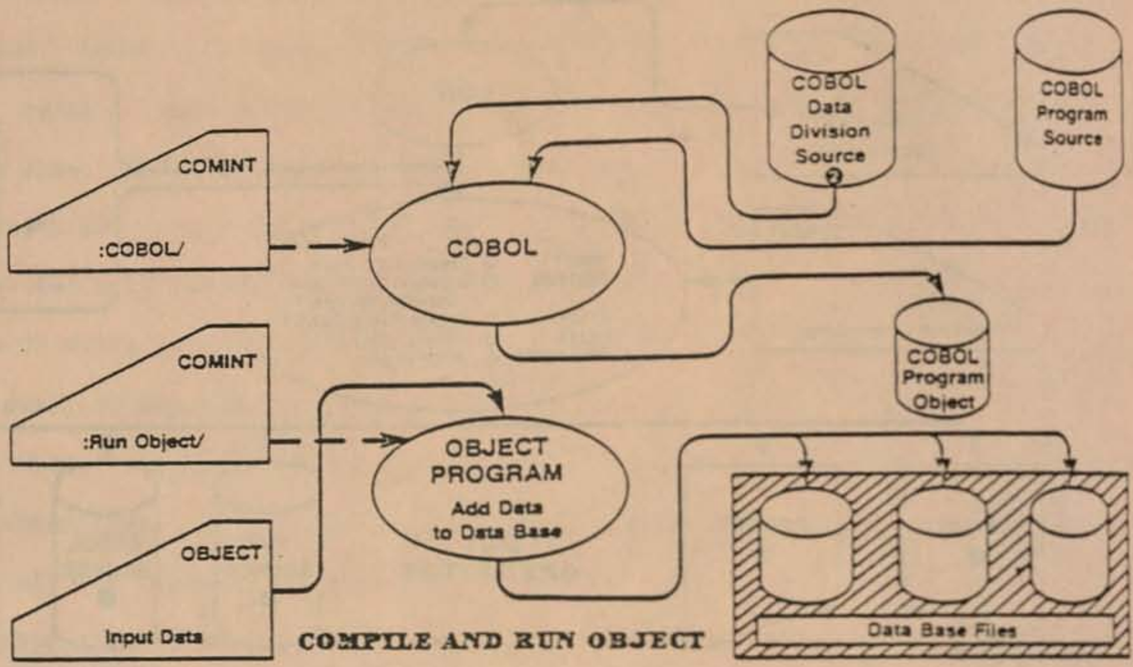
DDL OPERATION

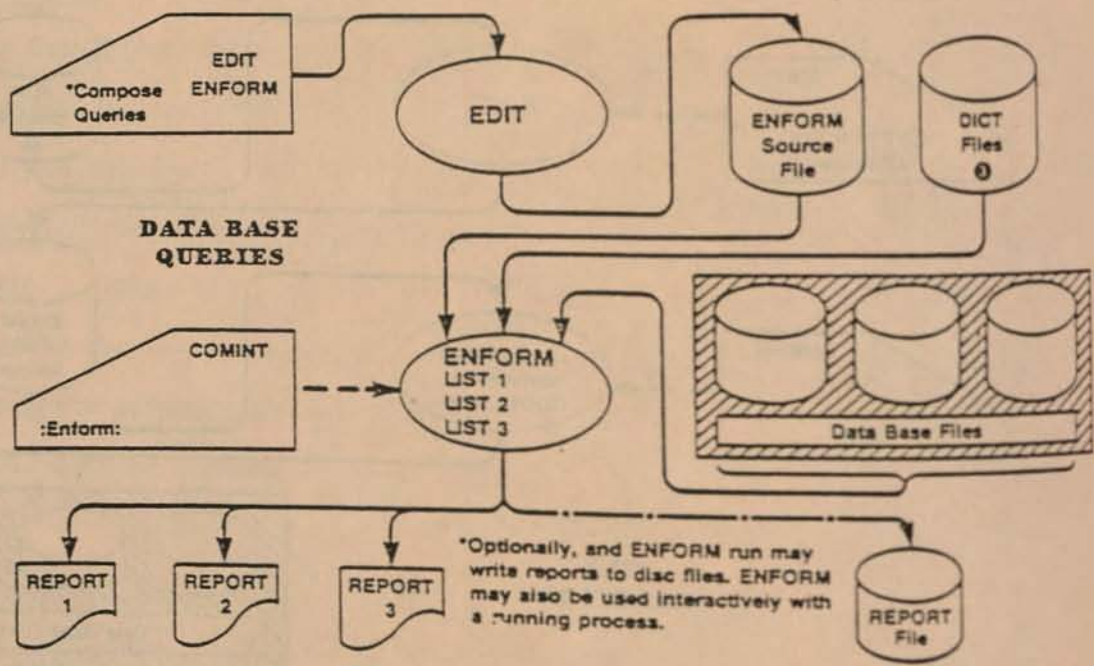


Source: Tandem

EXHIBIT III-19 (Continued)

DDL OPERATION





Source: Tandem

these statements and produces the required files (b).

The source file for a Cobol applications program. along with the Data Division statements, produced earlier by DDL, are processed by the Cobol compiler. When the resulting object program is executed, data is created and/or added into the data base (c). DDL is also capable of producing data definition statements for TAL and Fortran programs.

Data base inquiries, via the report generator Enform, use the Data Dictionary definitions, as shown in (d).

J. EVOLUTION OF TANDEM'S APPLICATIONS STRATEGY

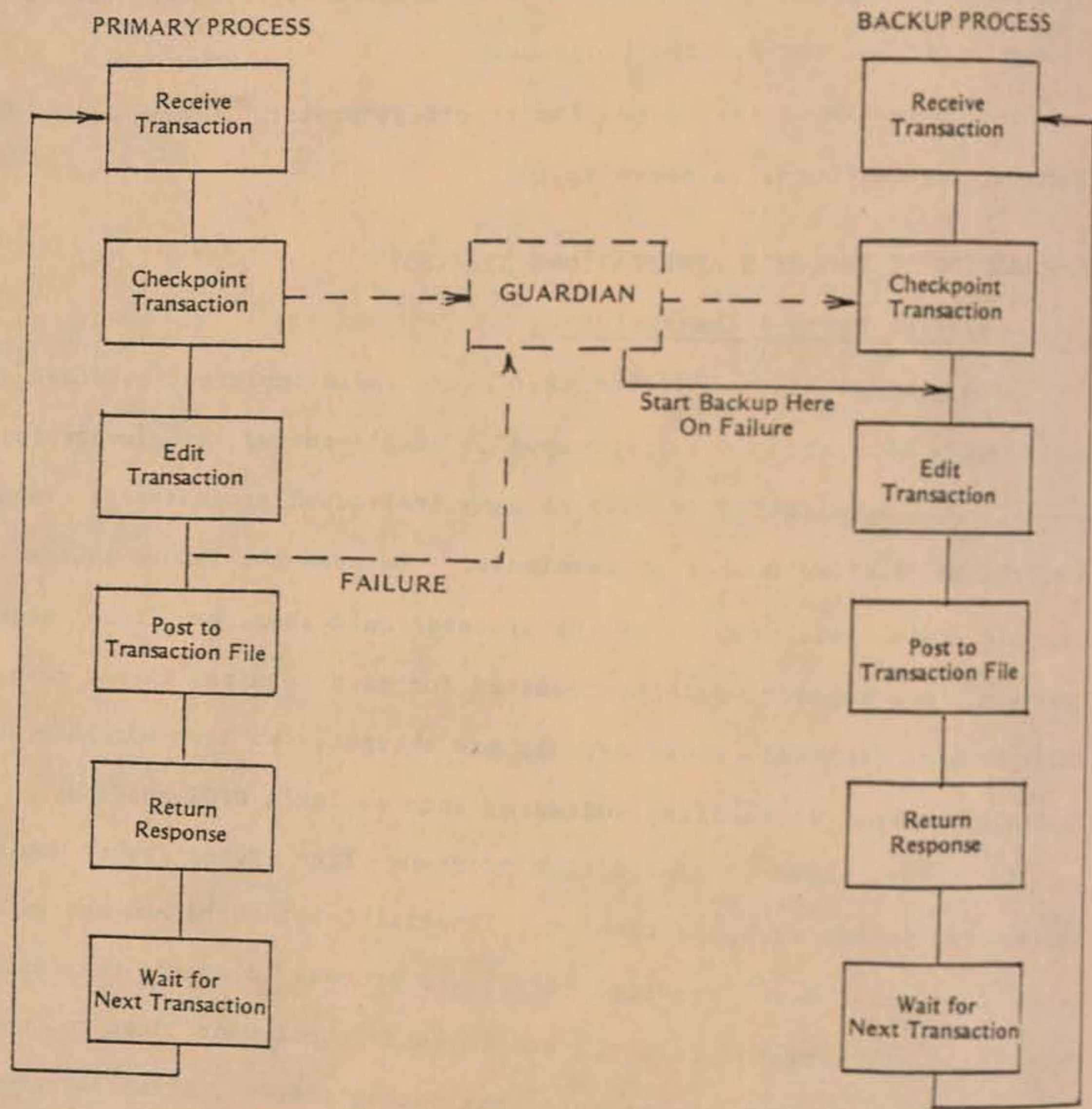
1. Process-Pairs & Checkpointing

Tandem originally believed that users could implement terminal handling applications by writing one "prototype", single-thread, single-terminal application, and duplicating it into as many individual processes as required to support the desired number of terminals. Because the Tandem system produces sharable code, all copies of the process could share one code segment. A separate data segment would be required for each terminal in any case, so the multiple-copy approach would be, it was thought, no less workable than the centralized terminal handling software, such as IBM's CICS and TSO.

In this scenario, application programs (like system tasks) would all be implemented in process-pair fashion. Special Cobol verbs and system calls in other languages were provided to allow a process to create its backup upon being initially created itself, and to send "checkpoint" data to the backup process. Through these checkpoints, the backup process, which is normally in a quiescent state, is kept informed of the progress of the computation; should the primary process fail (e.g. through a failure of the processor in which it runs), the backup process would be informed via the message system, and would take over by beginning anew from the last good checkpoint. Exhibit III-20

EXHIBIT III-20

CHECKPOINTING



Source: ITOM International Co.

outlines how the checkpoint procedure works in a simple transaction handling process.

Note that "checkpointing" in the Tandem sense differs from the conventional usage of the term, which generally signifies the saving, to disk, of a program's main memory image. In the Tandem system, checkpoint data is sent to the backup process, not the disk. More important, since code segments in the Tandem system are non-modifiable, only the data segment(s) need be saved. By a judicious program design, the amount of data needed to define the "state" of a process could be further reduced, so that much less than the full data segment need be sent to the backup.

Nevertheless, experience has shown that the whole concept of applications design based on process-pair and checkpointing is severely flawed. There are several areas of concern:

- o Overhead and system throughput.
- o Required level of user's skill.
- o Data base consistency and recoverability considerations.

Overhead. Tandem measurements have shown that 40%-50% of the CPU time is spent in the privileged (system) mode, an already large overhead. Several factors can contribute to an even greater overhead and corresponding reduction in system throughput. If a terminal handling application is designed as a multiplicity of single-thread, single-terminal process-pairs, where more than, say, 10 terminals are involved, one can expect to experience the following problems:

- o Significant system overhead due to excessive context switching, and to the large number of Process Control Blocks (PCBs), one of which the system maintains for each defined process.
- o Wasted main memory (and disk space) due to duplication of private buffer spaces in each process, which could otherwise be shared on a pool basis.
- o Loss of throughput becasue of the large volume of checkpoint messages

between process pairs, and messages between terminal handling processes and the data base application; the latter could be "batched" if terminal handling were centralized.

Note, incidentally, that with the extended addressing introduced in NonStop II, the size of a checkpoint message could be awesome indeed, which is one reason why Tandem is very reluctant to make extended addressing readily available to applications level programmers.

User Skills. Equally important, the design of checkpoint-based applications is far from a trivial task. In fact, a BS thesis on this subject was written at MIT as recently as June, 1981. Many subtleties are involved in designing to reduce the number of checkpoints, the amount of data in each checkpoint, and possible adverse interaction with other concurrent processes. One example of such subtleties is illustrated in Exhibit III-21.

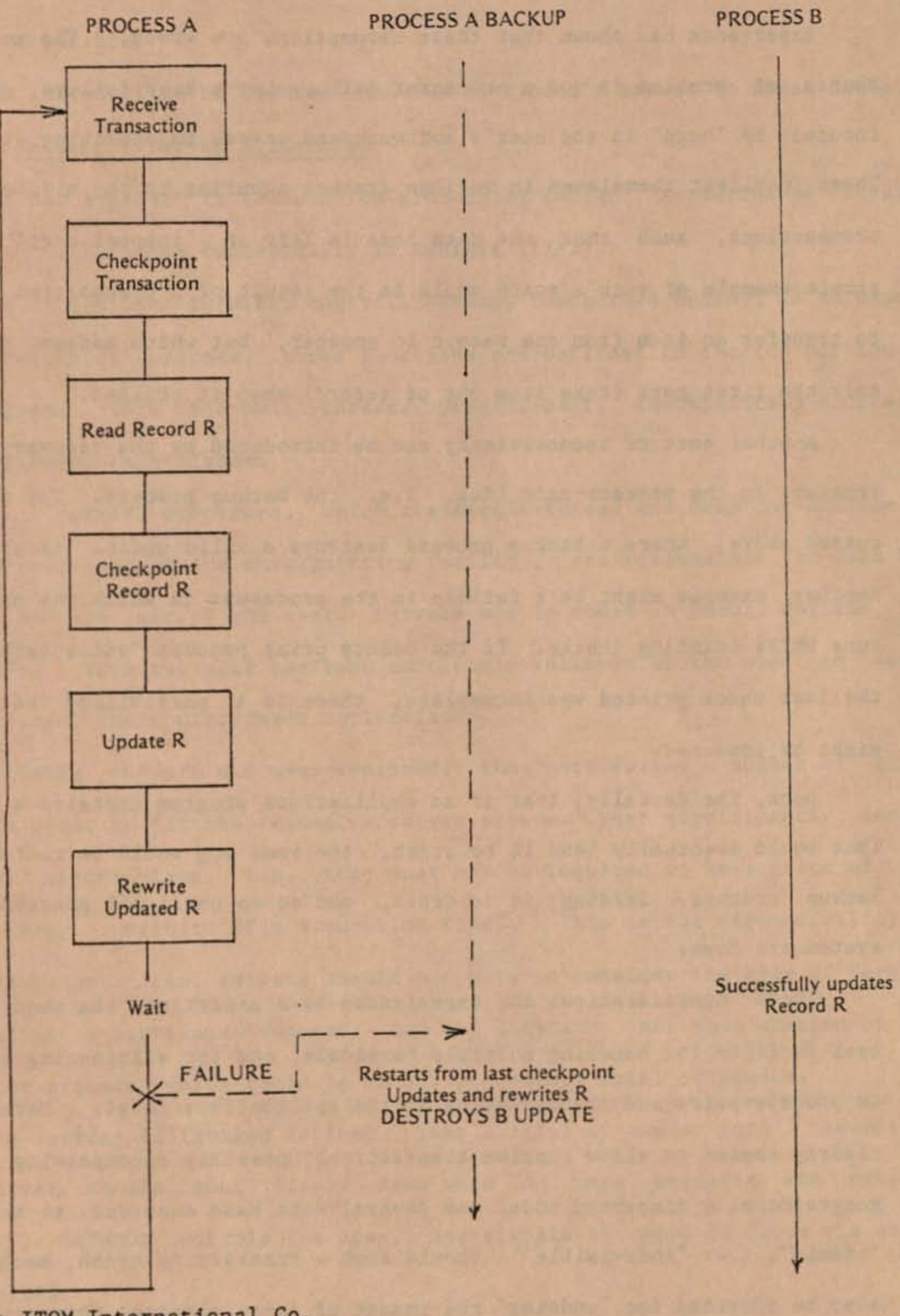
Here, A cursory examination might conclude that the two checkpoints in Process A are quite sufficient to recover from a processor failure at any point in the process. However, despite proper file/record locking, it can be seen that, should Process A fail in the "wait" loop following the record update, the backup process, by "rolling back" to the last good checkpoint following the record read, can destroy the update by Process B. A third checpoint, after the record rewrite by Process A, is clearly necessary.

Coping with such subtleties requires a high degree of programming skill and a deep understanding of the internal operation of the Tandem system. In addition to understanding the interaction between members of a process pair, the effect of other concurrent processes must be taken into account. An appreciation for the impact of a too-liberal checkpointing policy (too many checkpoints, too much checkpoint data) on throughput is also necessary.

Data Base Integrity and Recoverability. The implicit assumption in applications design based on process pairs and checkpointing is that if the processes accessing the data base are properly fault-tolerant, then the data base

EXHIBIT III-21

CHECKPOINTING SUBTLETIES



Source: ITOM International Co.

integrity is automatically assured; its recoverability is guaranteed by the disk mirroring technique.

Experience has shown that these assumptions are wrong. The most frequent source of problem is not a processor failure nor a disk failure, but errors induced by "bugs" in the user's software and errors in operating the system. These manifest themsleves in various crashes occuring in the middle of complex transactions, such that the data base is left an "inconsistent" state. A simple example of such a state would be the result of a transaction which meant to transfer an item from one record to another, but which managed to complete only the first part (take item out of record) when it crashed.

Another sort of inconsistency can be introduced by the recovery mechanism inherent in the process-pair idea, i.e. the backup process. The example discussed above, where a backup process destroys a valid update, is of this type. Another example might be a failure in the processor in which the print driver runs while printing checks. If the backup print process "rolls back", assuming the last check printed was incomplete, there is a possibility that two checks might be produced.

Note, incidentally, that if an applications program contains a serious bug that would eventually lead it to crash, the same bug would be contained in the backup process, leading it to crash, and so on until all processors in the system are down.

These considerations and experiences have underlined the need for a central facility for handling multiple terminals, and for eliminating the reliance on process-pairs and checkpointing at the applications level. Mechanisms were clearly needed to allow complex transactions (possibly encompassing a number of geographically dispersed nodes and several data base accesses) to be treated as "atomic", i.e. "indivisible". Should such a transaction crash, mechanisms must also be provided for "undoing" the impact of those portions that have executed.

Furthermore, in addition to disk mirroring, mechanisms for conventional data base restoration through periodic tape dumps, augmented by audit trails, were clearly desirable.

The introduction of Pathway™ and TMF is Tandem's answer to these needs.

2. Requestor/Server Structures

The new approach to transaction processing design, supported by Pathway™ and TMF, is depicted conceptually in Exhibit III-22.

The centralized terminal control, Pathway (described below), is an example of a "requestor" process, whose functions are outlined in the top portion of the diagram. This is a multi-thread, process-pair, checkpointing component, which is supplied by Tandem.

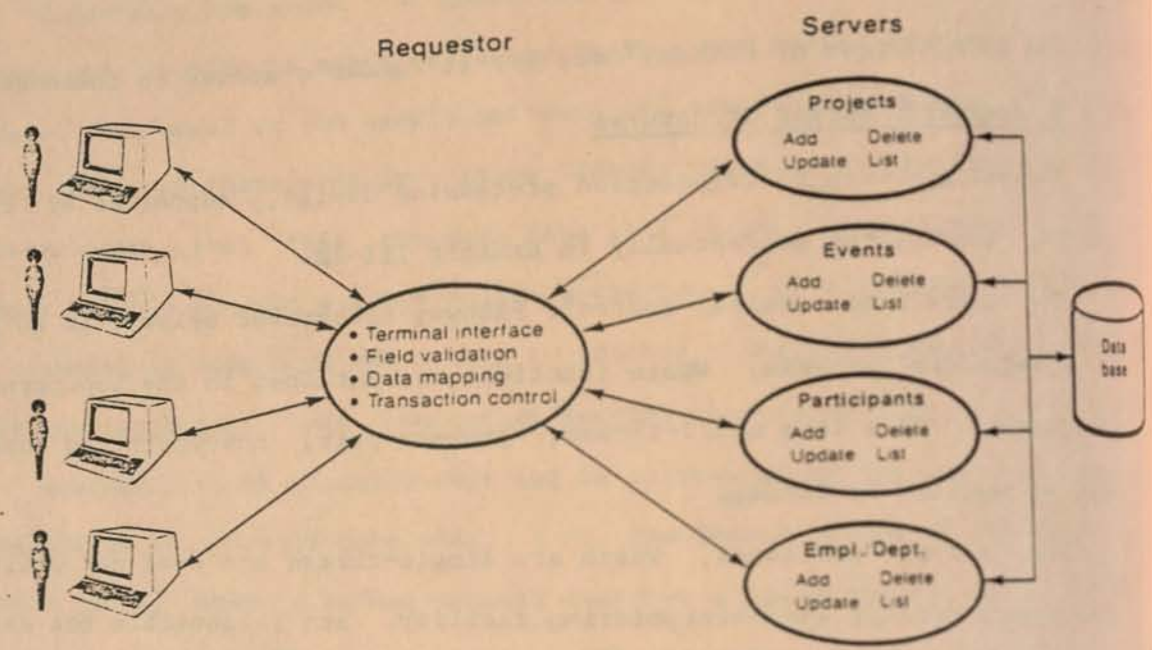
The "server" processes, which are single-thread and need not utilize the process-pair concept and checkpointing facility, are responsible for data base access, and are left to the user. Servers may be coded in Cobol, Fortran, TAL, or MUMPS. Thus the user has been completely relieved of the need to design process-pair, checkpoint-based applications.

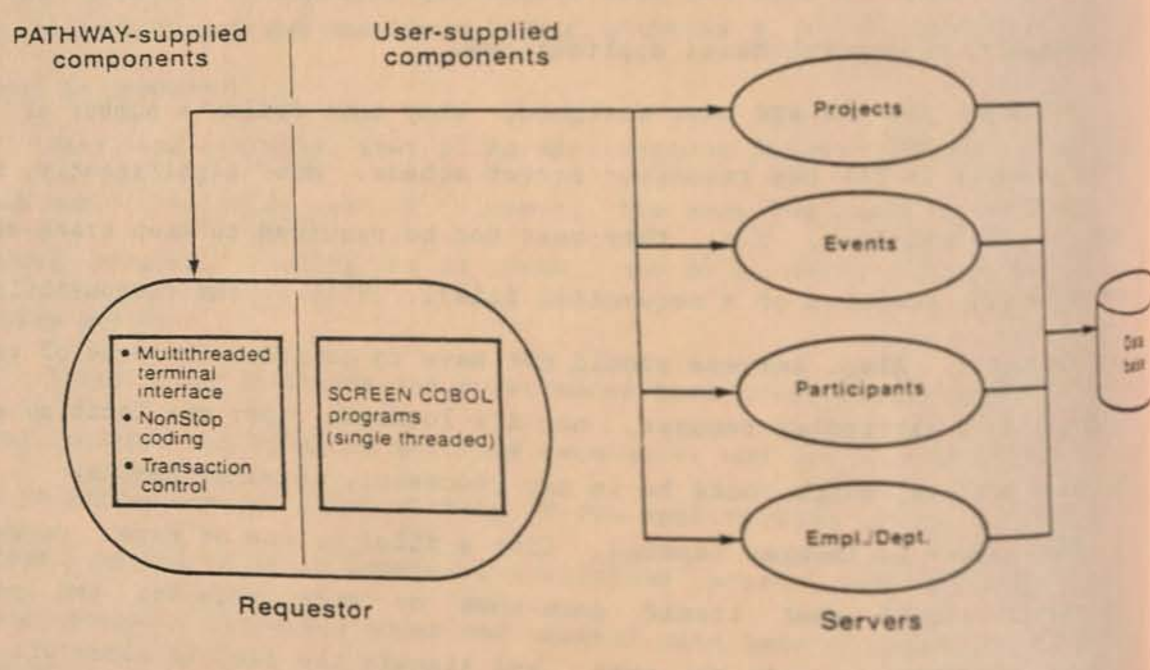
Although servers are user-designed, they must follow a number of guidelines in order to fit the requestor/server scheme. Most significantly, servers must be context-free, i.e. they must not be required to keep track of past events (e.g., position of a sequential file). This is the responsibility of each requestor. Also, servers should not have to consider the type of terminal originating a particular request, nor its location, nor the location of the requestor process, which could be in any processor, local or remote.

The server is invoked (opened, like a file) by one or more requestors. The server should shut itself down when no more requests are pending. Actually, PATHMON controls the open, and signals the need to close via an EOF on $RECEIVE.

EXHIBIT III-22

REQUSTOR/SERVER SCHEME





Source: Tandem

The requestor/server structure provides several advantages. First, it greatly simplifies the user's task, so that a far lesser degree of program design skill is required (though proper server design is still an art which needs to be learned by experience). Furthermore, requestors and servers can run in different processors (which may be geographically disperesed), thus contributing to concurrency and throughput, as well as supporting the "single system" illusion despite geographical dispersion.

A sample Cobol-coded server program is shown in Exhibit III-23. The program receives messages through the MESSAGE-IN queue and responds with either an error message or a database update message through the MESSAGE-OUT queue. ($RECEIVE is the file name which represents both queues). Syncdepth is a parameter which controls the level of message stacking on the queues. The 2-byte reply code is a Pathway™ requirement.

3. Pathway™

Pathway is a terminal control process, similar in purpose to the terminal management portion of IBM's CICS. Pathway, which replaces the earlier Envoy and Entry products, provides a centralized, multi-thread facility for handling terminals. The main-line components of Pathway are depicted in Exhibit III-24.

PATHMON is the Pathway monitor. It starts and stops both terminal control processes (TCPs) and user-supplied servers, and manages the links between them.

PATHCOM processes commands entered from the terminals (or from files or running processes). These commands describe terminals, TCPs, and servers, and request process start/stop. PATHCOM conveys these commands to PATHMON.

PATHTCP, the Tandem-supplied terminal control process, controls physical terminal I/O, and interprets screen Cobol object files. There can be several TCPs active concurrently (possibly in various processors), but each TCP is capable of handling multiple terminals of several types: "dumb" (ADM3), 6520, 6530, and 3270. Code is shared among terminals executing identical functions.

EXHIBIT III-23

SAMPLE SERVER PROGRAM

```
IDENTIFICATION DIVISION.
 PROGRAM-ID. EXAMPLE-SERVER.

ENVIRONMENT DIVISION.
 CONFIGURATION SECTION.
 SOURCE-COMPUTER. TANDEM/16.
 OBJECT-COMPUTER. TANDEM/16.
 INPUT-OUTPUT SECTION.
   FILE-CONTROL.
     SELECT MESSAGE-IN, ASSIGN TO $RECEIVE
        FILE STATUS IS RECEIVE-FILE-STATUS.
     SELECT MESSAGE-OUT, ASSIGN TO $RECEIVE
        FILE STATUS IS RECEIVE-FILE-STATUS.

DATA DIVISION.
FILE SECTION.
FD  MESSAGE-IN
    LABEL RECORDS ARE OMITTED.
  01 ENTRY-MSG.
    02 PW-HEADER.
       04 REPLY-CODE          PIC S9(4) COMP.
       04 APPLICATION-CODE    PIC XX.
       04 FUNCTION-CODE       PIC XX.
       04 TRANS-CODE          PIC 99.
       04 TERM-ID             PIC X(15).
       04 LOG-REQUEST         PIC X.
    02 ENTRY-GROUP.
       04 NAME-IN             PIC A(30).
       04 ADDR-IN             PIC X(20).
       04 DATE-GRP.
          06 MONTH-IN         PIC A(10).
          06 DAY-IN           PIC 99.
          06 YEAR-IN          PIC 99.

FD  MESSAGE-OUT
    LABEL RECORDS ARE OMITTED
    RECORD CONTAINS 1 TO 88 CHARACTERS.
  01 ENTRY-REPLY.
    02 PW-HEADER.
       04 REPLY-CODE          PIC S9(4) COMP.
       04 FILLER              PIC X(22).
    02 SERVER-RECORD          PIC X(64).

  01 ERROR-REPLY.
    02 REPLY-CODE             PIC S9(4) COMP.
    02 FILLER                 PIC X(22).
    02 ERROR-CODE             PIC S999  COMP.

WORKING-STORAGE SECTION.
  01 RECEIVE-FILE-STATUS.
    02 STAT-1                 PIC 9.
       88 CLOSE-FROM-REQUESTOR VALUE 1.
    02 STAT-2                 PIC 9.
```

Source: Tandem

EXHIBIT III-23 (Continued)

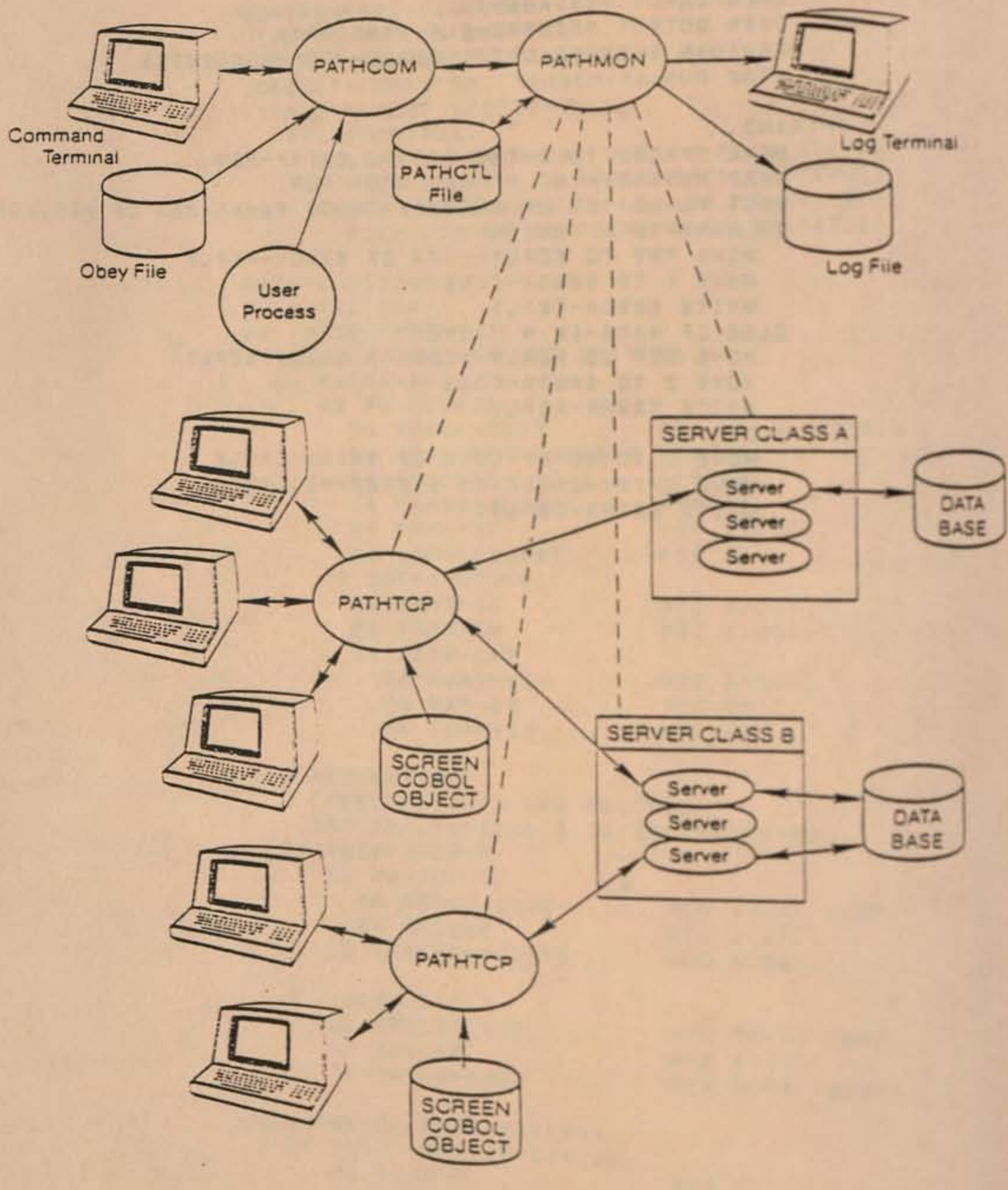
SAMPLE SERVER PROGRAM

```
PROCEDURE DIVISION.
BEGIN-COBOL-SERVER.
    OPEN INPUT MESSAGE-IN.
    OPEN OUTPUT MESSAGE-OUT SYNCDEPTH 1.
    PERFORM B-TRANS UNTIL CLOSE-FROM-REQUESTOR.
    STOP RUN.

B-TRANS.
    MOVE SPACES TO ENTRY-REPLY, ENTRY-MSG.
    READ MESSAGE-IN, AT END STOP RUN.
    MOVE PW-HEADER OF MESSAGE-IN TO PW-HEADER OF MESSAGE-OUT.
    IF NAME-IN = "SMITH"
      MOVE 999 TO REPLY-CODE OF ERROR-REPLY
      MOVE 1 TO ERROR-CODE
      WRITE ERROR-REPLY
    ELSE IF NAME-IN = "JONES"
      MOVE 999 TO REPLY-CODE OF ERROR-REPLY
      MOVE 2 TO ERROR-CODE
      WRITE ERROR-REPLY
    ELSE
      MOVE 0 TO REPLY-CODE OF ENTRY-REPLY
      MOVE ENTRY-GROUP TO SERVER-RECORD
      WRITE ENTRY-REPLY.
```

Source: Tandem

EXHIBIT III-24

PATHWAY SYSTEM STRUCTURE



Source: Tandem

TCPs communicate with servers through the message system.

The TCP is responsible for all data editing, conversion, and validity checks. In addition, multi-step transaction control is vested in the TCP. Exhibit III-25 depicts the TCP data area layout.

Screen Cobol is a Cobol-like language, which allows user to define and control terminal displays. Basic functions invokable through Screen Cobol are: display data and screens, accept data, send message to server, and call other Screen Cobol program units.

Under Pathway, the only part of the requestor that users must supply is a collection of appropriate SCREEN COBOL programs, which can be written as if they were single-thread processes. A sample Screen Cobol program is shown in Exhibit III-26.

A stand alone program, SCUP (Screen Cobol Utility Program), is available to manage object files produced by Cobol, primarily in terms of adding or deleting subprograms representing screen definitions. These definitions are created, modified, and documented with the aid of Pathaid, whose operation is depicted in Exhibit III-27.

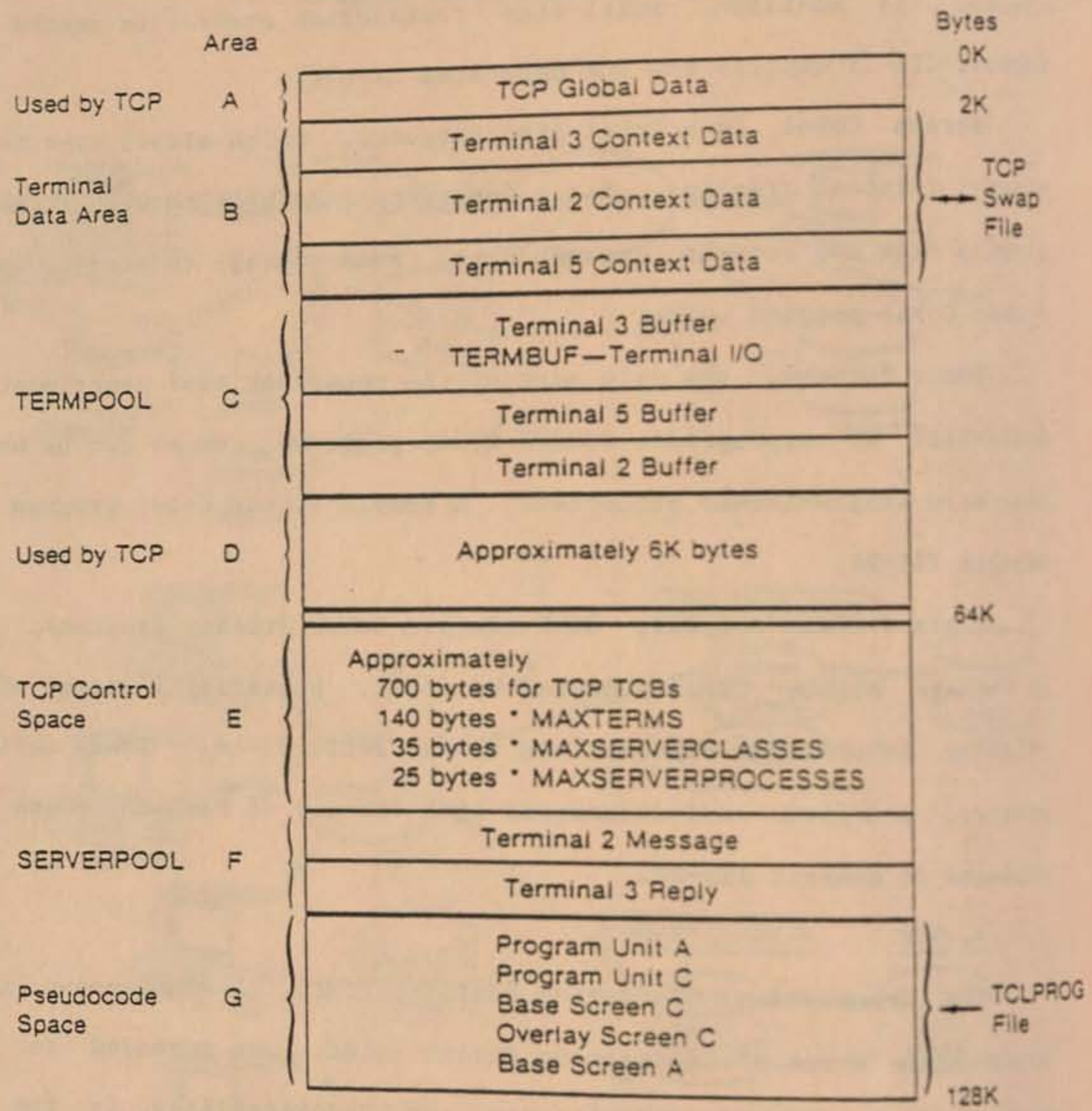
4. TMF

The Transaction Monitoring Facility (TMF), a Tandem-supplied product, along with a set of transaction design rules, are intended to address the problems of database consistency and recoverability in the context of concurrent transaction processing activities.

The goal of TMF is to provide system-level tools which simplify the maintenance of data base consistency at the applications level, in a concurrent (and possibly distributed) processing environment; and which aid in the recoverability of the data base following hardware or applications program malfunctions. The latter class involve such problems as process abnormal termination (abort) and deadlocks (e.g. infinite loops).

EXHIBIT III-25

TCP DATA AREA LAYOUT



Areas A, D, E — Areas used by the TCP and not available for terminal execution.

Areas C, F — Areas allocated based on SET TCP parameters supplied by the user.

Area B — Areas used for terminal data. Area size determines how many terminals can be controlled by a TCP without causing swapping; area can be increased by decreasing area C, TERMPOOL.

Area G — Area used for pseudocode; area can be increased by decreasing area F, SERVERPOOL.

Source: Tandem

EXHIBIT III-26

SCREEN COBOL PROGRAM

```
IDENTIFICATION DIVISION.
  PROGRAM-ID. EXAMPLE.

ENVIRONMENT DIVISION.
  CONFIGURATION SECTION.
  SOURCE-COMPUTER. T16.
  OBJECT-COMPUTER. T16,
   TERMINAL IS T16-6520.
  SPECIAL-NAMES.
   F1-KEY IS F1, F2-KEY IS F2, F3-KEY IS F3, F4-KEY IS F4
   F5-KEY IS F5, F6-KEY IS F6, F7-KEY IS F7, F16-KEY IS F16
   ATTENTION IS BLINK, HIDDEN IS HIDDEN.

DATA DIVISION.
   WORKING-STORAGE SECTION.
   01 WS.
      02 ERROR-MSG             PIC X(77).
      02 PASSWORD              PIC X(3).
      02 DEPT-HEADER           PIC X(3).
   01 EXIT-FLAG                PIC S9        VALUE 0.
      88 EXIT-PROGRAM          VALUE 1.
   01 ENTRY-MSG.
      02 PW-HEADER.
         04 REPLY-CODE         PIC S9(4) COMP.
         04 APPLICATION-CODE   PIC XX.
         04 FUNCTION-CODE      PIC XX.
         04 TRANS-CODE         PIC 99.
         04 TERM-ID            PIC X(15).
         04 LOG-REQUEST        PIC X.
      02 ENTRY-GROUP.
         04 NAME-IN            PIC A(30).
         04 ADDR-IN            PIC X(20).
         04 DATE-GRP.
            06 MONTH-IN        PIC A(10).
            06 DAY-IN          PIC 99.
            06 YEAR-IN         PIC 99.

   01 ENTRY-REPLY.
      02 PW-HEADER.
         04 REPLY-CODE         PIC S9(4) COMP.
         04 FILLER             PIC X(22).
      02 SERVER-RECORD         PIC X(64).

   01 ERROR-REPLY.
      02 REPLY-CODE            PIC S9(4) COMP.
      02 FILLER                PIC X(22).
      02 ERROR-CODE            PIC S999  COMP.
```

Source: Tandem

EXHIBIT III-26 (Continued)

SCREEN COBOL PROGRAM

```
SCREEN SECTION.
01 EXAMPLE-SCREEN BASE SIZE 24, 80.
  03 FILLER       AT 1, 20 VALUE "EXAMPLE SCREEN COBOL PROGRAM".
  03 FILLER       AT 3, 1  VALUE "DEPARTMENT :".
  03 DEPT-HEADER AT 3, 14 PIC X(3) FROM DEPT-HEADER OF WS.
  03 FILLER       AT 3, * + 10 VALUE "PASSWORD :".
  03 PASSWORD     AT 3, * + 2  PIC X(3) LENGTH 1 THRU 3, HIDDEN,
          UPSHIFT INPUT, MUST BE "AAA" "X", TO PASSWORD OF WS.
  03 DATA-IN.
     05 FILLER        AT 5, 1  VALUE "NAME :".
     05 NAME-IN       AT 5, 8  PIC A(30) LENGTH 1 THRU 30
                      TO NAME-IN OF ENTRY-MSG, FILL "_".
     05 FILLER        AT 6, 1  VALUE "ADDR :".
     05 ADDR-IN       AT 6, 8  PIC X(20) LENGTH 1 THRU 20
                      TO ADDR-IN OF ENTRY-MSG, FILL "_".
     05 DATE-GRP      AT 8, 1.
        07 FILLER     AT @, 1  VALUE "MONTH :".
        07 MONTH-IN AT @, * + 2  PIC A(10) LENGTH 1 THRU 10
             MUST BE "JANUARY", "FEBRUARY" USING MONTH-IN OF
             ENTRY-MSG, UPSHIFT INPUT, VALUE "FEBRUARY".
        07 FILLER     AT @, * + 4 VALUE "DAY :".
        07 DAY-IN     AT @, * + 2 PIC Z9 LENGTH 1 THRU 2, VALUE "15"
             MUST BE 1 THRU 31, USING DAY-IN OF ENTRY-MSG.
        07 FILLER     AT @, * + 4  VALUE "YEAR :".
        07 YEAR-IN    AT @, * + 2 PIC Z9 MUST BE 79, 80, 85 THRU 88
             USING YEAR-IN OF ENTRY-MSG, VALUE "80".

  03 FILLER           AT 10, 1 VALUE "REPLY -".
  03 SERVER-RECORD    AT 10, * + 2  PIC X(64)
                      FROM SERVER-RECORD OF ENTRY-REPLY.
  03 FILLER           AT 18, 1 VALUE
     "F1 - ENTER PASSWORD                 F5  - BLINK REPLY".
  03 FILLER           AT 19, 1 VALUE
     "F2 - ENTER DATA                     F6  - RESET ATTR REPLY".
  03 FILLER           AT 20, 1 VALUE
     "F3 - CLEAR INPUT                    F7  - RESET DATA REPLY".
  03 FILLER           AT 21, 1 VALUE
     "F4 - RESET DATA SCREEN              F16 - EXIT PROGRAM".
  03 ERROR-MSG        AT 24, 2 PIC X(76)  ADVISORY
                      FROM ERROR-MSG OF WS.
```

Source: Tandem

EXHIBIT III-26 (Continued)

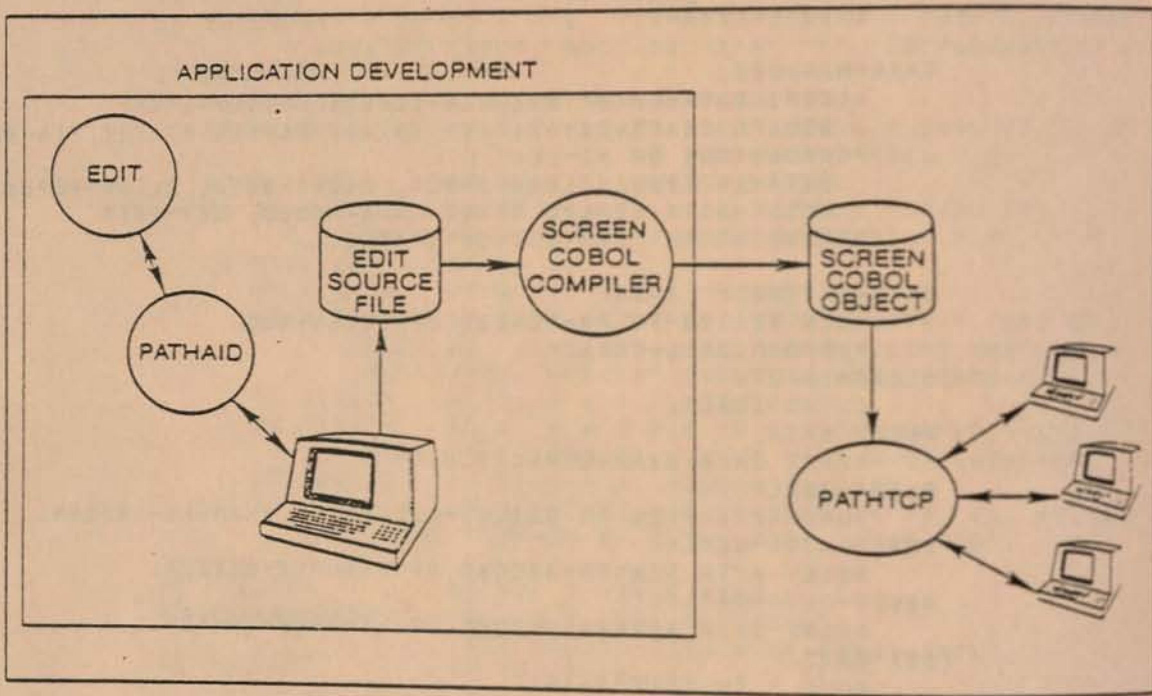
SCREEN COBOL PROGRAM

```
PROCEDURE DIVISION.
A-MAIN.
    DISPLAY BASE EXAMPLE-SCREEN.
    MOVE "MKT" TO DEPT-HEADER OF WS.
    DISPLAY DEPT-HEADER OF EXAMPLE-SCREEN.
    ACCEPT PASSWORD OF EXAMPLE-SCREEN UNTIL F1-KEY.
    PERFORM CASE-MANAGER UNTIL EXIT-PROGRAM.
A-EXIT.
    EXIT PROGRAM.

CASE-MANAGER.
    ACCEPT DATA-IN OF EXAMPLE-SCREEN UNTIL F2-KEY
      ESCAPE ON F3-KEY F4-KEY F5-KEY F6-KEY F7-KEY F16-KEY.
    PERFORM ONE OF
      DATA-ENTERED, CLEAR-INPUT, RESET-DATA, BLINK-REPLY
      RESET-ATTR-REPLY, RESET-DATA-REPLY, SET-EXIT
    DEPENDING ON TERMINATION-STATUS.

DATA-ENTERED.
    MOVE SPACES TO PW-HEADER OF ENTRY-MSG.
    PERFORM SEND-DATA.
CLEAR-INPUT.
    CLEAR INPUT.
RESET-DATA.
    RESET DATA EXAMPLE-SCREEN.
BLINK-REPLY.
    TURN ATTENTION IN SERVER-RECORD OF EXAMPLE-SCREEN.
RESET-ATTR-REPLY.
    RESET ATTR SERVER-RECORD OF EXAMPLE-SCREEN.
RESET-DATA-REPLY.
    RESET DATA SERVER-RECORD OF EXAMPLE-SCREEN.
SET-EXIT.
    MOVE 1 TO EXIT-FLAG.

SEND-DATA.
    SEND ENTRY-MSG TO "EXAMPLE-SERVER"
      REPLY CODE 0     YIELDS ENTRY-REPLY
            CODE 999   YIELDS ERROR-REPLY.
    IF TERMINATION-STATUS = 2 AND ERROR-CODE = 1
       MOVE "SMITH IS ALREADY ON FILE" TO ERROR-MSG OF WS
       PERFORM 901-DISPLAY-ADVISORY
    ELSE IF TERMINATION-STATUS = 2 AND ERROR-CODE = 2  .
       MOVE "JONES IS ALREADY ON FILE" TO ERROR-MSG OF WS
       PERFORM 901-DISPLAY-ADVISORY
    ELSE
       DISPLAY SERVER-RECORD OF EXAMPLE-SCREEN.

901-DISPLAY-ADVISORY.
    DISPLAY TEMP ERROR-MSG OF EXAMPLE-SCREEN.
    TURN TEMP ATTENTION IN ERROR-MSG OF EXAMPLE-SCREEN.
```

Source: Tandem

EXHIBIT III-27

PATHAID SCREEN BUILDER



Source: Tandem

Concurrency control to aid in these aims is established by a set of transaction design rules, which call for all transactions to have the attributes of being well-formed and two-phase. If all transactions conform to this model, Tandem claims that it can be proven that problems due to concurrency are entirely eliminated.

A transaction is well-formed if:

- o Each entity which is physically altered is locked at the time of alteration.
- o No entity is locked more than once.
- o All entities are unlocked by the time the transaction is completed.

A transaction fulfills the two-phase requirement if, after the first lock is released, no more entities are locked. That is, the transaction has a "growing phase", during which all locks are granted, and a "shrinking phase", during which all locks are gradually (or simultaneously) released.

TMF is capable of undoing the effects of an incomplete transaction (due, for example, to processor failure, applications program abort or deadlock, and loss of network communications.

TMF is capable, following a catastrophic failure (entire system down), of "rolling forward" to restore the data base. This is essentially accomplished by reapplying the effects of all completed transactions from a previous data base state, up until the time of failure.

To achieve these aims, the following are implemented:

- o Audited files, audit trails.
- o Enforcement of the locking protocol.
- o Online dump (to tape, typically) of data base and audit trail files, aided by a tape catalog facility.

Users can designate "audited volumes" (at SYSGEN time), within which specific files can be dynamically designated as "audited". For audited files, TMF automatically maintains audit-trail files.

Audit trail files contain the "before" and "after" record images as follows:

- o An insert to an audited file will result in the inserted record being written to the audit trail.
- o A delete from an audited file will result in the deleted record being saved in the audit trail.
- o An updated record in an audited file will result in both the original and the updated record to be saved in the audit trail.

Thus a partially-completed transaction can be "undone" by applying the "before" images from the audit trail. Inserted records are deleted; deleted records are reinstituted; and updated records are returned to their original status.

Rollforward involves loading the most recent data base dump of the files which are to be recovered, and applying the "after" images as indicated in the audit trail, from the point of the last dump. Some audit trail file dumps may have to be reloaded as well.

The locking protocol is enforced by TMF as follows. The user signals the beginning and end of a well-formed, two-phase transaction by invoking the Screen Cobol verbs BEGIN-TRANSACTION and END-TRANSACTION; equivalent system calls are provided in other supported languages. TMF then demands that the user first issue appropriate lock requests before inserting, deleting, or updating records in audited files.

Furthermore, TMF will not release locks at the points of user requests, but rather at the end of the transaction only (the only exception being a locked record that has not been updated). These actions guarantee that transactions are well formed and have the required two-phase attribute.

TMF provides the facilities for dumping audited files and audit trail files to tape. Dumped audit trails are automatically purged from the disk. TMF can be configured to dump audit trails automatically. Tandem recommends that audit trails be dumped to a mirrored disk.

The tape catalog facility, maintained by TMF, allows the user to specify the number of generations of on-line dumps which TMF is to manage. TMF keeps track of the relationship between audited file dumps and the corresponding audit trail file dumps. TMF informs the user of no longer needed dump tapes.

TMF system components and their interrelationships are depicted in Exhibit III-28.

Because of the requestor/server applications design structure, an interesting issue arises regarding the "ownership" of locks. If the server that obtained the lock also owned it, the server would have to release the lock before replying to the requestor; but if the transaction is a multi-step one, requiring the services of more than one server, the transaction would necessarily violate the two-phase rule.

On the other hand, the TCP couldn't possibly own the locks because it is serving multiple terminals and multiple transactions.

Instead, Tandem delegates lock ownership to the transaction itself. Before making requests to servers, the TCP obtains a unique transaction identification, TRANSID, consisting of a node number and a transaction sequence number. The locks are considered to be owned by this TRANSID.

TCP will checkpoint the terminal context upon transaction beginning and end.

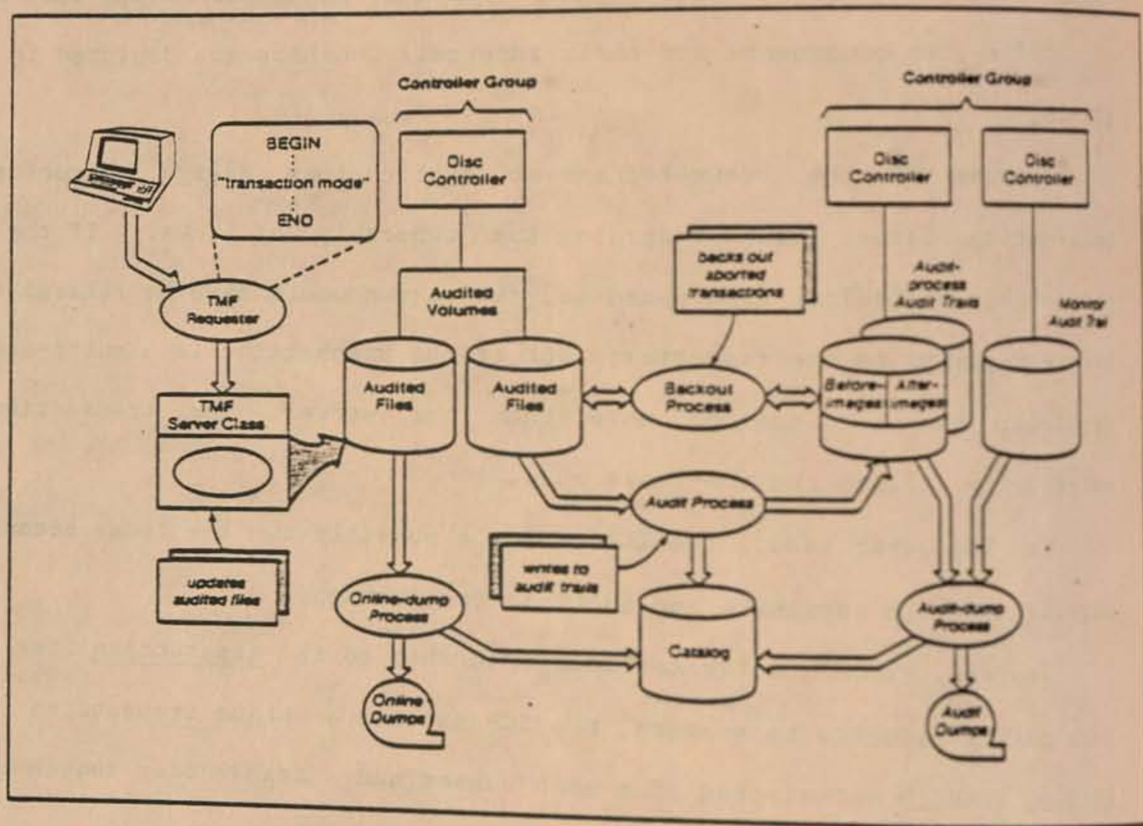
K. TRANSFER™ AND INFOSAT™

1. Introduction

In May, 1982, Tandem introduced two new products, TRANSFER™ and INFOSAT™, each consisting of new hardware and software components. TRANSFER is basically an electronic mail system, with the added important capability of handling

EXHIBIT III-28

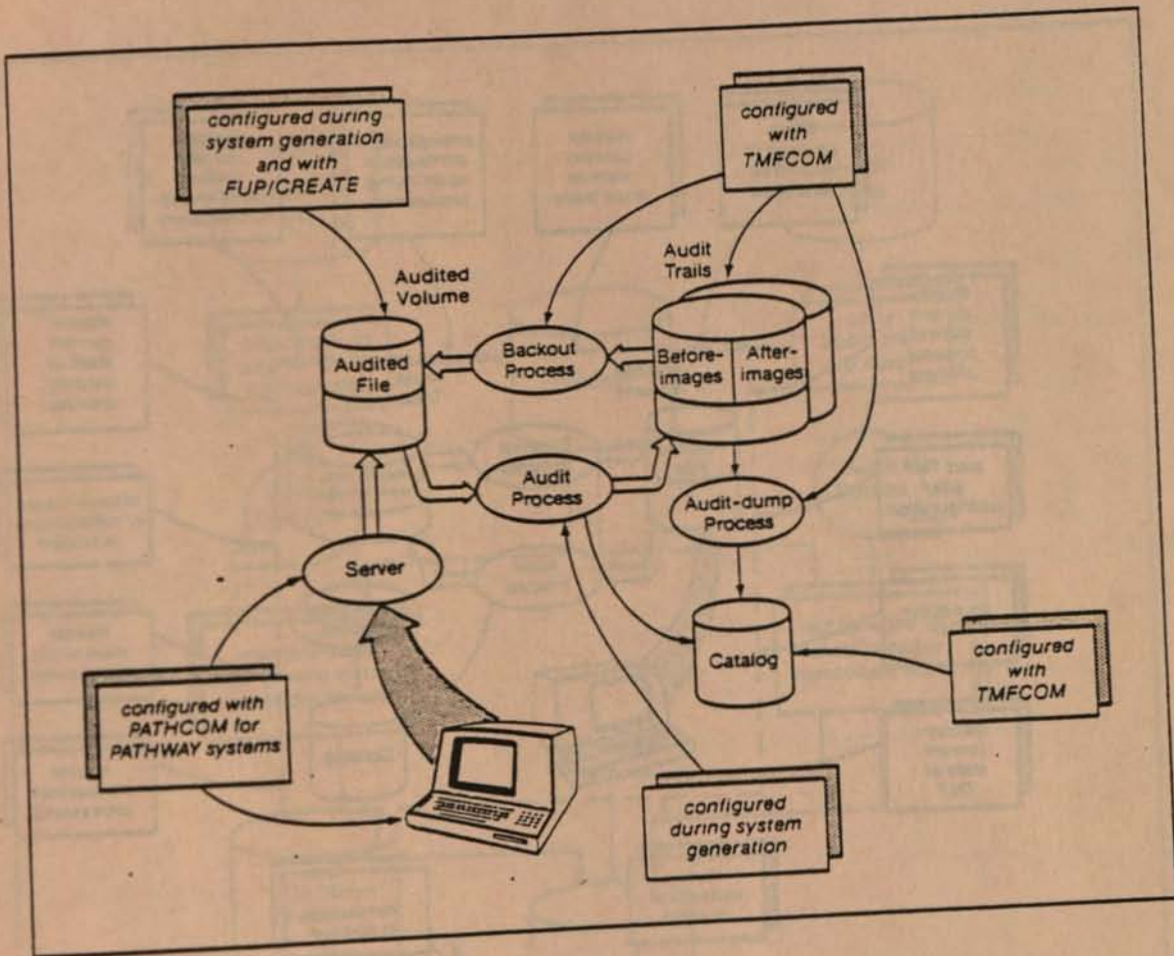
TMF SYSTEM OVERVIEW



Source: Tandem

EXHIBIT III-28 (Continued)

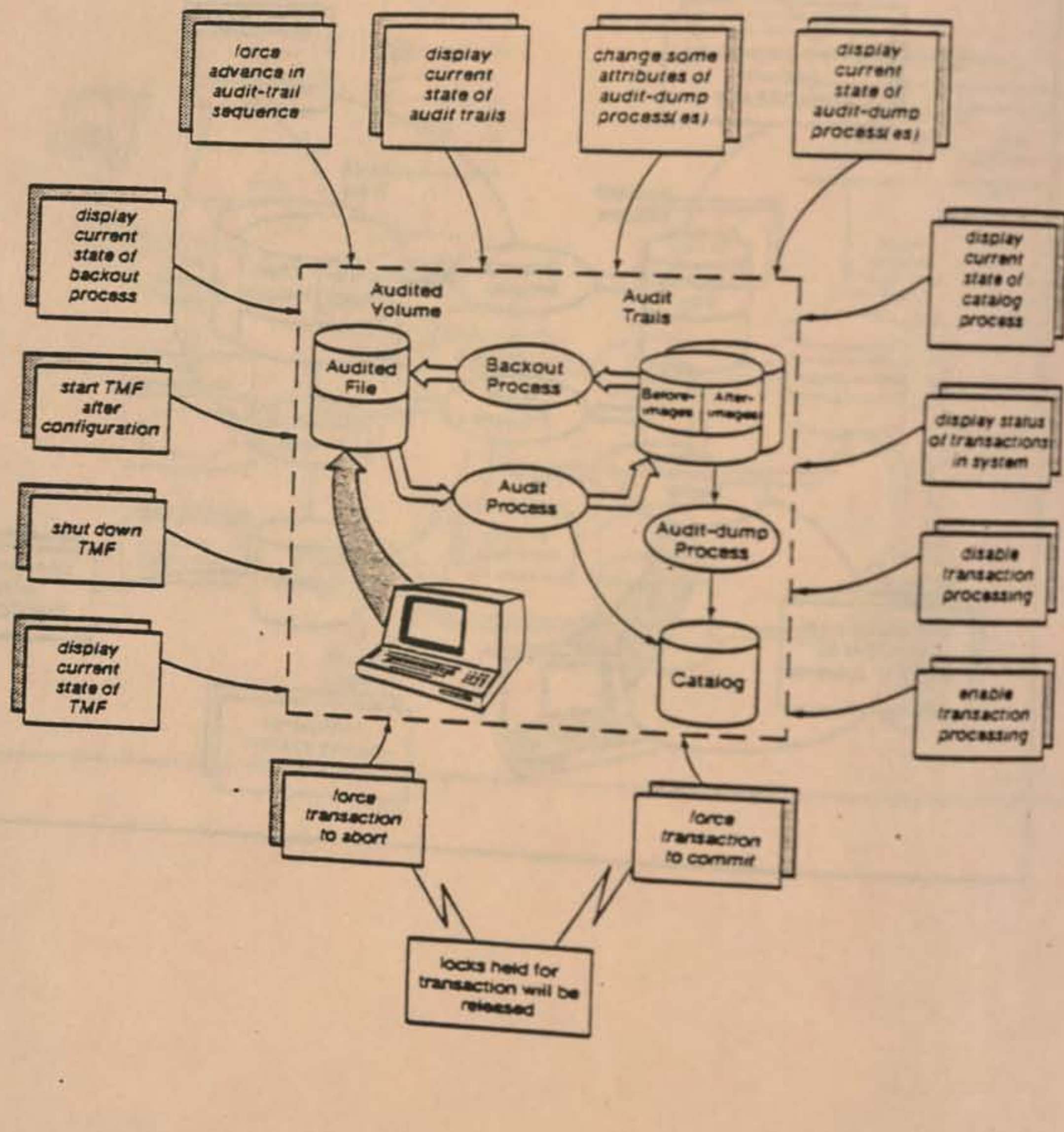
TMF CONFIGURATION OBJECTS



Source: Tandem

EXHIBIT III-28 (Continued)

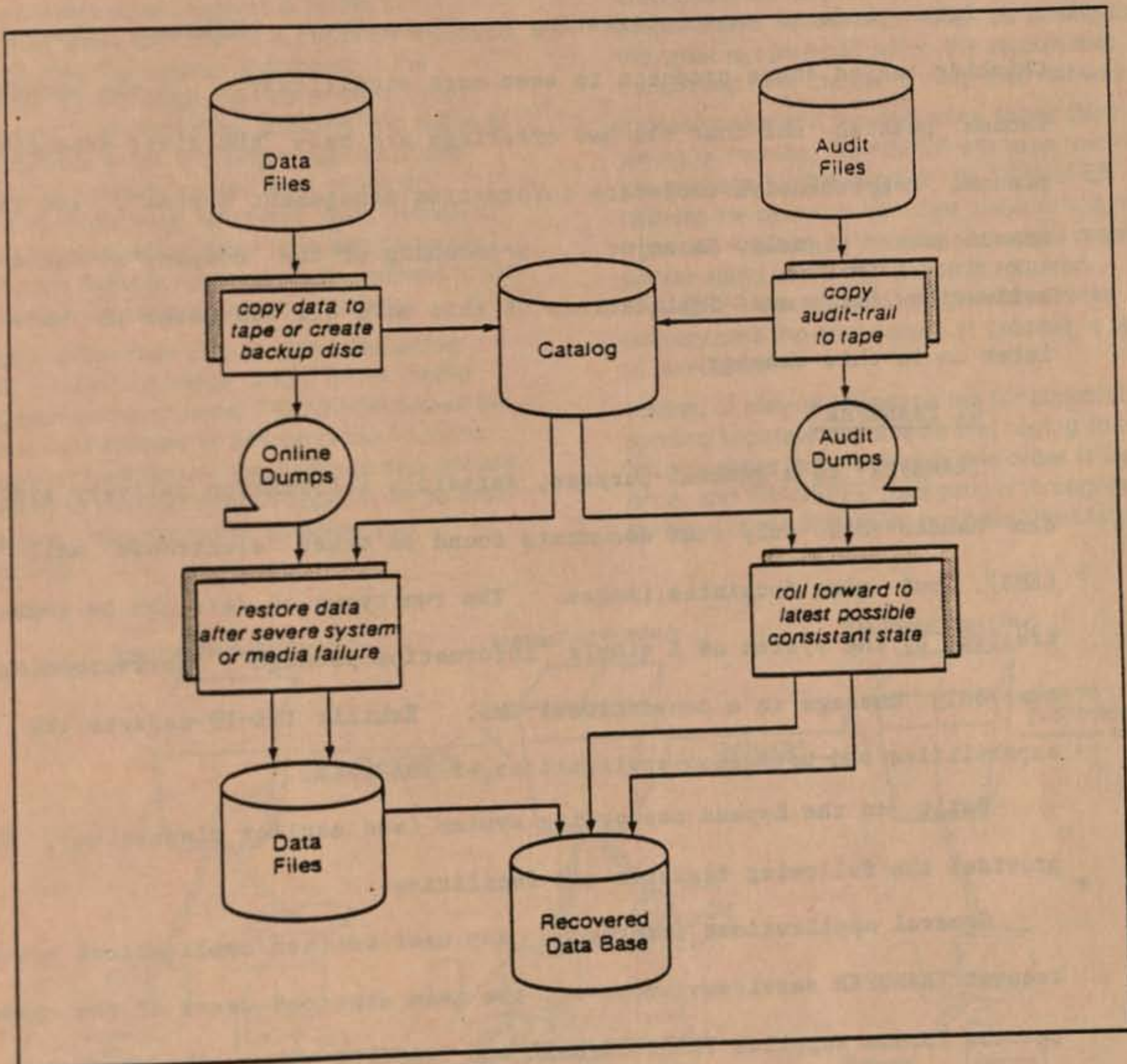
TMF OPERATING TASKS



Source: Tandem

EXHIBIT III-28 (Continued)

TMF DUMPING AND RECOVERY



Source: Tandem

"information packages" comprised of a combination of text documents and digitized facsimile images. It is scheduled for general availability in April, 1983. INFOSAT permits a Tandem node to interface to a low-cost satellite earth station. It is set for general availability in 3Q83.

Both products are interesting in themselves. However, the strategic thinking behind these products is even more significant. In the announcement, Tandem pointed out that the new offerings are only "the first products in a planned comprehensive corporate information management system", and that the announcement signals "a major... broadening of the company's focus". The motivation for, and implications of this move are discussed in more detail later on in this chapter.

2. TRANSFER™

TRANSFER™ is a general-purpose, versatile information delivery system that can handle not only text documents found on other electronic mail systems (EMS), but also facsimile images. The two types of data can be combined and treated by the system as a single "information package", corresponding to a text-only message in a conventional EMS. Exhibit III-29 depicts the overall capabilities and potential applications of TRANSFER.

Built on the Expand networking system (see earlier discussion), TRANSFER provides the following features and facilities:

General applications interface. Any user written applications process can request TRANSFER services. However, the main expected users of the system will be the Tandem supplied TRANSFER/MAIL and TRANSFER/FAX. The first is a basic electronic mail system, while the latter allows some U.S. Group I and II facsimile machines to interface to the TRANSFER system.

Facsimile support. The facsimile machine interfaces to the Tandem hardware via a Motorola 68K-based controller (model 6340), which in turn interfaces to the dual-ported 6303 or 6304 asynchronous communications controller. The

EXHIBIT III-29

TRANSFER APPLICATION

EXAMPLE APPLICATION: SALES ORDER TRANSACTION

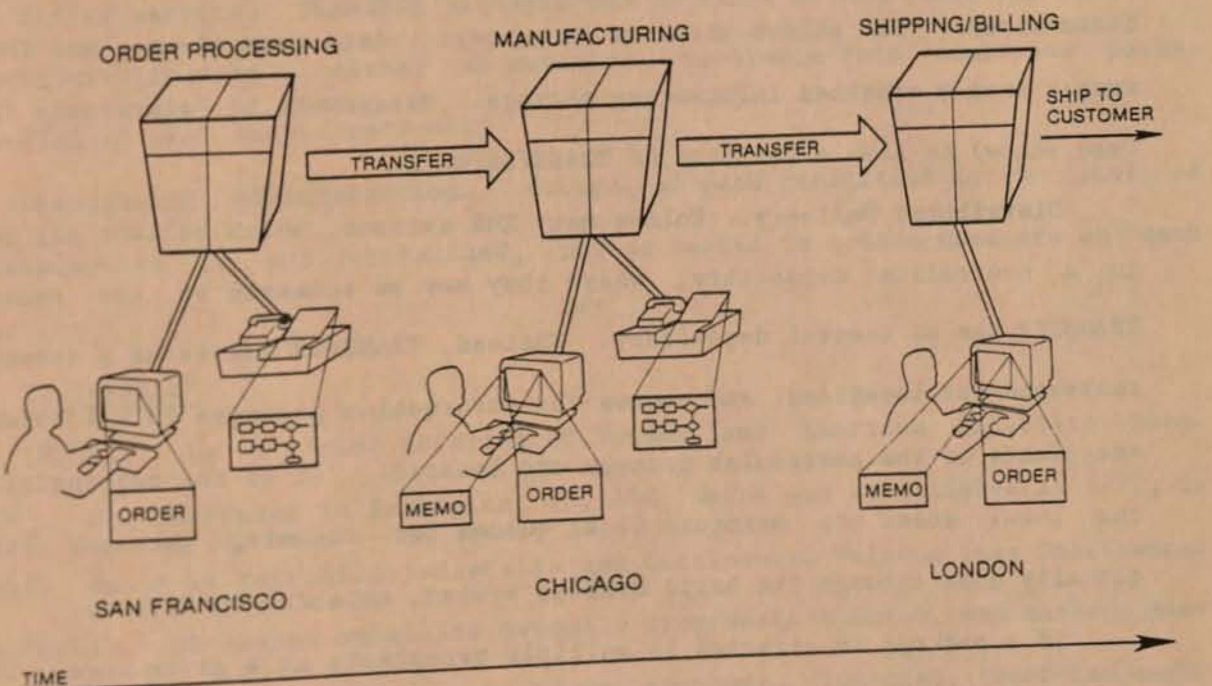
A typical sales order involves a series of sequential steps from the time the order is placed until the time the product is shipped to the customer. Even though the sequence of order processing, manufacturing, shipping and billing of one customer order is a single business transaction, it is typically treated as a series of separately automated functions. With TRANSFER these functions, which span time and geography and involve multiple types of media, appear to the user as one logical business transaction.

The sales order may involve formatted order details, a facsimile image, and a cover memo giving special instructions. TRANSFER allows the different data formats to be combined into one package and will deliver the package sequentially, according to the user-written application, to order processing, manufacturing, shipping and accounting.

Throughout the sequence, no paperwork has to be generated. All the information pertaining to the order is contained within the system and transmitted over the same integrated network.

It doesn't matter if the sequence spans days, weeks or months; TRANSFER will keep track of the package for the duration. As TRANSFER delivers the package from one stage to the next, from one location to the next, it invokes processes and/or alerts users that action is required. TRANSFER stores the package and assures delivery until the next person or process is ready to take action.

Instead of playing telephone tag for approvals, sending separate documents and having to wait for processes to be available, the order is input once, and TRANSFER transports it throughout the duration of the integrated business transaction.



Source: Tandem

6340 controller converts the analog tones produced by the fax machine (for transmission over the telephone network) into digital data, so it can be handled by the Tandem network in the same fashion as text messages. The controller also performs the inverse conversion, and can also convert ASCII-coded text to the signals necessary to drive the fax, thus obtaining a hard copy. Data compression (blank elimination) and restoration are also performed by the controller. In addition, the controller generates the signals to drive a voice synthesizer to provide voice operating instructions to the user; the user responds by touching keys on the telephone's Touch Tone® keypad.

TRANSFER/FAX, in concert with TRANSFER, supports store-and-forward operation, a facility now available only from specialized fax networks (e.g., ITT's FaxPak, Graphic Scanning's Graphnet) or from Tymnet (On Tyme II service).

Electronic mail. TRANSFER/MAIL is a user-friendly electronic mail composition and delivery system, working with the 6520 and 6530 terminals. It is implemented as a series of Screen Cobol routines under Pathway (see earlier discussion). It allows users to merge text, data base items, and facsimile images into a combined information package. Management of "electronic folders" (see below) is also a function of TRANSFER/MAIL.

Distributed Delivery. Unlike many EMS systems, which collect all messages in a centralized depository, where they may be accessed by the recepients, TRANSFER has no central depository. Instead, TRANSFER maintains a directory of correspondent locations, and routes the information packages to all nodes where recepients of the particular package are located. It is the responsibility of the local nodes to maintain local queues for incoming packages (this is actually done through the basic message system, extended by Expand).

If a package is directed to multiple recepients at a given node, only one copy is transmitted to, and stored at, that node.

Multipart Packages. Any kind of digitally-encoded data may be entered into the information packet, which is treated as an entity. Packages may be short (say 1 page of text) or long (say 100 pages), and may also include digitized facsimile images.

Time-staged delivery. Correspondents can specify when the information package is to arrive at the destination nodes. Among the options available are immediate delivery, delivery within a specified window, and "no earlier than" or "no later than" a specific date and time-of-day. However, as noted above, packages are actually distributed immediately; local nodes control later delivery to the local recepients.

Assured delivery. TRANSFER keeps track of an information package until it is received by the intended recepient(s). If the pacakge cannot be delivered, or is not accessed within the specified limits, it is returned to the originator for further action, which may be to let the package expire, or to resubmit it with a new expiration date.

Filing service. TRANSFER packages may be filed at the receiving nodes in "electronic folders", either as entities, or broken into component parts, according to user specifications.

Distributed administration. Control of such facilities as the list of correspondents is not centralized, but is vested in system managers at each node.

3. INFOSAT™

INFOSAT™ is a joint offering of Tandem and American Satellite Corp. (ASC®). Headquartered in Rockville, MD, ASC, which was established in 1972, is jointly owned by Fairchild Industries and Continental Telecom (nee Continental Telephone). It leases satellite capacity from Western Union, and markets end-to-end satellite data services, based on low-power, low-cost, roof-top earth stations, manufactured by Vitalink of Mt. View, CA.

The ASC service differs from those offered by Satellite Business Systems, Harris Corp., or M/A-Com in two respects. First, it offers a relatively low cost ($6K/mo.) service by using a low-cost, low-speed (dual 56Kbps) earth station, of which many can be multiplexed onto the a single, wide-bandwidth satellite transponder. Earth stations offered by SBS and others are typically very large, very expensive ($100K/mo), and remotely-located, hence requiring an expensive land-line to connect to the customer's site. These earth stations generally operate at the full 6.3 Mbps capacity of the transponder (though SBS is planning a multiplexed service). Second, ASC offers standard equipment which allows the user to further multiplex each earth station among a multitude of diverse, low-speed users, such as terminals, fax machines, teletypes, and voice (telephone). The others suppliers typically leave these multiplexing tasks to the user.

INFOSAT will use a new Vitalink earth station, which uses a 5-meter (15 ft) Cassegranian dish, which is small enough and light enough to sit on a roof-top. Two independent 56Kbps channels are maintained by two sets of solid-state, low power (5-10W) transmitting amplifiers, low-noise receiving amplifiers, and associated electronics. These channels can be used concurrently for more bandwidth, or, should one link fail, the other can be used to carry all traffic (much like the Tandem system). FCC approval for this earth station is expected by year-end 1982.

Tandem will provide a controller to interface the earth station to the Tandem hardware, and a software driver to interface to Expand and TRANSFER. Tandem will also provide RF modems, to convert between digital signals and a modulated carrier, indicating that Tandem does not plan to use ASC's multiplexing hardware (which performs this function). Tandem will also be responsible for maintenance of the entire system.

L. COMING ATTRACTIONS

In September, 1982, Tandem is expected to announce software products that will allow its computers to particpate in IBM's SNA networks.

Another development expected soon is a fiber-optics based local area network, which will be able to link up to 14 Tandem nodes over a fiber-optic cable (1 kilometer maximum) at a signaling rate of 32 Mbps (4 Mbyte/sec).

M. ASSESSMENT

Tandem's phenomenal success so far has been due to a number of factors:

- o Early success in obtaining venture capital.
- o Foresight in identifying OLTP as a fast-growing market.
- o Willingness to engineer a new product to meet market demand.
- o High employee productivity and loyalty.
- o High margins due to end-user orientation.
- o High customer loyalty.
- o Management flexibility and responsiveness to changing markets and technologies.

Venture capital. There is no doubt that Jim Treybig's association with the venture capital firm of Kleiner, Perkins was crucial in obtaining appropriate initial funding for the fledgeling company, at a time when high-technology start-ups in general, and computer start-ups in particular, had great difficulties in raising seed money. This achievement was all the more remarkable considering that at the time (1974-5), both the size of the transaction processing market, and the validity of the proposed Tandem system concepts, were far from clear.

Market foresight. Initial capital, however, cannot create a market success. To achieve that, a company must first have a product that satisfies a market demand. The foresight that Tandem's founders had in identifying the on-line transaction processing market as a growth segment was clearly a major contributing factor to the company's subsequent success. Again, it must be remembered that, at the time, mainframe-based airline reservation systems were practically the only visible OLTP applications. It was far from clear whether there was a significant number of other, smaller-scale OLTP applications. Nor was it obvious that such applications would be receptive to Tandem's fault-tolerant system ideas.

Tandem's founders made another astute observation when the company got started. They correctly perceived that the majority of OLTP applications would require no great "number crunching" capabilities, and hence could be satisfied with an architecture based on a multiplicity of relatively low-powered, minicomputer-class processors.

Product innovation. Tandem freely admits that it did not originate any major, new hardware or software concepts. Nevertheless, by melding together a number of existing technologies and concepts, Tandem created a consistent, "clean" design that promised substantially better fault-tolerance than the previous, jerry-rigged systems. Such systems used essentially-unmodified conventional hardware and software and provided pseudo-fault-tolerance at best.

Tandem's willingness to break with the past yielded not only a "clean" design, but several other important benefits as well:

- For 7 years, no one else was willing to make the substantial investment involved in such a sharp break with the past.
- Simplified manufacturing and testing, since all system sizes comprise of the same basic components.
- Cost-effectiveness, due to the use of minicomputer technology.
- "Graceful growth", i.e. the ability to add capacity to meet a growing load, without impacting the existing applications.
- The same underlying mechanisms permitted geographically-dispersed Tandem networking (Expand).

It is impossible to over-estimate the benefits that Tandem gathered by having virtually no comparable competition in the first 7 years of its existence. This allowed Tandem to establish such an overwhelming leadership position in its field that it no longer need fear being upstaged by another fault-tolerant system supplier.

"Graceful growth", or modularity, is inherent in the Tandem design (and, in fact, in most consistent FT designs). This comes about because additional capacity can be obtained by plugging in additional processors. The message system isolates the applications programs from such configuration details as the number of processors and the specific processors serving particular I/O devices. Hence, growth can be achieved with little or no impact on existing applications.

This has been of enormous importance to Tandem for at least two reasons. First, graceful growth represents a clearly superior way to accomodate expected or unexpected increase in the demand for service, particularly when compared with the alternatives. Even with vendors that offer "compatible families" -- of which, other than IBM, there were only a few in the mid-1970s -- the user still has to either purchase excess capacity initially, or go through an upgrading process (wheel in the new machine, wheel out the old), with the attendant disruption in service. When the new machine is not compatible with the old, the pain of the software conversion is excruciating. In 1970, six years after its introduction, numerous IBM System/360 installations were still running "emulation mode" to avoid such conversions.

Contrast this with the Tandem approach, where the salesman is able to bid a low-cost, minimum-configuration, two-processor system initially, and promise that capacity can be increased by, perhaps, a factor of 8-10 by just plugging in processors and I/O controllers. Many customers find this so attractive that they make the decision to buy Tandem primarily because of modularity.

This, in turn, creates the second advantage. In precious few cases was Tandem ever required to prove that its system would indeed offer higher availability and less down time than competing conventional systems. In fact, to this day, other than a theoretical reliability calculation done in 1977, no empirical data is available to prove that claim. This is partly because such data is very difficult to collect (one would have to set up, side by side, a Tandem system and some other system, in essentially identical applications, and carefully maintain up-time statistics for a number of years). Luckily, however, because of the great, obvious advantage of the "graceful growth" offered by Tandem, many "buy" decisions were made because of that factor, accepting Tandem's fault-tolerant claims on faith.

Now, with hundreds of existing installations, Tandem need no longer worry about "proving" its FT capabilities. Instead, it can -- and does -- deflect such requests by supplying the prospective customer with a reference list of existing, satisfied customers.

The significance of the graceful growth feature became clear only gradually. Another, possibly even more significant discovery was the fact that the same underlying mechanisms could equally-well support a network of geographically-dispersed Tandem nodes. A Tandem node is, in fact, a local network of processors. The addition of a small number of relatively minor software components (Expand) allows the basic message system to handle remote nodes, accessible through long-haul communications links.

Tandem itself maintains the largest Expand network to support its internal operations. Only a few Tandem customers operate significant Expand networks. Nevertheless, the fact that this capability can be demonstrated now is of crucial importance in many situations. Often the initial system involves just one node, or a few independent nodes; but a fully-distributed system is part of the long range plan. When the basic Expand networking facility is considered in conjunction with Pathway and the requestor/server structure, a powerful and flexible distributed processing system emerges. The recent TRANSFER and INFO-SAT products further build on this base.

Employee productivity. High employee productivity is certainly another important element in the company's success. Just prior to the June, 1982 quarter, sales per employee were running at about $100K, substantially above the IBM figure. Turnover, at about 7%, is perhaps one-third to one-half the average in Silicon Valley. Tandem's employee indoctrination program, stock ownership plan, and uniquely congenial working environment are all designed to promote employee loyalty and productivity. It is critically important for Tandem to maintain high productivity, not just for profitability: without it, the company's ambitious growth plans would require an impossible growth in its work force.

End user orientation. Profitability is aided by Tandem's concentration on the end-user business, allowing it to maintain high margins. Tandem sells some two-thirds of its output to end users.

Customer loyalty. Nearly half the Tandem work force is engaged in marketing and customer support activities. Quality service and support promotes customer loyalty, expressed in the high level of repeat orders, which have been running at about half of all processors shipped in a given year. This also proves that the sales strategy of "buy small now, expand painlessly later" is indeed working.

Management flexibility. Tandem's management may be a bit too informal to sustain their growth objectives ($1.1 billion by FY 1985); but their astuteness in observing market and technological trends and their readiness to make changes to accomodate such developments have been amply demonstrated. This has certainly been true at the time the company was founded. More recent examples include the introduction of TMF and Pathway, which in a sense repudiate some of the original Tandem concepts; and the introduction of TRANSFER and INFOSAT, representing a significant broadening of the company's focus.

N. PROGNOSIS

1. The Microprocessor Challenge

Tandem is now being challenged by a fast-growing list of would-be competitors. Such companies as Stratus, Synapse, Computer Consoles, Parallel Computer, and Sequoia (all discussed elsewhere in this report) are also targetting the high-integrity transaction processing market as their primary objective. Without exception, the newcomers base their fault-tolerant designs on microprocessors, especially the Motorola 68000. The Intel 432 and even 8085 are also being employed by a few new designs.

In a general sense, the maturing microprocessors and solid-state memories are creating a technological environment in which new designs, previously considered impractical due to economics, are becoming quite practical. This environment is rather similar to the one which existed when Tandem got started: then it was the maturity of minicomputer technology and architecture that made the Tandem design possible and gave it its price/performance edge.

Microprocessor technology, in particular, is creating pressures on Tandem in several specific ways:

- Microprocessors (and dense, low cost memories) are making new designs, especially self-checking ones (e.g. Stratus, Intel 432) economically feasible.
- Some new microprocessors (e.g. the 68K) are architected internally as 32 bit CPUs, a significant advantage relative to Tandem's 16-bit architecture.
- Standardized operating systems and third-party software are becoming available for the new microprocessors, allowing newcomers to short-cut the costly and time-consuming software development process.

Tandem contends that microprocessors will not give its competitors any significant cost advantage, because the cost of the CPU logic is insignificant, compared to the rest of the system. Exhibit III-30 shows the distribution of costs in a typical Tandem system, proving, according to Tandem, that CPU logic is responsible for just 4.5% of the system's cost. Actually, the figure is significantly higher, because a microprocessor replaces not just the logic, but also all of the WCS and diagnostics components, and a good deal of the channel costs. Newer MPUs with on-board MMUs will also replace the cache (actually memory management) component.

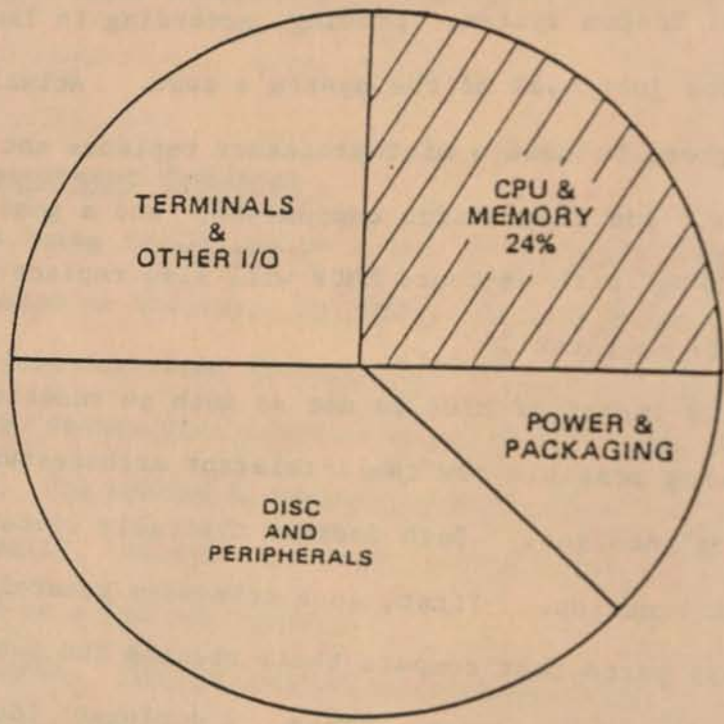
But the main impact of MPUs is not so much in reducing costs per se, but primarily in making possible new fault-tolerant architecture alternatives such as "self-checking" designs. Such designs typically contain, in effect, four "copies" of each function. First, each subsystem generally contains two identical functional parts that compare their results and generate an error signal upon discovering a disagreement. Then, a duplexed (duplicated) subsystem, which also contains identical self-checking halves, takes over.

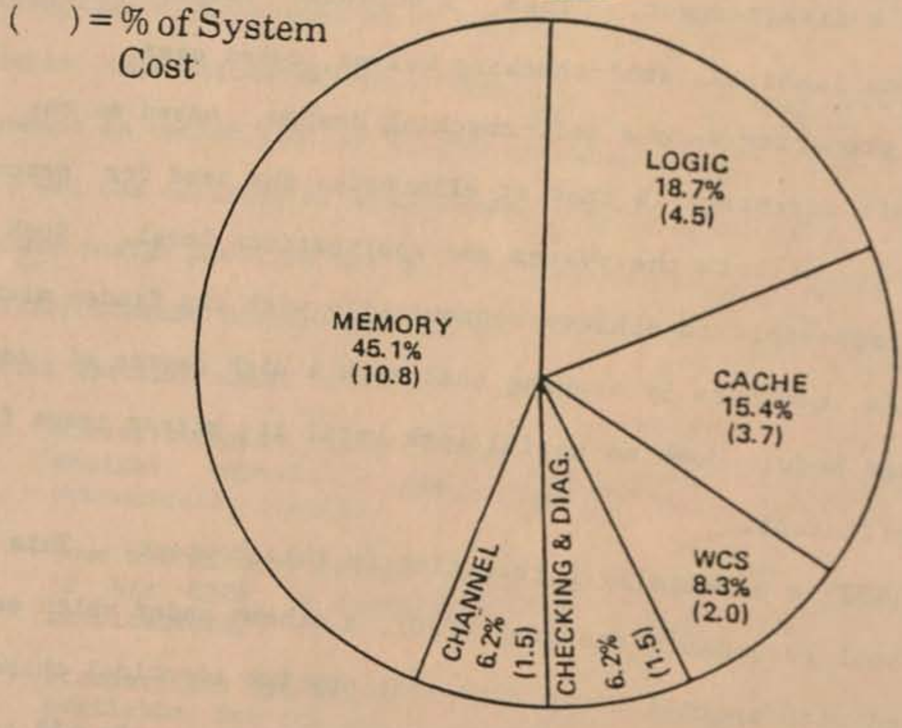
Stratus is promoting such a self-checking design, based on the Motorola 68K MPU. Its main advantage is that it eliminates the need for process-pairs and checkpointing, at both the system and applications level. Such a design would have been impossible to achieve economically with the Tandem minicomputer approach. Tandem counters by arguing that such a high degree of redundancy, where the duplexed module does no useful work until its mirror image fails, is wasteful and inefficient.

The Intel 432 is especially interesting in this context. This chip set features functional redundancy checking (FRC), a scheme under which each output pin is equipped with special logic such that any two identical chips can be connected together as a self-checking unit. Furthermore, the 432 processors are self-dispatching, as in the Synapse system, to assure configuration inde-

EXHIBIT III-30

ALLOCATION OF TANDEM SYSTEM COSTS





Source: Tandem

pendence and hence graceful growth. Finally, the object-oriented 432 architecture is more suitable for the devlopment of fault-tolerant software than the more conventional, "flat" architectures employed in current systems.

The Synapse design would have also been impossible in 1974-5. Here, a potentially large number of processors execute programs directly from a shared memory system. They can do so efficiently mainly because each contains a significant amount (16KB) of high speed cache. The cost and board space that would have been taken, using older memory technologies, would have made such a system impractical.

Tandem, too, can -- and is -- using microprocessors; for example, its facsimile controller (see earlier discussion of TRANSFER) is 68K-based, and it is quite likely that a follow on to the 6530 terminal will also use that MPU. And, of course, Tandem can avail itself of the advances in bit-slice, gate array and custom VLSI technology, to obtain improved price/performance levels. But in the CPU area, Tandem is essentially shackled to its 1974-vintage, 16-bit architecture, because of the huge investment in proprietary software, both by the company and by its customers.

This gives the newcomers a decided advantage, because such MPUs as the 68K are architected internally as 32-bit CPUs, and offer a large addressing space. The 68K, for example, uses a 24-bit address and can linearly address 16 MB, just as the IBM 370 and 4300 mainframes do.

Tandem, and some of its customers, have been chafing against the addressing limitations inherent in the Tandem 16-bit architecture for some time now. The Guardian operating system, for example, simply ran out of address space. How to solve the address space problem and break out of the 16-bit mold is a classical dilemma which Tandem, like other mini-makers before it, had to face. Unlike a number of mini-makers who "bit the bullet" and developed new 32-bit architectures, Tandem opted for a less-painful, but less fundamental, solution.

The added segments and extended addressing features of the NonStop II system, introduced in April, 1981, are short-term, "finger-in-the-dike" expedients, which suffer in comparison with the "clean", linear, 16MB space of such MPUs as the 68K.

Software is generally regarded as a major Tandem advantage. Both Tandem and its customers have developed an array of software products over the past seven years or so. Tandem is counting on its software lead to keep the competition at bay. Newcomers, according to the Tandem rationale, will have to offer comparable software in order to compete. This will be difficult, costly, and time-consuming; and meanwhile, Tandem will not be standing still, but will add even more sophisticated software products. In this way, the company hopes to remain a "moving target" to its would-be competitors.

However, some of the newcomers are refusing the play the game by the Tandem rules. They plan to combine microprocessor-based hardware with the UNIX™ operating system. UNIX is already available for the Motorola 68K and other 16/32 bit MPUs. The idea is to make the necessary internal modifications to support the fault-tolerant hardware, but to leave the file system, shell, and other user interfaces intact. This would appeal to users already familiar with UNIX. Even more important, this would permit the use of third-party developed applications packages, which are expected to abound as the popularity of UNIX increases. In this way, these newcomers hope to short-circuit the software development problem.

2. Local Area Networks

Tandem is facing another technological challenge, from a rather unexpected quarter. Local area networks (LANs) are schemes for sharing a single communications channel (usually a coaxial cable) among multiple, intelligent workstations. Ethernet is perhaps the best-known of the "baseband" LAN class, although many other alternative systems are available in this class, as well as in the more exotic "broadband" class.

Althogh LAN technology is still in its early stages, LANs are significant because it is fairly certain that a LAN of some kind will be a key element in the paperless, electronic "office of the future". In the context of fault-tolerant systems, however, LANs, combined with low-cost, microprocessor based workstations, are calling into question some of the basic premises of the design approach taken by Tandem (and other FT suppliers).

The DOSC system (discussed elsewhere in this report) is an example of a LAN-based system which achieves very low cost by providing fault-tolerant features selectively. In this system, the very low-cost, 8085-based work-stations are considered "expendable" and offer no special fault-tolerance. These workstations access a central data base over a duplicated channel. The "file server" computer which controls the data base features full redundancy, and full disk mirroring is employed.

Tandem already recognizes that its initial preoccupation with providing extensive fault-tolerant features to protect against failures in individual processors, rather than the data base, has been misplaced. With the introduction of TMF, the company in effect acknowledged that data base consistency and integrity are the key issues, and that these attributes cannot be guaranteed by making the individual processes fault-tolerant.

Tandem evidently means to pursue this line of thought further by providing in the future workstations with far more power. Its decision to design and manufacture its own terminals makes sense only in this context. Up to now, Tandem carefully avoided investing resources in low-volume peripheral manufacturing. The volume of terminals shipped by Tandem is far too low to justify a "make" decision. But if future processing power is to be invested more and more in the terminals, rather than in the present processors, then in-house control over the design of the terminal is desirable.

3. Tandem Refocuses to Meet Challenges

The recent introduction of the TRANSFER and INFOSAT products provides a valuable clue to the strategic thinking upon which Tandem's future direction is likely to be based.

These new facilities are, of course, two more mileposts along the "moving target" route, by which Tandem hopes to keep, and possibly widen, the gap between itself and any of the new fault-tolerant system suppliers.

Beyond that, TRANSFER and INFOSAT represent a significant broadening of the company's focus, as Tandem itself puts it.

The strategy behind these -- and expected follow-on products -- is two fold: first, to capitalize and build on existing Tandem capabilities, especially the networking facility, Expand, in order to address new markets for corporate data communications and information networks. Despite slower-than-expected growth in these fields, especially in data communications, there is little doubt, that over the longer range, these will be the prime growth markets, probably well into the 21st century. The satellite connection will be especially significant in the future.

Second, Tandem fully recognizes that it is not well equipped to compete in the low-price combat zone, in which some of the microprocessor based designs from the newcomers will have substantial price advantage. It reckons that a typical system, priced at $200K, will cost it some $60K in non-chargeable support services over the life of the system, so it cannot -- and does not wish to -- fight by reducing prices much.

Tandem's forte has always been competing with superminis and with mainframes. Against the first, Tandem competes by offering fault-tolerance at roughly the same price. Against the mainframes, Tandem wins by convincing the prospect to buy relatively low cost, minimum configuration systems initially, and expand later by plugging in more components.

With TRANSFER and INFOSAT, Tandem is moving farther away from the low-price arena and deeper into the mainframe turf, where the company hopes to gain "account control" through the corporate communications network.

4. The Management Challenge

Despite the growing competitive pressures and technological challenges, Tandem's leadership position is so solidly entrenched that these are not likely to be a major concern. By far the most serious challenge facing Tandem is not competition but the management of growth.

Given the spectacular past performance of company, it is tempting to conclude that its growth has been due in large measure to capable and stable management. It is certainly true that, despite some high-level defections (in marketing, for example), the key management posts are held by people who have been with the company for a long time (e.g., Treybig, the founder, and Marshall, who joined early).

It is also true that the company is a major user of its own computers, some 100 of which are involved in supporting company operations and providing management controls.

Tandem recognizes the significance of the management challenge. The Tandem Management Institute, under co-founder Jim Katzman, was established to provide training in management skills to Tandem employees going up the ladder of low and middle management.

These are all positive signs. But there are some negatives, too. The present management structure tends to be somewhat amorpohous and informal. Some twenty vice-presidents -- a large number by any measure -- report to the "office of the president", consisting of Treybig and Marshall. Informality is perhaps best exemplified by Treybig's "sign-up-for-yourself" appointment book.

There seems to be a substantial degree of duplication and lack of precise definition of responsibilities, especially in marketing, where two home-office vice presidents are supplemented by four regional vice presidents. In manufacturing, materials management is the responsibility of one vice president, while assembly and test are under another. Other ambiguities exist in software development and in corporate services.

There are signs that point to possible recent management slip ups, which may be due to the informal nature of Tandem's present management. For example, the decision to pursue legal action against Stratus Computers seems to have been taken without full consideration of its obvious impact, which is to underline the credibility of Stratus as a Tandem competitor. Tandem argues that it had no choice, since it had to protect its trade mark NonStop. Still, one can legitimately ask why Tandem did not try to settle such a relatively minor matter before launching the legal action. Out-of-court contact between the two companies after the suit was, in fact, responsible for several changes in the Stratus advertisements that Tandem found objectionable.

Also somewhat puzzling was the decision to bring terminal manufacturing in house. Tandem's terminal volume is far too small to justify such a move, particularly when viewed in light of the company's long standing policy to farm out as much manufacturing as possible, and to buy rather than make all peripherals, in order to conserve resources for more important corporate goals, such as customer support. Again, it is hard to avoid the impression that the decision was taken without sufficient management analysis.

The moderation in growth which the company exhibited over the three quarters ended in June, 1982, is also a source of concern. Most disturbing is the drop in employee productivity, especially in the June quarter, which resulted in a hiring freeze. Another problem is the earnings drop in the June quarter, compared to the preceding quarter.

Taken together, these indications could be used to argue that Tandem's past success has been primarily driven by the size of the OLTP market, not by the skills of its management.

Whether or not such an evaluation has merit will become clear in the near future, as Tandem continues to cope with highly adverse world-wide economic conditions. One conclusion, however, seems beyond argument. It is that Tandem's future lies in the way in which it responds to its greatest challenge: the management of growth.

CHAPTER IV

STRATUS

A. BACKGROUND AND FUNDING

Stratus Computer, Inc. was founded in May, 1980 by William E. Foster, Robert A. Freiburghouse, and Gardner C. Hendrie, all of whom are still in key management positions with the company. Initially based in Cambridge, MA, Stratus moved in June, 1980 to its present leased, 16,000 sq. ft. plant in Natick, MA. An additional 10,000 sq. ft. will be occupied in June, 1982, to support expanded manufacturing. In addition, Stratus leases sales and service office space in 8 U.S. cities.

Employment in April, 1982 stood at about 90, of which 35 were in development, 41 in marketing and sales, 10 in operations and 4 in G&A. The company's name carries no special significance.

Initial funding of about $1.7 million was furnished by three venture capital firms: Hellman, Gal Capital Corp.; Institutional Venture Partners; and General Electric's Business Development Services, Inc. (BDSI).

A second round, completed in January, 1981, brought an additional $5 million. In addition to the three original investors, participants in this round also included the Charles River Partnership III; Palmer Corp.; Olivetti Corp.; and Merril, Pickard (B of A).

In mid-April, 1982, a third round of financing yielded approximately $8 million in additional funds via a private placement of preferred stock. Participants in this funding included, in addition to six of the 7 original investors, Hambrecht & Quist, Oak Management Partners, and Stratus employees. The company believes that it is now adequately funded to meet its projected needs through calendar 1983.

A few weeks earlier, Stratus announced that it had granted Olivetti exclusive distribution rights for the Stratus/32 product line in Italy, France, Spain, South Africa and South America. The multi-year agreement, which could eventually be worth $40 million, involving as many as 200 systems, also gives the giant Italian office equipment and electronics concern the right to incorporate the Stratus/32 in its own products on an OEM basis. According to Stratus, incidentally, Olivetti's equity position in Stratus is not significant.

The company announced its Stratus/32 product in November, 1981. The first delivery occured in February, 1982. By August, 1982, 12 systems are said to have been shipped to Olivetti in Ivrea, Italy and to U.S. customers, including Merril Lynch; Thom McAnn, a nationwide chain of shoe stores; and West Lynn Creamery (a local business).

In mid-April, the company inked a nationwide third-party maintenance agreement with INDESERV. Based in Littleton, MA, INDESERV is an association of independent service organizations, with more than 170 offices in the U.S., Canada, and Puerto Rico. At one time, INDESERV had a contract to service Tandy/Radio Shack computers in some areas, an arrangement which was since dropped by Tandy, apparently due to dissatisfaction with INDESERV. INDESERV is currently contracted to support the WICAT line, which, like Stratus', is based on the Motorola 68000 MPU.

The company says that the purpose of the INDESERV agreement is to offer service in areas not covered by Stratus' own direct service organization, which is planned for all major U.S. cities. So far, INDESERV's responsibility is limited to Memphis, TN.

In February, 1982, the company received a compliment of sorts from Tandem, the leader (and, up to now, the only participant) in the high-integrity transaction processing market. Tandem filed a law suit against Startus, triggered by full page ads which Stratus ran in Computerworld during February, 1982.

Tandem charged that the ads, which compared the Tandem and Stratus offerings, were misleading and inaccurate in their treatment of Tandem, and misused the term NonStop, a Tandem trademark.

Tandem asked the court for an injunction to stop the publication of those ads. Stratus has since revised the offending ads to eliminate all mention of Tandem and of "non-stop" systems. The company says it did so in order to settle the suit, although it believes the ads were not misleading, and it plans to continue its agressive advertising. The incident is significant, because it clearly indicates that Tandem, a $300 million firm virtually dominating its market, considers upstart Stratus to be a serious threat.

B. MANAGEMENT

The Stratus management team is led by founder and president William E. Foster, who was previously vice president of software development at Data General. Earlier, he was computer systems engineering manager with Hewlett Packard, where in 1973 he assumed responsibility for managing the hardware and software development of the HP 3000 family, which eventually attained notable success in the marketplace (after rather severe initial problems).

Robert A. Freiburghouse is vice president for software at Stratus. He was previously founder and president of Translation Systems, Inc., a software company that implemented a number of PL/1 subset and Fortran '77 compilers on various minicomputers, including DEC, DG, Prime, Wang, and Honeywell. Earlier, he was manager of Multics language systems at Honeywell.

Gardner C. Hendrie is Stratus' vice president for hardware. He was formerly engineering director at Data General. In 1965, he was responsible for the development of one of the earliest minicomputers, the DDP-116 at 3C, which was later acquired by Honeywell.

John P. Morgridge, vice president of marketing, joined Stratus in October,

1980. Previously, he was with Honeywell Information Systems for 20 years, serving last as VP of marketing and planning.

John H. Curtis, vice president of finance, joined Stratus in January, 1981. Previously, he was controller and director of materials at Applicon. Earlier, he was with Arthur Andersen.

James E.D. Austin is Stratus' VP of manufacturing. He was formerly the sixth employee of Data General, where he later became manager of mechanical design services.

Key development personnel includes Steven H. Webber, operating systems project manager (formerly with HIS); and Robert Reid, a DEC System 20 CPU designer.

C. COMPANY ORIENTATION AND MARKET CONCEPT

The company freely admits that it is going after the Tandem market, as the contested ads illustrate. The key difference in the Stratus approach is that the fault-tolerant mechanisms are implemented primarily in hardware, unlike the Tandem system in which these mechanisms are to a large extent the responsibility of the software. This approach eliminates the need for the process-pair concept and checkpointing procedure, which is expensive in terms of computer resources.

Stratus achieves its fail-soft objectives primarily through a dual-redundant, self-checking hardware design, dubbed Continuous Processing, in which all critical subsystems within a "processing module" can be replicated ("duplexed"). Duplexed system run in tight synchronism with each other, performing identical tasks and producing identical outputs. Each such subsystem is self-checking; this is usually achieved by having duplicate circuits which are given identical inputs, and whose outputs are continuously compared. If the outputs do not agree at some point, the subsystem declares itself at fault. At that time, the duplexed subsystem simply continues to carry load, while the defective unit is removed for repair.

A "processing module" contains all the subsystems of a conventional computer system: processor(s), memory, and I/O controllers; each such subsystem may be duplexed within the module. Up to 32 such modules may be interconnected over a ring-type LAN, dubbed StrataLINK, (which may be optionally duplexed).

The key factor which makes the Stratus self-checking solution possible from the price/performance standpoint is the emergence of the new generation of 16-bit microprocessors and other advanced LSI parts. These chips, which were not available when Tandem designed its product in the 1974-76 time frame, now make it possible to build self-checking designs at acceptable costs and performance levels. At the same time, costs of software and of personnel are skyrocketting, Stratus points out. This makes the software-based fault-tolerant solutions (a euphemism for Tandem) less attractive.

Prices of typical systems range from about $130K to upwards of $1 million. Stratus plans to address end-users directly, via its own sales force. Sales and service offices have already been established in Boston, New York, Chicago, Dallas, Houston, Tampa (FL), Washington D.C. and Los Angeles.

Stratus plans to offer an extensive range of basic software tools, including the Virtual Operating System (VOS), Cobol, Basic, PL/1, Fortran '77, Pascal, and communications support (IBM RJE and 3270 protocols). Stratus encourages vertical applications software developed by independent, third party software suppliers. The applications software for Thom McAnn and West Lynn Creamery was developed by such third parties.

Stratus company visualizes a cooperative selling arrangement under which end-users would be sold jointly by a team composed of Stratus people and the third party software developers. Stratus would undertake to service the hardware and basic software, leaving the applications software maintenance to the third parties. The software third parties would be recompensed on a royalty basis, i.e. receive a fee for each Stratus system sold which uses the particular applications software.

D. PRODUCT CONCEPT

As indicated earlier, the key concepts upon which the Stratus Continuous Processing system is built are:

- o Self-checking logic on each PC board, generally using dual circuits whose inputs are identical and outputs are continuously compared. This self-checking logic is responsible for error detection.
- o Duplexed subsystems, executing in tight lockstep; should one subsystem become faulty, its duplexed counterpart simply continues to carry load while the faulty unit is being repaired.

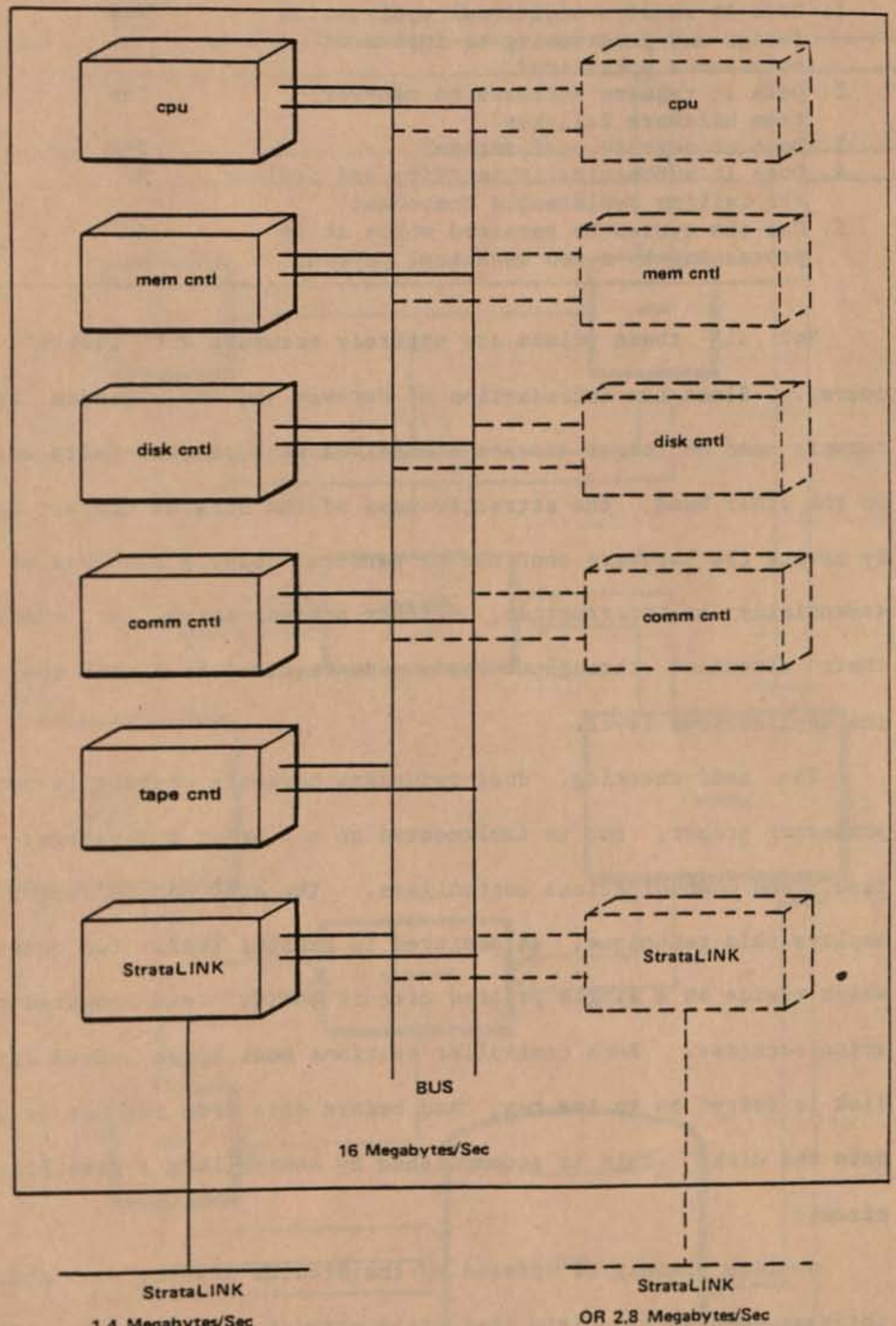
This scheme is implemented within a framework of "processing modules" (PMs), each of which contains at least one copy of each subsystem found in a typical computer system. Specifically, a processing module contains a processor (actually two processors, as described below), a memory system with its control, disk controller, communications controller, tape controller, and a "StrataLINK" controller, responsible for interfacing to the coaxial cable LAN scheme which interconnects the modules.

Optionally, to achieve fault-tolerant operation, each of these subsystems may be duplexed within a processing module. (Stratus requires that the first PM in the system must have duplexed subsystems). Exhibit IV-1 depicts a processing module in which all subsystems, save the tape controller and its drive(s), are duplexed.

The advantages attained by this design, as compared with "software based" fault-tolerant systems (i.e., Tandem), are stated by Stratus to be as follows:

EXHIBIT IV-1

STRATUS DUPLEXED PROCESSING MODULE



Source: Stratus

	Other Failsafe Systems	Stratus Solution
1. Does it require additional application design and programming to implement continuous operation?	Yes	No
2. Does it require software to recover from hardware failures?	Yes	No
3. Does it degrade performance?	Yes	No
4. Does it automatically identify and isolate the failing replaceable component?	No	Yes
5. Can the system be repaired while it is processing by a non technical person?	No	Yes

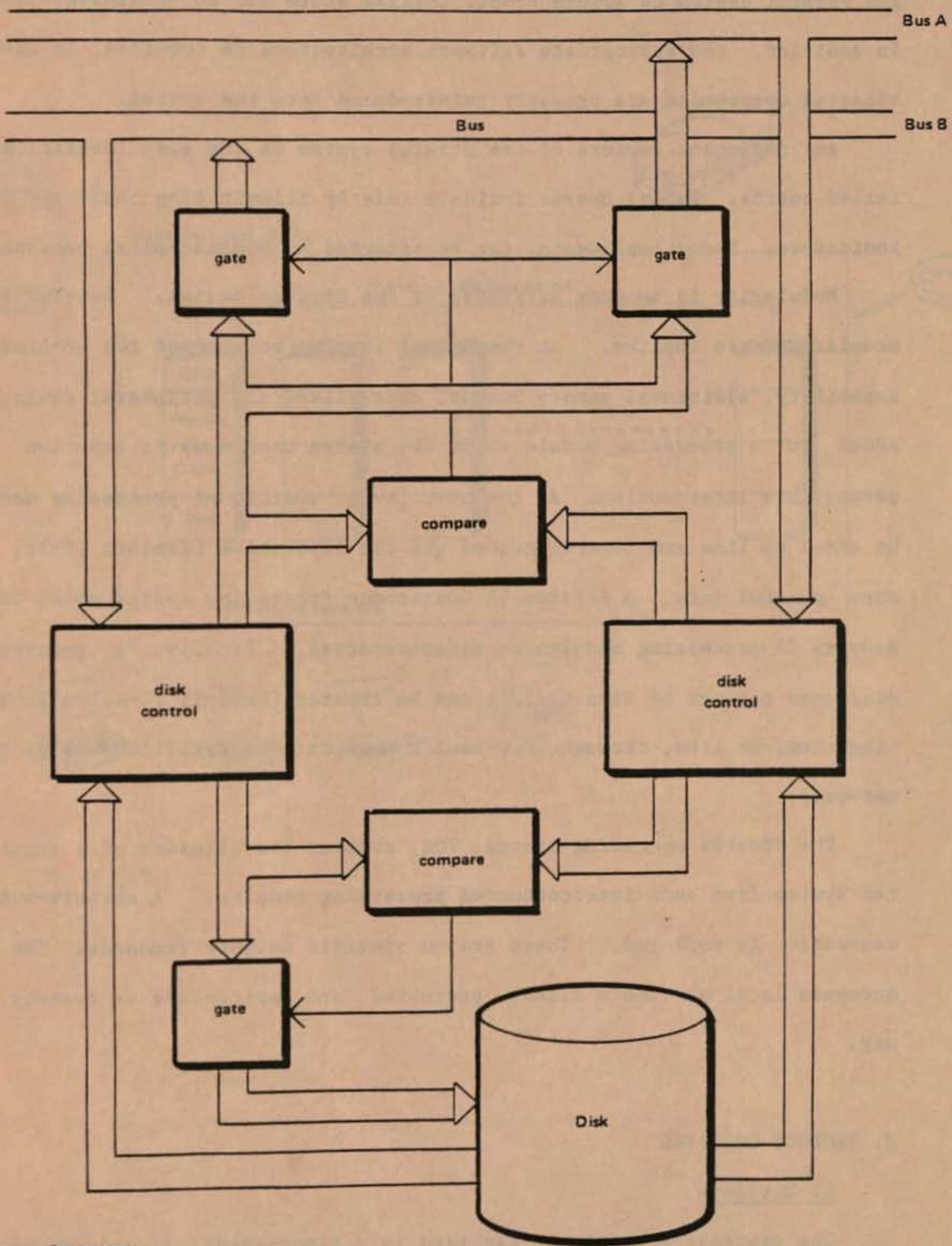
Not all these points are entirely accurate with respect to Tandem, of course. Since the introduction of Pathway and TMF, Tandem application programmers need no longer concern themselves with process-pairs and checkpointing. On the other hand, the attractiveness of the Stratus concept cannot be denied. By having the hardware continue to perform, despite the loss of a module, with essentially no interruption, neither process-pairs nor checkpointing, with their attendant throughput loss, are required at either the system level or the applications level.

The self-checking, dual-redundant hardware concept is not limited to the processor proper, but is implemented on all major subsystems, including disk, tape, and communications controllers. The disk controller, for example, also employs this technique, as depicted in Exhibit IV-2. Two controller circuits, which reside on a single printed circuit board, are compared on both read and write accesses. Both controller sections must agree before data read from the disk is passed on to the bus, and before data from the bus is actually written onto the disk. This is accomplished by controlling a gate from the comparison circuit.

On-line repair is offered by the Stratus system, of course; no fault-tolerant system can claim that title without this feature. This implies that failed components can be taken off-line for repair, and then returned to ser-

EXHIBIT IV-2

SELF CHECKING DISK CONTROLLER



Source: Stratus

vice while the rest of the system continues to operate essentially without interruption. This requires independently switched power to each subsystem, and careful design to assure proper initial state and to eliminate transients. In addition, the appropriate software architecture is required, to assure that repaired components are properly reintroduced into the system.

An important feature of the Stratus system is the easy identification of failed boards. Failed boards indicate this by illuminating their red "trouble" indicators. Board replacement can be effected by non-technical personnel.

Modularity is another attribute of the Stratus design. Several levels of modularity are implied. At the lowest level, because of the on-line repair capability, additional memory boards, controllers and peripheral devices can be added to a processing module while the system continues to function with no perceptible interruption. At the next level, additional processing modules may be added on line and interconnected via the StrataLINK (Exhibit IV-3). In its more general form, a Stratus/32 Continuous Processing system could contain as many as 32 processing modules so interconnected. Finally, a geographically-dispersed network of Stratus/32's can be created (Exhibit IV-4) by interconnecting them, on line, through long-haul communications facilities (e.g. telephone network).

The Stratus operating system, VOS, creates the illusion of a single computer system from such interconnected processing modules. A network-wide naming convention is employed. There are no specific network commands. The user can accesses local or remote files, processes, and peripherals in exactly the same way.

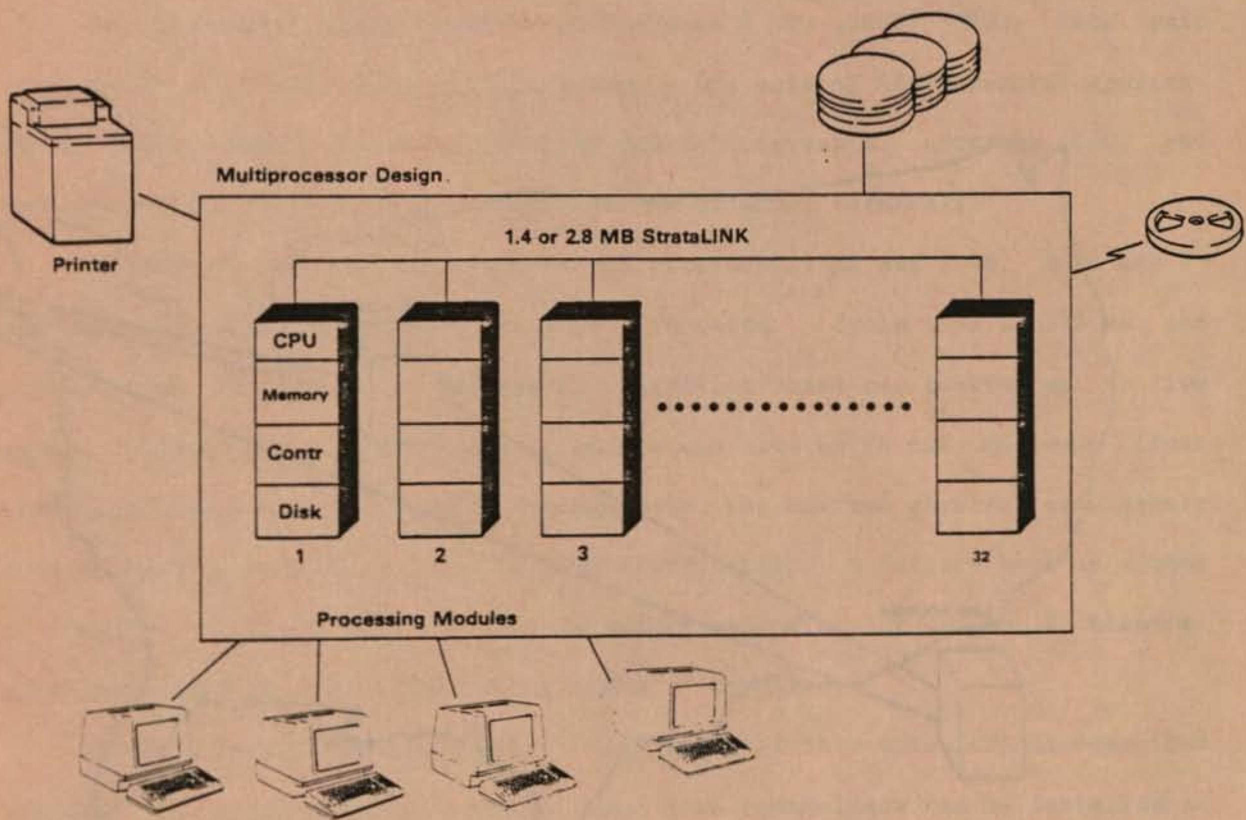
E. PRODUCT OVERVIEW

1. Hardware

The processing module is packaged in a floor-standing cabinet which houses

EXHIBIT IV-3

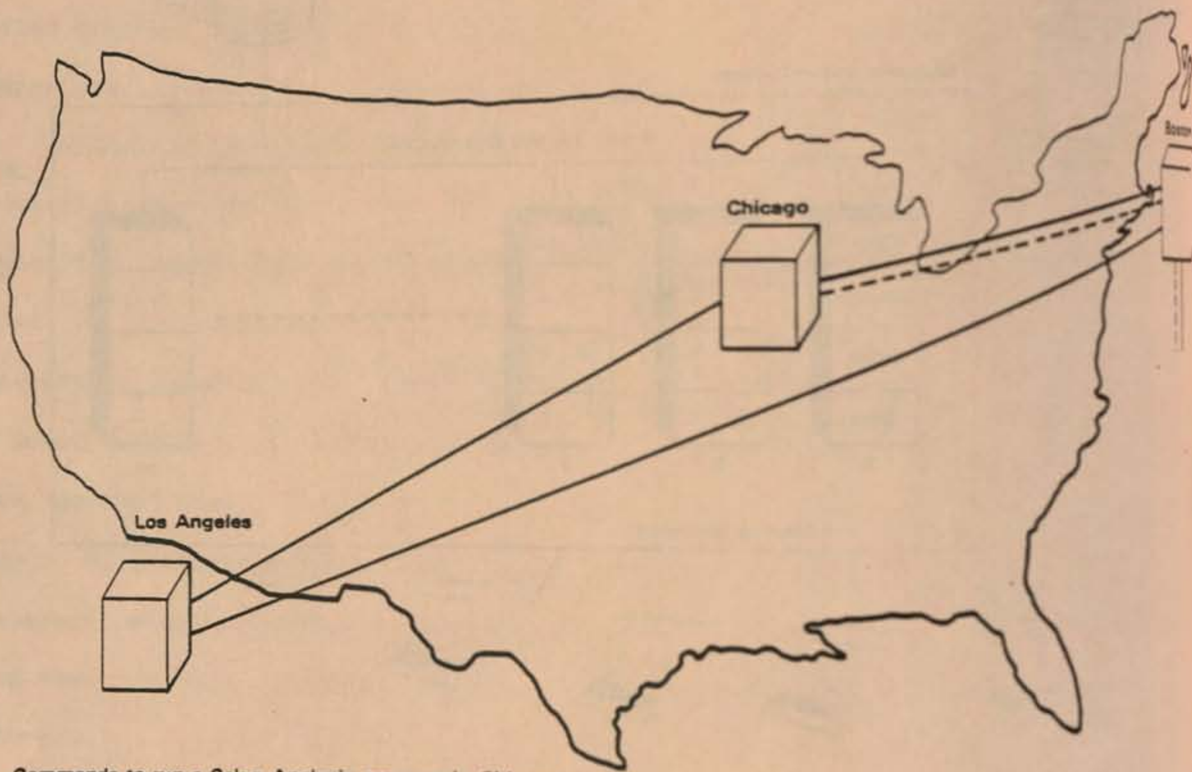
STRATUS/32 NODE WITH STRATALINK™



Source: Stratus

EXHIBIT IV-4

STRATUS NETWORK



Commands to run a Sales_Analysis program in Chicago
Login sid. sales on Chicago
Sales_analysis
Logout

Source: Stratus

a 20-slot card cage (Exhibit IV-5) with two (i.e. duplexed) power supplies and two (i.e. duplexed) backplane buses, the latter used for internal communications between the module's subsystems at the maximum rate of 16 MB/sec.

Each of the subsystems described below occupies one 16x20" PC board.

The processor board carries two pairs of 8 MHz 68000 MPUs. Each pair arranged in a self-checking configuration. One pair of 68Ks executes applications tasks, while the other 68K pair fields interrupts, controls I/O, and performs screen formatting functions for the attached terminals.

The memory board is available in two versions, 1 MB and 2 MB. Both are 4-way interleaved and implemented with 64 Kbit chips. Cycle time is 375 ns. and access time is 125 ns. The memory controller board can control up to two memory boards, and the processing module can have up to two duplexed (four individual) memory controllers. Consequently, the maximum physical main memory in a processing module is duplexed 8 MB (16MB total). A battery back-up system is capable of supporting the maximum memory expansion for up to 8 minutes. Additional external batteries can be added if required.

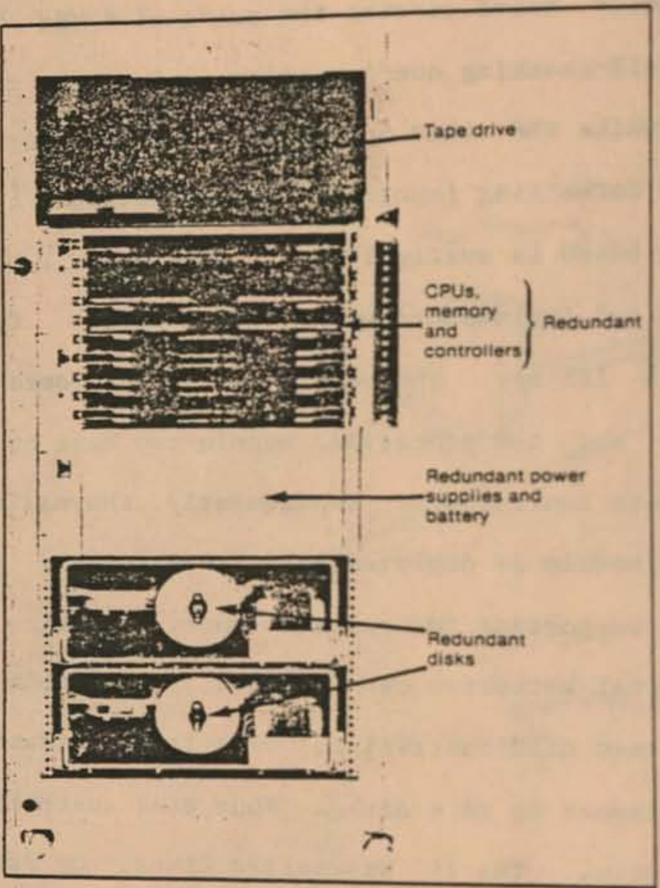
The Z80A-based disk controller, with its duplicate circuitry as described earlier, can support up to 4 disks. Four disk controllers can be installed in a processing module. The 14" Winchester disks, by Priam, are offered in formatted capacities of 30, 60, and 142 MB.

The tape controller, also Z80A based, controls one Cipher streaming drive (25/100 ips). Its main function is to back up the non-removable disks and to provide a vehicle for software distribution.

The Z80A-based communications controller board can control up to 16 adapter boards. These adapters plug into a communications panel in the rear of the cabinet (i.e. they do not take card cage slots); the panel also houses the RS232C connectors (which are too bulky and could not be easily accessed if they

EXHIBIT IV-5

STRATUS/32 PHYSICAL PACKAGING



Source: Stratus

were placed in the card cage).

A synchronous adapter board has one port (one communications line), while the asynchronous adapter has two ports. A special adapter board carries a calendar clock and one asynchronous interface; the latter is required for remote diagnostics, for which purpose a 1200 baud modem is included. Only one such adapter is required within a Stratus/32 system; i.e., all processing modules can use it. Therefore the initial communications controller can support up to 15 synchronous or 30 asynchronous terminals, while subsequent controllers can go up to 16 and 32, respectively.

Communications between processing modules within a single Stratus/32 complex is carried over a coaxial cable based, ring type local area network dubbed StrataLINK. The StrataLINK controller, which occupies one slot, can signal at the rate of 1.4 MB/sec (11.2 Mbps).

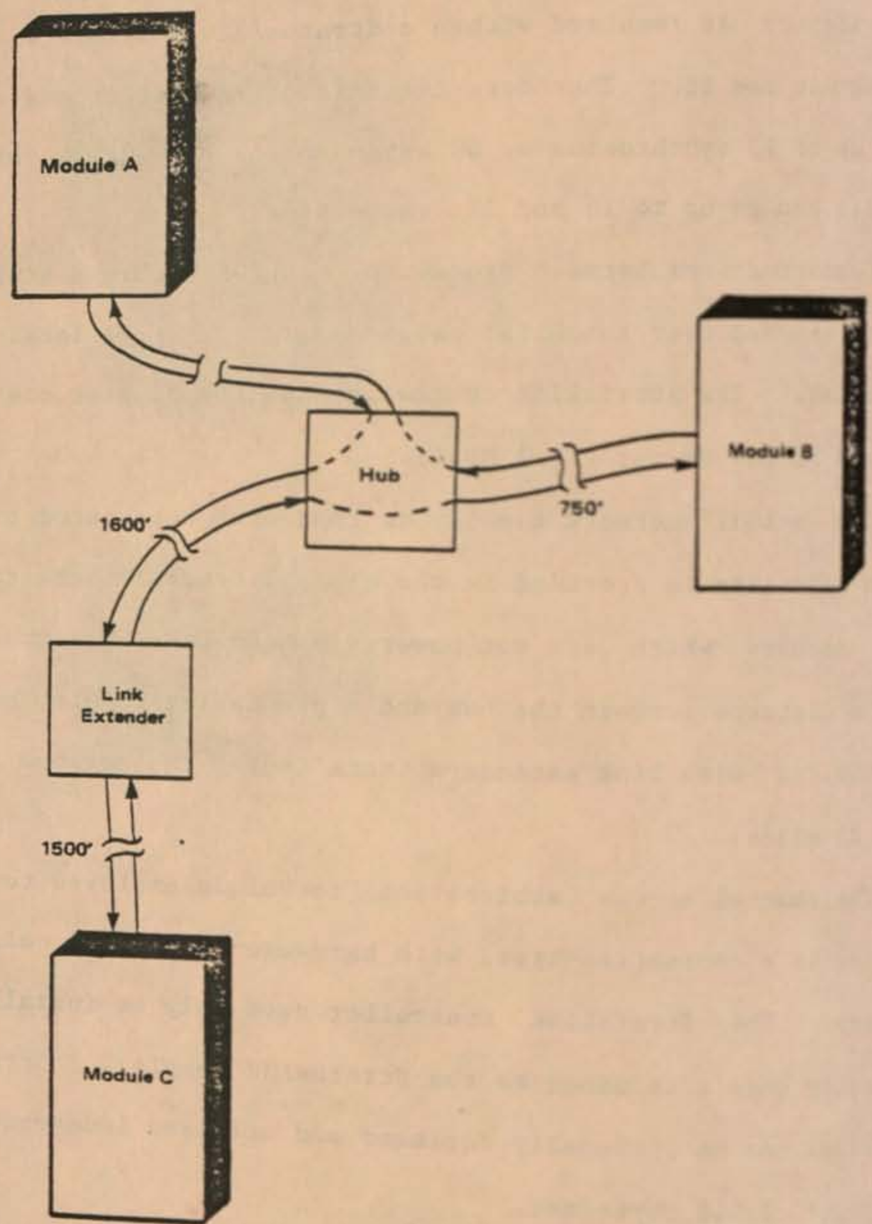
The actual network topolgy is that of a hub-routed ring (Exhibit IV-6). Bypass circuitry is provided in the central control (hub) to bridge over processing modules which are not powered up and hence maintain the ring. The maximum distance between the hub and a processing module, normally 750 ft., can be 1,500 ft. with link extenders installed. The maximum ring length is nominally 25 miles.

The channel access (arbitration) technique employed to regulate the use of the ring is a contention-type, with hardware-controlled collision detection and recovery. The StrataLINK controller need only be installed when the second processing module is added to the Stratus/32 complex. StrataLINK controllers and cables can be optionally duplexed and utilized independently for a combined throughput of 2.8 Mbyte/sec.

Although the StrataLink, which, like the Dynabus in the Tandem system, is used to link processing modules, runs at substantially lower rate, Stratus points out that StrataLink serves file transfer between PMs exclusively. Un-

EXHIBIT IV-6

MULTIPLE MODULE SYSTEM



Source: Stratus

like the Tandem system, it carries no "I'm alive" messages, which are not used in the Stratus system, nor page traffic, which is handled inetrnally by each PM. (Tandem might counter that the Stratus design requires a separate disk for each PM).

The minimum, initial processing module, which must be duplexed, takes up 11 slots and contains 18 microprocessors as follows:

	Slots	68000	Z80A
Processor (duplexed)	2	8	0
Memory Control (duplexed)	2	0	0
1 MB Memory (duplexed)	2	0	0
Disk controller (duplexed)	2	0	4
Tape Controller	1	0	2
Comm. Controller (duplexed)	2	0	4
TOTAL	11	8	10

In addition, the minimum first processing module also contains two 30 MB Priam disk drives (mirrored), one magnetic tape drive, clock/async adapter board with modem, one dual-port async adapter board, and the VOS operating system. This system is priced at $120,000.

A medium-size configuration, with two processing modules, 6 MB of RAM, 572MB of disk storage, 50 CRT terminals, a Dataproducts 300 lpm line printer (600 or 900 lpm optional) or a NEC 55 cps letter-quality printer, and VOS is $350,350; monthly maintenance fee for this configuration is $2,347.

A larger configuration with five processing modules, 12 MB RAM, 1.4 billion bytes of disk storage, 200 CRTs, 3 line printers, 5 letter-quality printers, tape drive and VOS is priced at about $1M, with monthly maintenance of $7,550.

2. Recovery Strategies

As indicated earlier, the fault-tolerance in the Stratus system is mainly hardware-implemented. Nominally, the sequence of events that takes place once a subsystem is diagnosed as faulty (generally by its own self-checking circuitry) is as follows:

- o Processing automatically continues on the duplexed subsystem.
- o A red "trouble" light is lit on the failed board; no complex diagnostics are required.
- o The operating system, VOS, receives a "maintenance" interrupt.
- o Maintenance software, called by VOS, determines the type of failure, first checking the the comparator circuits.
- o Transient failures are logged in an error file, the red indicator is turned off, and the failed board is resynchronized by the operating system and returned to service.
- o Hard failures turn on a red "trouble" light on the system's front panel, and an alert message is sent to a selected operator's CRT.

When a failed processor board is returned to service, a maintenance interrupt is generated. The functioning processor board momentarily pauses from its normal tasks in order to write its "state" (register contents etc.) into memory, from which the just-repaired processor copies it, so it is ready to resume running in synchronism. Upon command from the surviving processor, the repaired processor restarts, and synchronism is re-established. The repaired processor is said to have been "reeducated" by the surviving processor.

A similar process takes place when a freshly-repaired memory board is reinserted. The processor board in charge of that memory copies into it the contents of the corresponding surviving memory. This process does interrupt normal processing module functions, but for a very short interval. Stratus calculates that the re-education of a 2MB memory board should take no more than a half-second.

The disk duplexing strategy is the conventional <u>disk mirroring</u> technique, described elsewhere in this report. This technique is used by virtually all vendors of fail-soft systems. In the Stratus implementation of this technique, disk writes are executed to both disks, while reads are satisfied from the drive whose head is nearest the desired data. A failed disk returned to service is brought to a mirrored condition on line, by interspersing the copying activities from the surviving disk with operational accesses to that disk.

An interesting problem arises in connection with the duplexing of the communications board. The communications backplane, to which the terminals attach, is connected to both communications controllers. Should one controller fail, operation continues, uninterrupted, via the other controller.

3. Software

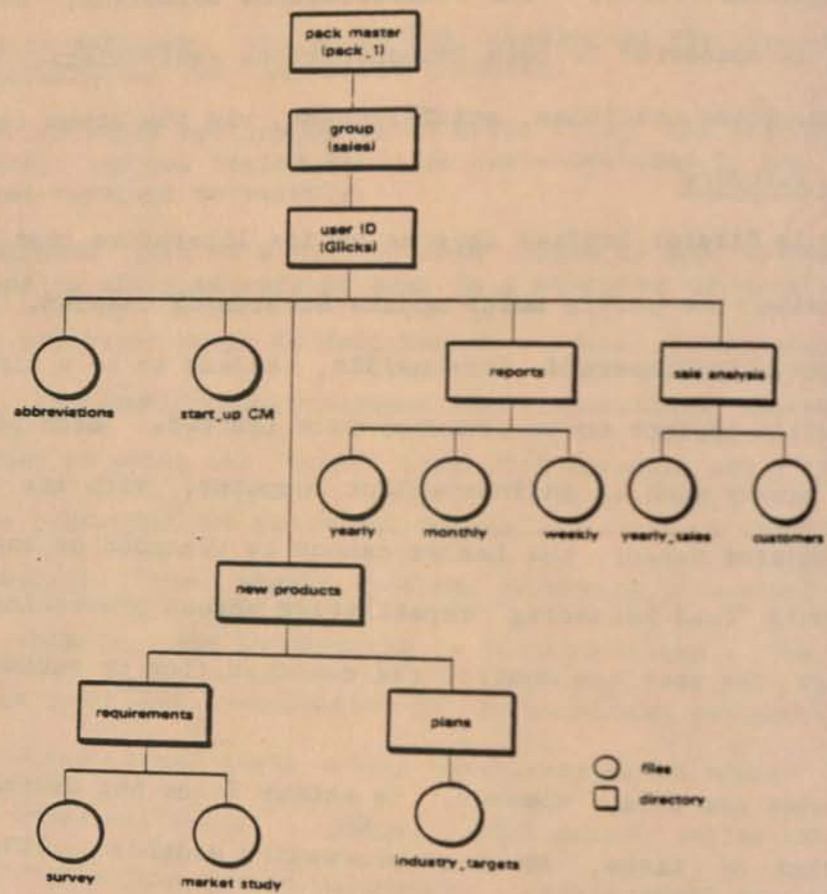
While Stratus implies in some of its literature that the operating system, VOS, makes the entire multi-module Stratus/32 complex, or even a network of geographically-dispersed Stratus/32s, appear to be a single computer system, the reality appears to be somewhat more limited. Each processing module operates pretty much as an independent computer, with its own terminal users and disk-resident tasks; the latter cannot be executed on any other PM. There is no dynamic "load balancing" capabilities across processing modules' boundaries, although the user can control the configuration to achieve static load balancing.

Users are able, however, to access files and devices, and to invoke the execution of tasks, in other processing modules. This is accomplished by establishing a unique system-wide naming conventions for processing modules, files, file directories, and devices. Users can access a "foreign" file by referring to its path name, i.e. a string consisting of the names of the processing module in which the file resides, and the names of all directories in the tree-like hierarchy leading to the specific file (Exhibit IV-7).

The local VOS copy maintains a directory of available global resources (processing modules and devices). When a reference to a non-local resource is encountered, the local VOS evidently forms a message to its counterpart in the

EXHIBIT IV-7

DIRECTORY HIERARCHY



Source: Stratus

destination module and ships the message either over the local StrataLINK, or the long-haul facility if the destination is a geographically-remote member of the StrataNET. The scheme is rather similar to Tandem's Expand networking system.

VOS facilities are otherwise quite conventional and typical of interactive systems. CPU scheduling is priority controlled; the priorities are dynamically adjusted so that highly interactive tasks can get higher priority relative to "CPU hogs" (number crunchers). Users can issue line commands, or can invoke "fill-in-the-blanks" command screens for all system commands. The latter feature is important, because it allows users to begin using the system with a minimum of training.

The I/O system supports large files (logically limited to about 2 billion bytes, with each record limited to 32K bytes) of three types: sequential, relative, and fixed. Any file can be indexed by any number of indexes, which may be embedded in the records, or free-standing. Three file access methods are supported: sequential, random, and indexed. Any access method can be used on any file type, except random access to a sequential file. Sequential files are buffered by VOS in 4KB chunks, so that sequential accesses, especially reads, can be frequently satisfied from the memory buffer. VOS also sorts disk access request bursts by head and sector position to optimize disk access time.

Security is achieved by log-in passwords, and the conventional virtual memory protection mechanisms which can designate memory pages as read only, execute only, or read/write. Files and directories are also protectable. A system administrator, i.e. a user with a password designating special privileges, can control the security system, and set many other system parameters. The system administrator can operate from any terminal. Any user can control access to his own files and directories.

The remote diagnostic facility can be used for both software and hardware problem diagnosis. Stratus has established a "remote support center" to provide such remote diagnosis services. The company is counting on this facility to greatly reduce the number of on-site service calls, and to improve the effectiveness of field servicemen by providing information about the problem ahead of time.

A screen editor and a "binder" (linking loader) complete the system software.

Languages offered include:

- COBOL, at the ANSI '74 Level 2 implementation.
- PL/1, ANSI X3.74 with some Stratus extensions.
- Basic at the ANSI X3.60 '78 "minimal" level.
- Fortran '77.
- Pascal.

All compilers produce identical binary object modules, so programs and subprograms produced by different compilers can be integrated via the binder. In addition, the compilers generate output that can be operated on by a symbolic debugger. An assembler is also offered; however, Stratus regards PL/1 as the "VOS systems programming language", and contends that the assembler is unnecessary.

Other software offered include a word processing system, including spelling verification; IBM 2780/3780/HASP (RJE) and 3270 protocol emulation; transaction processing monitor; and screen formatter.

F. ASSESSMENT

Of all the "new wave" of Tandem competitors in the high-integrity OLTP market, Stratus represents the most significant challenge, as underlined by the legal action Tandem took against it in February. There are a number of reasons for this:

Stratus is clearly farthest along in terms of product development, both hardware and software. The company has made a number of bona-fide customer shipments since February, 1982. The fact that the hadrware and software are demonstratable now is, of course, an immense advantage relative to several other newcomers who are still in the design and development phase.

Stratus has also managed to develop an extensive array of proprietary software in a very short period. Especially significant are the networking capabilities, which are rather similar to Tandem's Expand.

The Stratus self-checking hardware product concept is very sound, consistent and highly appealing. While these attributes in themselves are no guarantee of success, they are certainly important in gaining user acceptance initially.

Management, although relatively young, does possess a reasonable depth of experience.

On the negative side, Stratus does not seem to have paid much attention to the issues of data base consistency and recoverability, perhaps because they felt that disk mirroring, plus the fact that each processing module has its own disk, are enough. In particular, Stratus does not seem to have products comparable to Tandem's TMF and Data dictionary.

On the whole, Stratus appears to have made an excellent start. Given the size of the potential market for high-integrity OLTP systems, the company has every prospect of success.

CHAPTER V

SYNAPSE

A. BACKGROUND AND FUNDING

Synapse Computer Corporation was incorporated in August, 1980. Initially, the company operated in Menlo Park, CA, moving into its present 31,000 sq. ft. plant in Milpitas, CA in July, 1981. Employment in August, 1982, stood at 67, with 39 engaged in development and 15 in marketing and support, and 12 in manufacturing.

Synapse (a biological term denoting the interconnection between two adjacent neurons over which information, in the form of nervous impulses, travels) is not related in any way to a similarly named Falmouth, MA company which manufactures single board microcomputers. Synapse filed suit against the Massachusetts company to force it to change its name.

Synapse is funded primarily through venture capital. The initial round, which yielded about $1.7 million, occured in November, 1980, and included two nearly-equal participants. One was a group of private investors, headed by Jesse I. Aweida, chairman of STC; the group is believed to have also included Carl Carman (NBI, ex-Data General) and Bob Towbin of Rothschild, Unterberg & Towbin. The other participant was Technology Ventures Investors, a venture capital fund of which Shugart Associates cofounder and former president James Bochnowski is a general partner. Aweida and Bochnowski are both currently Synapse directors.

A second financing round, which yielded a little over $6 million, was completed in May, 1981. The eight well-known participants were Bessemer; Burr, Egan & Deleage; Hambrecht & Quist; Interwest Partners; Merrill, Pickard (B of A); Westven; Sofinnova; and Sevin-Rosen, the venture operation of former Mostek president L.J. Sevin and New York electronics consultant Ben Rosen. William Burgin, a general partner in Bessemer, sits on the Synapse board.

A third round of financing round, concluded at the end of June, 1982, yielded $5.9 million. The eleven previous participants contributed $2.9 million, while $3 million came from five new investors: Morgan Stanley, Stanford University, U. of Rochester, J.F. Shea & Co. (associated with Hambrecht & Quist), and Sharjah Group, a London-based, Saudi Arabian controlled firm.

The company plans to formally announce its product in early August, 1982.

B. MANAGEMENT

The Synapse management team is headed by president and director Mark Leslie, 36, who previously was Western Area Director for Data General. That responsibility encompassed, in addition to North American sales, some system engineering, field service, and the associated personnel, finance and administration functions. Earlier, he held various technical and marketing positions with Data General, IBM and Xerox Data Systems (nee SDS).

Elliott Nestle, 46, has been the company's vice president for system development since its inception, and is also a Synapse director. Along with Leslie and two others, he is considered a "founder". Prior to joining Synapse, Nestle was the director of the Western Development Center for Perkin Elmer's Computer Systems Division (nee Interdata). In that capacity, he was responsible for both an LSI development organization and a Systems Implementation group. Earlier, he held various technical and technical management positions with Interdata, Electronic Associates (EAI), and Bell Labs.

Stanton "Stan" Joseph, 47, is the vice president of marketing and one of the four founders. Prior to joining Synapse, he was director of National Federal Marketing for Data General; his organization was responsible for sales to the federal government and to prime contractors on government jobs, along with the associated system engineering, field service, and contract administration. Earlier, he held sales and marketing management positions with DG, XDS, HP and Bendix.

Stanley J. Meresman, 35, is vice president of finance and administration, chief financial officer, and corporate secretary. Although he joined Synapse only in November, 1980, he is regarded as a founder, apparently because of the key role he played in arranging the first financing round. Prior to joining Synapse, he was director of finance for Verbatim. Earlier, he held various accounting and financial management posts with System Industries and Arthur Andersen & Co.

Richard Garlick, 41, is vice president of manufacturing. Prior to joining Synapse, he held various manufacturing management and field service positions with Computer Elections Systems (a manufacurer of computerized voting systems), IBM, Memorex, and STC.

Gerald J. Denny, 37, is vice president of customer service. Prior to joining Synapse, he held a variety of marketing, sales, and customer support management posts at HP.

Key staff in the development operations include Gerald Clancy, director of software development (ex-DG); Waguih Boctor, group leader for Transaction Processing (ex-PE Computer Systems Div.); George Franzen, group leader for operating systems (ex-DG); Dave Frankenberger, group leader for hardware design (ex-PE Computer Systems Div.); Stephen Jones, group leader for data base systems (formerly with Lawrence Livermore Labs.); and Mehdi Jazayeri, group leader for languages (formerly with TRW-Vidar).

Synapse points to the variety of backgrounds represented by its management and key development personnel as an asset, because "spin off" companies, where key personnel is drawn primarily from one existing firm, tend to re-engineer ("do it right") rather than innovate.

C. COMPANY ORIENTATION AND MARKET CONCEPT

The company defines the intended applications for its computer system as "high integrity transaction processing", meaning the same OLTP market addressed by Tandem. However, rather than focus on the availability (non-stop) issue, the company stresses a variety of features and capabilities in its system (see Product Concept section below) that address the installation productivity objective. In that context, availability becomes only one of several considerations, which also include programming productivity, hardware and software throughput, modularity for graceful growth, data base consistency and integrity, etc.

Synapse articulates its corporate goal thus: "Anyone serious about transaction processing will consider Synapse". That is, the firm aims to establish itself as a major available alternative in the transaction processing market.

The company plans to go mainly after end users, directly and through vertical markets system integrators. It hopes for a mix of 40% end users, 40% system integrators, and 20% OEMs. Synapse defines "transaction processing" as involving real time activities against a 'real' data base, as contrasted with the still-very-common capturing of real time transactions for off-hours batch processing. High integrity is a prime requirement in such on-line transaction environments. Synapse believes that this market is driven primarily by the dramatic reductions in the cost of mass storage. The firm identifies the following applications and industries as general candidates for high integrity transaction processing:

APPLICATION	INDUSTRIES
Reservation systems	Airline, hotels, car rentals
Credit authorization	Retail
On-line tellers, ATM	Banking
Stock transfer	Brokerage, banking
Automated stock brokerage	Brokerage
Point of sale	Retail
On-line inventory control	Distribution, manufacturing
Integrated material/mfg.	Discrete manufacturing

Information retrieval systems | Security agencies, libraries

The end-user orientation of the company is underlined by its approach to customer service. Synapse has established this function as an independent division (under G.J. Denny), reporting directly to the president. The division, which aims to be self-funding and generate 25-30% of the company's revenues, encompasses all customer interface activities and "provides quality audits to internal departments". Service points have already been established in New York, Washington, Chicago, San Francisco, and Atlanta, and are planned for Dallas and Los Angeles. Also planned is a support center, which will offer remote diagnostics and telephone support.

As of August, 1982, the company had orders for two systems. One is from a systems house, for an information retrieval application in a government agency. The other order, also from a systems integrator, is for a consumer banking application. Synapse declines to provide additional details at this time. The product was officially announced in early August. The present schedule calls for the first shipment to occur in October, 1982, with full production commencing in the 4th quarter of 1982.

Typical system pricing is expected to begin at about $300K.

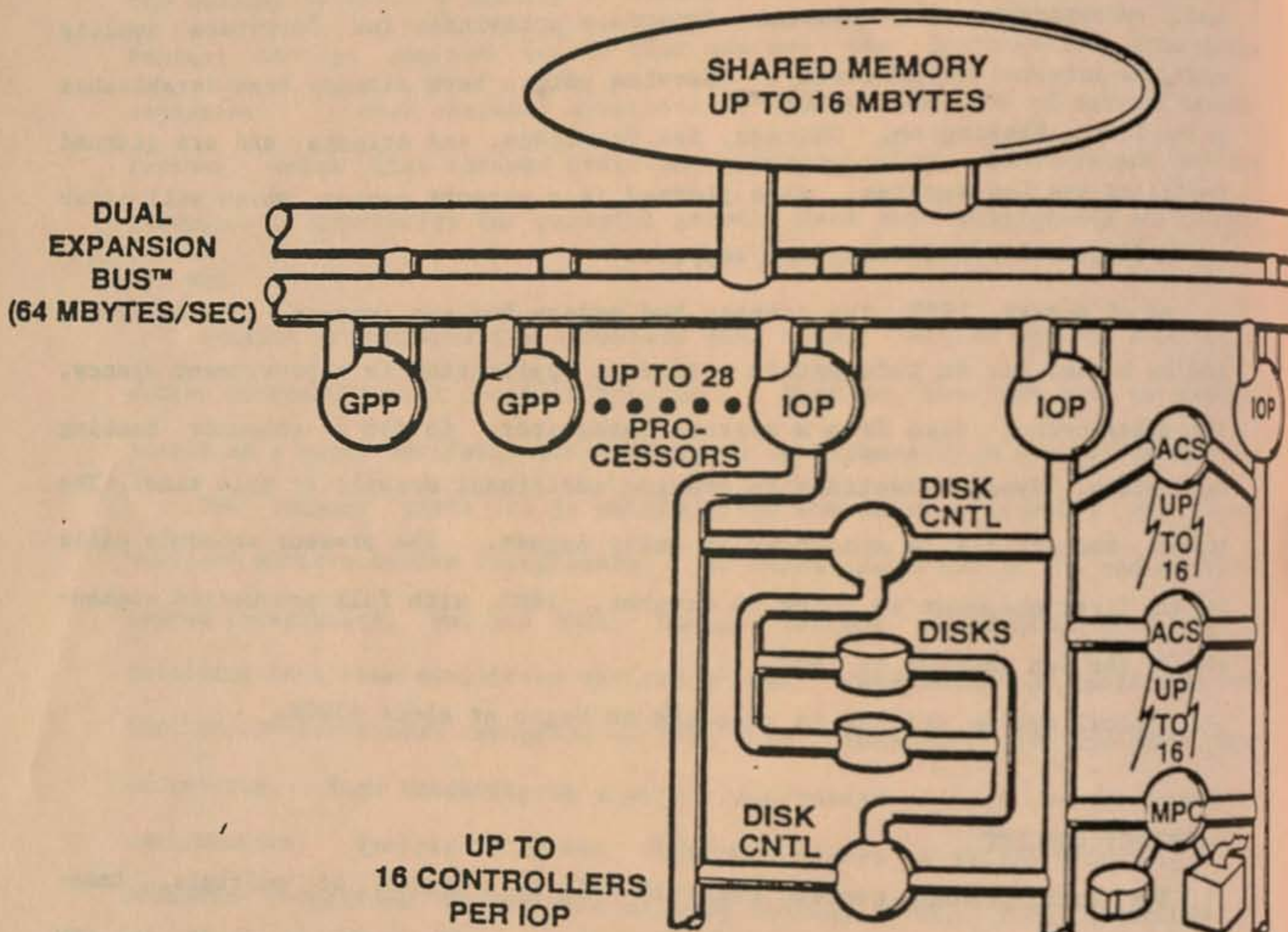
D. PRODUCT CONCEPT

The basic product concept (**Exhibit V-1**) is a system of multiple, independent processors sharing a common main memory ("tightly coupled" in IBM lingo). The system treats the processors as a pool from which computing resources are drawn in response to user demands.

Synapse refers to this arrangement as the "N+1 model", denoting a system in which, for each critical resource or facility (e.g., GPPs, IOPs), N identical components can be configured, sufficient to service the expected load, plus one additional component, to provide resiliency. The "N+1" configuration

EXHIBIT V-1

SYNAPSE ARCHITECTURE



Source: Synapse

yields high availability because the probability that two identical components will fail at the same time is very much lower than that of a single component failure. Hence providing just one more component than the N "required" ones is enough to provide a very high degree of availability, provided the faulty component can be returned to service before another similar component fails. Even in that event, additional faulty components would generally result in degraded performance, rather than a catastrophic "crash".

The processors, all of which are based on the Motorola 68000, are specialized into three roles: general purpose processor (GPP), mass storage processor (MSP), and gateway communications processor (GCP). The MSP and GCP are actually nearly identical IOP boards; they differ mainly in the software driving the 68K. The GPP's, which have no local memory and execute programs directly from shared memory, have a 16KB high speed instruction and data cache. They communicate with shared memory over a pair of 32-bit parallel, 32 Mbyte/sec buses.

In contrast with the GPP, each IOP has 128KB of local memory, which is used to store a portion of the operating program. I/O controllers are buffered, so there is no need to use the IOP's memory for this purpose. Up to 28 processors of the three types can be accommodated in the system's rack.

Synapse says it is optimizing its product to provide the following characteristics, which the company believes are the essential ones in the high-integrity transaction processing environment:

- Support many terminals.
- Support large, relational data bases.
- Provide data integrity.
- Provide availability at the applications level.
- Provide a high degree of modularity.
- Provide ease of use and productivity.

These objectives are achieved as follows. Multiple terminals are supported by one or more powerful, 68000-based communications processors. A proprietary relational data base management system is a key Synapse offering. Data integrity consists of four elements, which are achieved as indicated below:

- o Consistency, by the software enforcing the acceptance of complete transactions only.
- o Accuracy, by providing "reasonableness" checks at the screen input and at the destination (disk output); the Application (data) Dictionary aids in this objective.
- o Availability, achieved at the applications level, via the resilient hardware and through automatic checkpointing synchronized with data base transactions.
- o Security, achieved by protection mechanisms which verify not only the user's right to access a given program (and reverifying this after a crash), but also by checking a program's right to use given data.

Consistency and accuracy are achieved by an "automated 5-rule transaction model", which, according to Synapse, makes them transparent to the user. Removing this concern from the user also contributes greatly to productivity.

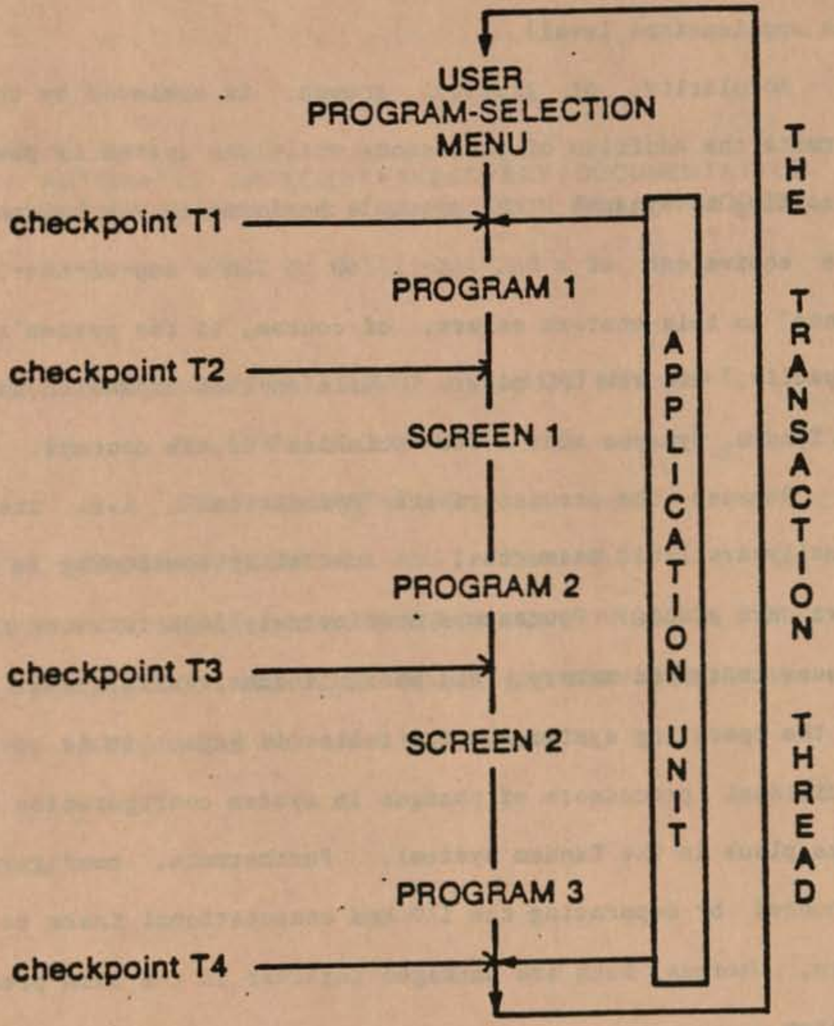
Synapse emphasizes the distinction between availability at the applications level (i.e. data base consistency considerations) as contrasted with mere hardware availability.

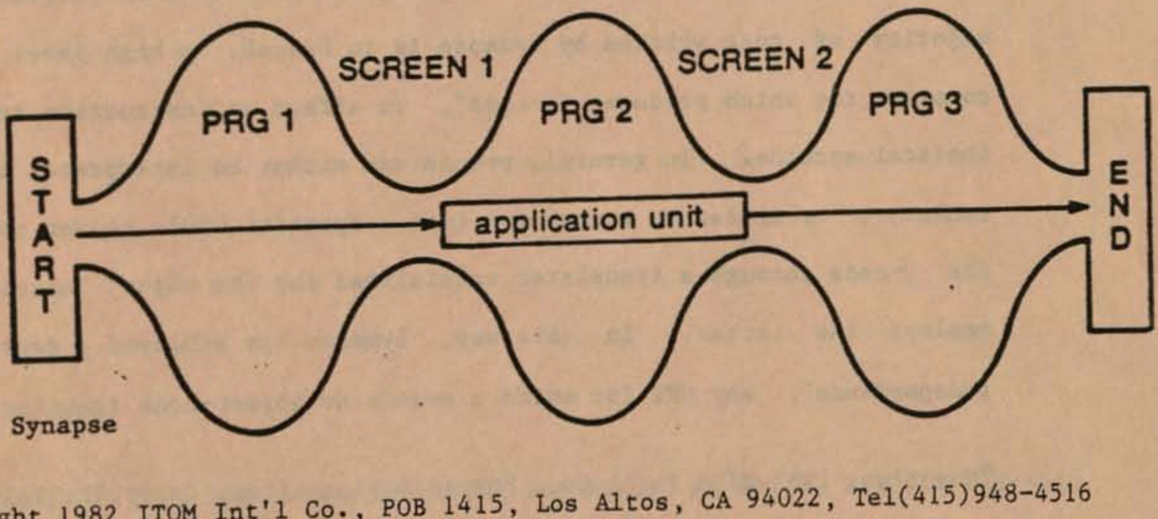
Synapse characterizes its own approach as a "multiprocessor" system, in which processors cooperate to execute a given load, contrasted with the "multicomputer" systems from Tandem and Stratus, in which tasks must be assigned, by default or by the user, to specific processors.

The main mechanism which facilitates recovery in the Synapse system is checkpointing (Exhibit V-2), which at one time was also key in the Tandem approach. The Tandem experience has shown that the proper application of checkpointing requires a very high degree of programming skill and deep understanding of the system's internal operation. Synapse proposes to avoid this difficulty by regularizing the transaction design process, according to a "5-

EXHIBIT V-2

SYNAPSE CHECKPOINT MODEL





Source: Synapse

rule transaction model" (Exhibit V-3). (A similar set of rules is being used by Tandem in conjunction with TMF, which has largely replaced checkpointing at the applications level).

Modularity, or graceful growth, is achieved by the basic design which permits the addition of processors while the system is powered and functioning. According to Synapse, the system's performance can be smoothly increased from the equivalent of a DEC VAX-11/780 to IBM's top-of-the-line 3081. "Performance" in this context refers, of course, to the system's transaction-handling capacity, not raw CPU power. While on-line expansion is also fully supported by Tandem, Synapse adds a few 'wrinkles' to the concept.

Because the processors are "symmetrical", i.e. treated like a pool of equally-available resources, no special system tuning is required when processors are added. Processors continuously look for work to do, represented by queues in shared memory, and assign themselves to tasks. Since only one copy of the operating system and its tables is kept, it is not necessary to inform individual processors of changes in system configuration (a process which must take place in the Tandem system). Furthermore, configuration flexibility is enhanced by separating the I/O and computational tasks to independent processors, whereas both are packaged together in the same processor in the Tandem system.

Finally, modularity has another significance in the Synapse context. The majority of code written by Synapse is in Pascal, a high level language the compiler for which produces "P-code", in effect an instruction set of a hypothetical machine. In general, p-code can either be interpreted by a p-machine emulator, or it can be translated into a specific CPU's object code by passing the p-code through a translator specialized for the object machine. Synapse employs the latter. In this way, Synapse has achieved a degree of "chip indepnedence"; any MPU for which a p-code to object-code translator exists, or

EXHIBIT V-3

SYNAPSE TRANSACTION MODEL

AUTOMATIC INTEGRITY/RECOVERY/DOCUMENTATION
WITH THE SYNAPSE TRANSACTION DESIGN MODEL

(1) FORCE DEFINITION OF APPLICATION UNIT

2-LEVEL SECURITY

SELF DOCUMENTING

(2) PROGRAM SEGMENTS MUST TERMINATE

(3) ONE SCREEN PER PROGRAM, ONE PROGRAM PER SCREEN

(4) CHECKPOINTS MUST OCCUR BETWEEN PROGRAMS

(5) RECOMMEND NO IN-LINE COMMITS

Source: Synapse

can be created, can be employed in the Synapse system, with a relatively minor impact on the system and higher level software. This approach was adopted after a painful experience suffered when the company, which initially set out to develop its system based on the Intel iAPX432 MicroMainframe™, had to switch to the Motorola 68000 when progress in the Intel chip family proved slower than expected.

Ease of use and the attendant productivity benefits are achieved through a variety of mechanisms and features. These include the Application Dictionary (a data dictionary), unattended operation, self-configuration, automated integrity/recovery, independence of screen, terminal, and data processing, the relational data base system, and the integrated, compatible system of languages and utilities.

Exhibit V-4 depicts the relative importance Synapse attaches to each of the design goals outlined above.

E. PRODUCT OVERVIEW

Technical details of the Synapse system have not been released at this point. The following is an attempt to piece together a rational picture from the available bits and pieces.

1. Hardware

The main product concept, as described earlier, is that of multiple processors operating against a shared memory system. Synapse likes to call this a "distributed shared memory system". Processors are specialized into three types: general purpose (computational) processor, GPP; mass storage (disk or tape) processor, MSP; and a gateway communications processor (GCP) for local and remote terminal support. All processors are based on the Motorola 68000; 8 MHz vesrions are currently used, but 10 MHz parts are planned. As indicated

EXHIBIT V-4

SYNAPSE DESIGN CRITERIA

TRANSLATING BUSINESS GOALS INTO DESIGN CRITERIA:

A = Primary Goal of Design Criteria
B = Secondary Goal of Criteria
C = Free By-product from Achieving other Design Goals

SYNAPSE IMPLEMENTATION GOALS	DESIGN CRITERIA IN ORDER OF IMPORTANCE: 1. DATA INTEGRITY	2. APPL. AVAILABILITY	3. MODULARITY	4. EASE OF USE
1. AUTOMATE INTEGRITY/RECOVERY	A	A	A	A
2. FAULT-TOLERANCE + PERFORMANCE	C	A	A	C
3. SMALLER BECOMES LARGER SYSTEM	N/A	B	A	A
4. FILE ACCESS EASE + SPEED	B	N/A	N/A	A
5. ON-LINE SECURITY	B	N/A	N/A	A
6. ON-LINE TOOLS	B	B	N/A	A
7. TECHNOLOGICAL INDEPENDENCE	C	C	A	C

Source: Synapse

earlier, the MSP and GCP are software-specific variants of the same IOP board.

The system is packaged in a floor-standing, 39"-wide rack, hosting two card cages, each supporting 32 slots, and featuring a triple-redundant power supply system, with majority voting.

The 15"x17" Boards are multilayered (up to 10 layers in the GPP, which hosts some 300 chips). Memory boards carry 1 MB of RAM with full ECC, using 64 Kbit chips. Memory may be 4-way, 2-way, or non-interleaved, requiring 4, 2 or 1 memory controller boards.

Other board types include IOP (MSP, GCP); 8-drive disk controller; multi-purpose controller (tape, printer, timers); and the dual-ported, advanced communication system (ACS) board, which is also based on the 68K and hosts 256KB memory and the RS232 interfaces for up to 16 ports. ACS is expected to support a variety of async, bisync and bit-synchronous protocols.

Only the lower card cage is equipped with the dual buses to shared memory, and can accomodate processor boards. The total number of processors configurable is limited to 28, of which no more than 16 may be IOPs. Synapse plans to support 6250 bpi STC tapes and compact, Fujitsu high capacity disks (150-400MB per spindle).

As indicated earlier, processors access memory over a dual 32-bit parallel, 32 Mbyte/sec bus system, for an effective throughput of 64 Mbyte/sec.. The arbitration of bus usage is apparently centralized for each bus, and is probably based on slot-dependent priorities, with the higher priorities probably going to the GCP and MSP. The GPPs, which execute programs residing in main memory, are buffered through their caches, to minimize the load on the memory buses. IOPs have 128KB local memory each, and execute code from their local memories.

The GPP supports, for each process, a logical address space consisting of 1 MB of code and 1 MB of data, in pages of 2KB each. Translation tables (segment descriptors and page table entries) reside in main (shared) memory, but the hardware address translation box includes a 64-entry cache where translation data for the most recently referenced pages is kept.

Shared data segments are possible and provide for interprocess communications. The data base management system uses main memory as a "pool" of I/O buffers; these buffers are mapped into the user's address space as required. Process priority is dynamically alterable.

The disk and communications controllers are dual ported, and are normally attached to two IOPs each, so that the failure of an IOP does not knock out the controller.

The dual-ported ACS communications board can support point-to-point asynchronous, bisynchronous, and bit-synchronous protocols. Any ASCII terminal can be used; the ACS will resolve terminal idiosyncracies so that the operating systems deals only with standardized, "virtual" terminals. Televideo terminals are currently being used by Synapse.

Exhibit V-5 shows some possible configurations of the Synapse system.

2. Recovery Strategies

A single copy of the operating system and its tables is kept in shared memory. GPPs execute directly from shared memory (through their caches), while IOPs have private copies of the driving software in their on-board memory. The processors contain ROM-based self-test and bootstrap programs which allows them, on initialization and after crashes, to load the appropriate program from shared memory (IOPs), or to begin execution at the correct point in shared memory (GPPs).

In normal operation (Exhibit V-6), processors of a give type are treated like a pool of equally-available, equally-capable resources. At initialization, I/O point, or upon completion of each task, and after a crash, a proces-

EXHIBIT V-5

POSSIBLE CONFIGURATIONS

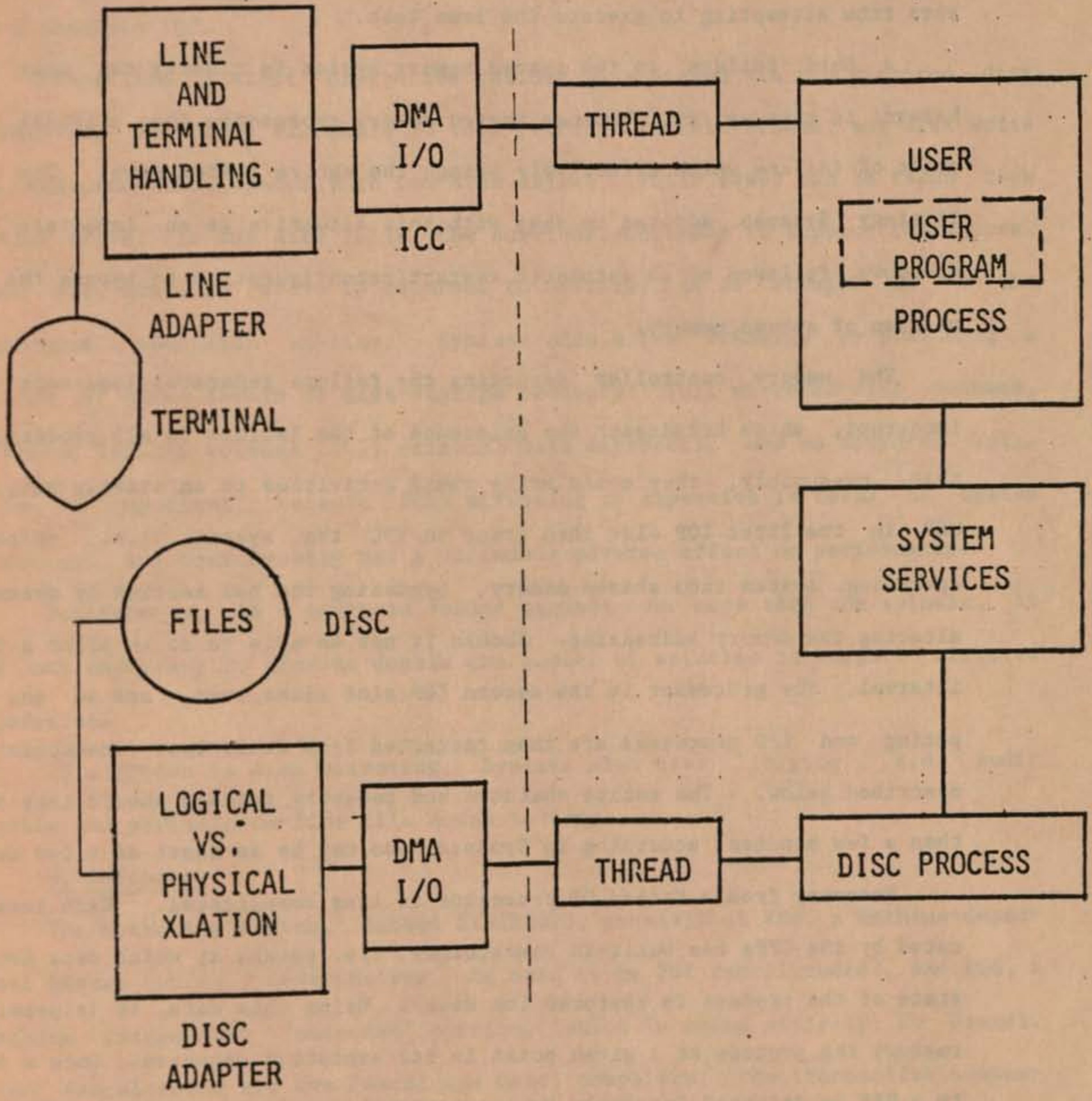
COMPONENT	SMALL	ARBITRARY PROCESSOR MIX MEDIUM	LARGE	MAXIMUM
GPP	2	6	12	16
MSP	1	3	5	8
GCP	1	2	3	4
MEM (MB)	4	8	12	16
DISKS (WINCHESTER 474-MB)	2-4	8-10	12-32	36-56
TAPES (6250-bpi/125-ips)	1	2	4+	6+
PORTS*	32	64-96	128-196	256+

* NOTE: The number of terminals is greater than or equal to the number of ports.

Source: Synapse

EXHIBIT V-6

NORMAL WORK FLOW



Source: Synapse

sor enters a "wait" mode in which it continually scans the relevant work queue ("thread") in shared memory for work to do. Upon finding a waiting task, the processor assigns itself to the task and executes it. An interlock system, using semaphores in shared memory, is employed to prevent two or more processors from attempting to execute the same task.

A hard failure in the shared memory system is clearly the most severe hazard in this system, because shared memory represents the critical single point of failure which effectively brings the entire system down. The overall strategy Synapse adopted to deal with this situation is an immediate system shutdown, followed by an automatic restart/reconfiguration to bypass the failed portion of shared memory.

The memory controller detecting the failure generates some sort of an interrupt, which broadcasts the existence of the failure to all processors, so that, presumably, they could bring their activities to an orderly halt. The MSP in the first IOP slot then tries to IPL the system, i.e., reload the operating system into shared memory, bypassing the bad section by dynamically altering the memory addressing. Should it not be able to do so after a timeout interval, the processor in the second IOP slot takes over, and so on. Computing and I/O processes are then restarted from their last checkpoints, as described below. The entire shutdown and recovery process should take no more than a few minutes, according to Synapse, and may be as short as a few seconds.

Recovery from a failed GP processor is less complicated. Each task executed by the GPPs has built-in checkpoints, i.e. points at which data about the state of the process is captured (on disk). Using this data, it is possible to restart the process at a given point in its execution sequence. Once a failure in a GPP is detected (probably by conventional parity, watchdog timer, etc.), another processor can take over the interrupted process from its last checkpoint.

A failed MSP or GCP conceptually is no more severe than a GPP failure, provided the backup processors are able to access the peripherals or terminals attached to the failed processor. This is accomplished by equipping the critical controllers (disk, communications) with dual ports, with each port attached to a separate IOP.

Protection against disk drive failure is achieved via the mirrored disk mechanism, described elsewhere in this report. In this scheme, any disk write is executed simultaneously to two disk drives, while reads can be taken from either drive. If one disk fails, the survivor continues to support the system. When the repaired drive is returned to service, it is brought up to the "mirrored" condition on-line. Synapse adds a few 'wrinkles' by providing a choice of three levels of mass-storage recovery: full mirrored disk volumes, mirrored logical volumes (only critical data mirrored); and no mirrored data. This is important, because full mirroring is expensive in terms of system resources, and consequently has a noticable adverse effect on performance.

Furthermore, if a mirrored volume extends over more than one spindle, it is not necessary to provide double the number of spindles to support mirrored operation.

In addition to disk mirroring, Synapse also uses "logging", i.e. audit trails and periodic on-line file dumps to tape.

3. Software

The operating system, dubbed SYNTHESIS, consists of KOS, a machine-dependent kernel (which, nevertheless, is said to be 90% Pascal-coded), and EOS, a machine independent "extended" portion, which is coded entirely in Pascal. Also Pascal-coded are the Pascal and Cobol compilers, the transaction processing (TPS) software, and the DBMS. This is the main reason for the claim that the Synapse system is "instruction engine independent" and could accomodate different MPUs with minimal impact on the system software.

The Command Line Interpreter (CLI) combines Unix-like pipes with concepts borrowed from Data General's AOS operating system.

The TPS system software resides in shared memory and provides terminal handling, session control, and screem formatting functions (Exhibit V-7).

Synapse developed much of its software before the system's hardware became available (the hardware is still in various stages of debugging at this time). This was accomplished by writing a KOS simulator, which runs on an in-house, DEC VAX 11/780. COBOL, Pascal, TPS, and the DBMS are already operational on this simulator, and significant portions of the software needed minor or no modifications to run on the Synapse hardware.

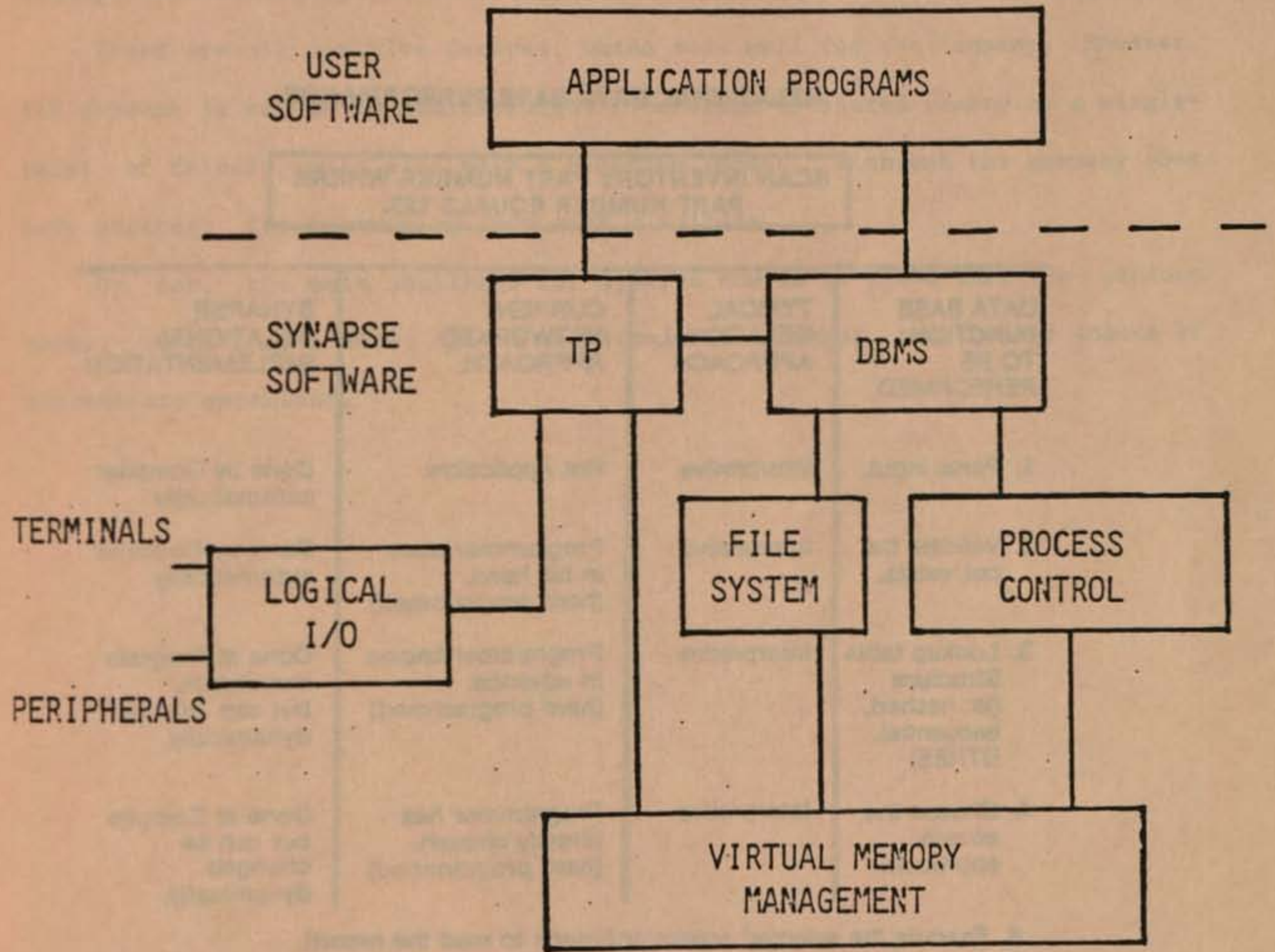
The other key software element to be offered by Synapse is a relational data base system, said to have been developed by Synapse. The Synapse implementation is said to have the following main features:

- o Interface to a system-wide data ("Application") dictionary.
- o Built-in support for data integrity and system availability.
- o Performance equal to that of an indexed-sequential access method.
- o Ease of use.
- o Provides basis for future distributed DBMS.
- o Support for data consistency via assertions (range checks) at both the screen input and disk write (destination) stages.
- o Built-in DBMS interfaces in the compilers and utilities.

Some of the performance and other advantages of the Synapse implementation, as compared with conventional network-type DBMS and with interpretive relational DB systems, are oulined in Exhibit V-8, which shows the steps involved in a typical DBMS activity.

EXHIBIT V-7

TRANSACTION PROCESSING SYSTEM



Source: Synapse

EXHIBIT V-7

RELATIONAL DATA BASE

RELATIONAL DATA BASE PERFORMANCE

SCAN INVENTORY PART NUMBER WHERE PART NUMBER EQUALS 123.

DATA BASE FUNCTION TO BE PERFORMED	TYPICAL RELATIONAL APPROACH	CURRENT NETWORKED APPROACH	SYNAPSE RELATIONAL IMPLEMENTATION
1. Parse Input.	Interpretive	Not Applicable.	Done by Compiler automatically.
2. Validate the col. exists.	Interpretive	Programmer does in his head. (hard programmed)	Done by Compiler automatically.
3. Lookup table Structure (le: hashed, sequential, BTREE)	Interpretive	Programmer knows in advance. (hard programmed)	Done at Program Installation, but can change dynamically.
4. Choose the access approach.	Interpretive	Programmer has already chosen. (hard programmed)	Done at Compile but can be changed dynamically.

5. Execute the selected access approach to read the record.
6. Return to the application program with the record.

Source: Synapse

F. ASSESSMENT

With the conclusion of the third financing round, Synapse has obtained a significant amount of capital. It has important and well-known backers. The company already has two orders, and shipments are imminent. The "N+1" product concept is interesting and well-differentiated from that of Tandem and Stratus.

These are all positive factors, which bode well for the company. However, the product is yet to be demonstrated. The issue of shared memory as a single-point of failure could also have a negative impact, although the company does have strategy for recovering from such a failure.

By far, the main challenge for Synapse now is to prove that the product works. Once that's done, given the size of the market, the company chance of success are excellent.

CHAPTER VI

AUGUST SYSTEMS

A. BACKGROUND AND FUNDING

August Systems, Inc. (Salem, OR) was founded in September, 1978 by John H. Wensley, formerly of SRI, where he developed most of the concepts that underly the fault-tolerant techniques employed by the firm. He was joined by two SRI colleagues, who are no longer with the company, and a fourth founder, formerly with Burroughs. August currently operates in a leased, 12,000 sq. ft. plant, and, as of July, 1982, employs 52, of whom 10 are in marketing and sales, 25 in development, 10 in operations, and 5 in G&A. The August name has no special significance relative to the product, other than its general meaning ("marked by majestic dignity and grandeur").

Until early 1980, the company was funded by the founders and a few private investors at about $0.5 million. In March, 1980, August obtained approximately $1 million in venture capital. This was followed by three other financing rounds, totalling about $5 million, half of which was raised in the last round, completed in April, 1982. The seven outside investors currently are InnoVen; Welsh, Carson, Anderson & Stowe; Northwest Growth Fund; North Star; Oak Management; Brentwood Associates; and Interwest Partners.

The company's somewhat erratic early history was marred by the departure of some of the founders, and by a lack of market acceptance for the initial product, dubbed the BC series. Although the product was working and demonstratable, according to the company, it was specialized for a narrow range of applications. After gearing up for a large order from a specific customer that did not materialize, the product was discontinued.

August indicates that, at the end of April, 1982, it had 7 firm orders for its new system, dubbed Can't Fail 300. Three are already installed (the first installation occured in November, 1981), and the remaining four are scheduled for May installation. The typical customers are such companies as Monsanto a Dow Chemical. One system is installed at the Brookhaven National Laboratory Long Island. Prices of Can't Fail system vary from as little as $40K upwards of $700K, depending heavily on the number of monitoring and/or con "points" in the process.

The company has also installed, in Holland, one PCS 300, programm controller used as a "program development" tool.

B. MANAGEMENT

John Wensley, the company's founder and its technical "guiding light", also chairman of the board. He was previously with the Stanford Resear Institute (SRI).

David W. Willoughby, president, was formerly president of Axxa Corp. troubled Citicorp subsidiary that is now a subsidiary of Anaconda-Ericsson.

John Wimer, vice president of marketing, was formerly with Measurex. president of operations is Larry Chapman, ex-Testdata. Engineering vice pre dent is Dr. Anthony ("Tony") Frederickson, formerly with Measurex. Vice pre dent for hardware development is Bob Anderson, ex-Motorola. David Grubb, e Burroughs, is vice president of product management. Tom Linnemann is contro ler.

Some of the key hardware and software development staff are Karl Boek heide and Jim Crossland, both ex-Burroughs; Raul Femenia, ex-Measurex; Steve Frison and David Boggs.

C. COMPANY ORIENTATION AND MARKET CONCEPT

From its inception, the company sought to apply its fault-tolerant techn logy to real time, process control applications. This remains true of new, Can't Fail 300 and PCS 300 product lines. In this respect, August differs markedly from Tandem, Stratus, and Synapse, all of which are pursuing the high-integrity, on-line transaction processing market.

The process control environment differs significantly from transaction processing in several respects. While both require the computer system to operate in "real time", the process control situation is characterized by much more critical timing constraints. Whereas a user at a terminal might be concerned with response times of the order of seconds, the process control computer must accept inputs, process them, and output results typically within milliseconds, and sometimes even in microseconds.

Another difference is that, while transaction processing is typically disk I/O bound, due to multiple, concurrent on-line accesses to one or more large, disk-resident data bases, real time monitoring and control of an industrial process is generally characterized by a heavy computational load and relatively light (or non-existent) disk I/O activity.

One important consequence of these characteristics of the process control environment is that computational tasks generally must reside in main memory, since there is no time to load them from a disk. Although August offers optional multiple disks operating in mirrored fashion (discussed elsewhere in this report), this is not a frequent requirement. On the other hand, a key issue which August addresses is is how to extend fault-tolerance to such process I/O subsystems as analog/digital converters, sensors, actuators, and clocks. These considerations are reflected in the August products as described in the Product Concept section below.

The application areas in which the August products can be usefully applied include most types of industrial monitoring and process control, including chemical, paper, petroleum/gas, and metals production; food processing; nuclear and fossil-fuel power plant control; wind tunnel test systems; experimental nuclear accelerators; etc. There are also many aerospace and military applications; however, August is not attempting to address those.

Currently, the company is marketing directly to end users. It is looking for vertical markets system integrators.

D. PRODUCT CONCEPT

The architectural implementation the August product is based on a fail-soft concept, developed by Wensley and his associates at SRI in the mid-70's, called Software-Implemented Fault Tolerance, or "SIFT" for short. The concept was developed originally, under NASA auspices, in connection with the design of a fault-tolerant aircraft control computer.

The key SIFT ingredients are N-modular-redundancy (NMR) and software implemented majority voting. Triple-redundant (TMR, a special case of NMR) majority voting systems are not new; in fact, one such system, dubbed FTMP, using hardware bit-by-bit voting, was developed, concurrently with SIFT and as an alternative to it, in the same NASA-sponsored airborne application.

In TMR systems, three processors are given identical inputs and execute identical code; comparison circuits continually "vote" on the outputs of the processors. In the "voting" process, a discrepancy between one processor and the other two is handled by "voting out" the "odd" processor, which is regarded to be in error. The data generated by the two processors that are in agreement is taken to be good. The probability that all three processors will yield different results is very much lower than that of a single processor failure.

SIFT too relies on triple-redundant hardware, but differs in that it relegates the voting function to the software, rather than the hardware. This is made possible by the nature of the process control computation, which generally consists of repetitive iterations through fixed algorithms, where the output data of each iteration becomes input data for the following iteration. Thus it is generally sufficient to vote on the output of (input to) each iteration, rather than try to track each intermediate step.

Several important advantages are obtained with the SIFT approach. Since triple redundant voting circuitry is not required, the system can be implemented with off-the-shelf components. August, in fact, is basing its processor on the Intel 8086. Furthermore, when a processor does develop bad data (i.e., it is voted out at some particular iteration), it is automatically "brought back in line", because it discards its own results and uses the "good" data, on which the other two processors are agreed, as the input for the next iteration. Finally, because voting is software controlled, it is possible to apply it selectively to specific programs and specific data; when the system is not in the triple-redundant mode, the individual processors can execute different tasks, e.g., data reduction or program development activities.

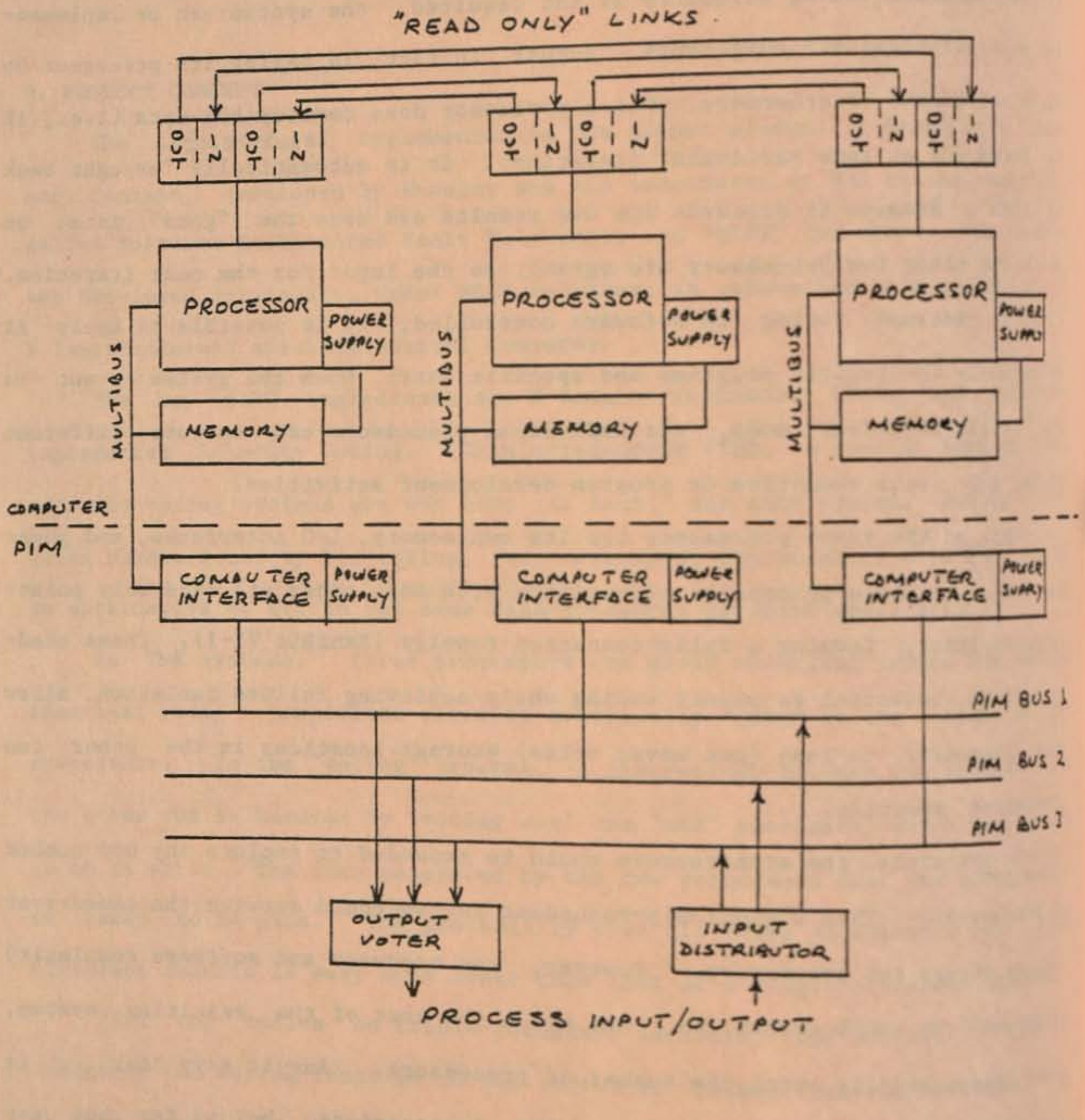
Each of the three processors has its own memory, I/O interfaces, and power supply. The three processors communicate with each other via read only point-to-point links, forming a fully-connected topolgy (Exhibit VI-1). These read-only links, essential to permit voting while achieving failure isolation, allow each processor to read (but never write) storage locations in the other two processors' memories.

In principle, the architecture could be expanded to include any odd number of processors. Thus a quantuply-redundant system could survive the concurrent failure of any two processors. However, the hardware and software complexity introduced by such extensions, and hence the cost of the resulting system, grows exponentially with the number of processors. August says that it is preapred to supply systems with more than 3 processors, but so far has not found demand for such systems.

The triple-redundant architecture is carried over to the process I/O (see

EXHIBIT VI-1

CAN'T FAIL™ 300 ARCHITECTURE



Source: ITOM International Co.

earlier exhibit). Each Process Interface Module (PIM) has three computer interface (CIF) boards, each connected to one of three redundant processors, or control computer modules (CCM). Each CIF board controls an independent, local bus in the PIM. Process I/O boards plug into the PIM. Input boards distribute the incoming signals, typically generated by various sensors and analog-to-digital converters, to the three CCMs via the three CIFs, so that the CCMs may vote on the input data. Output boards receive three values, one from each CIF/CCM, and perform hardware voting before transmitting the signal to the process, typically to actuators and digital-to-analog converters. Each CIF and its bus is powered by a separate power supply, although more than one PIM may be supported by a given supply.

E. PRODUCT OVERVIEW

August has basically two products, of which the main one is the Can't Fail™ 300 line. The other, PCS 300, is a "programmable controller", which is essentially used as a program development tool for the Can't Fail™ 300. It can also be used as an operator's control console, through which the user specifies, in graphic, menu-driven fashion, the organization of the process, the types of equipment attached to the various monitoring and control "points" in the process, and the logical relationships between these equipments. In the remainder of this section, attention will be focused on the Can't Fail 300, the company's main offering.

1. <u>Hardware</u>

Each of the three identical CCMs consists of three 12"x16.75" Multibus boards. One board contains the CPU, which is based on the Intel 8086 16-bit MPU. In addition to the MPU, the board hosts up to 16KB of PROM and up to 32KB of RAM. The communications board implements the read-only links between the

CCMs.

A control board has several functions, of which the most significant is the clock voting algorithms. Each CCM is driven by an independent real time clock, but the clock values are voted on and any bad reading corrected in the same way as computational data is voted on. This is important, because without a consistent time base, majority voting can become ineffectual.

Standard Multibus is supported, so additional memory (up to 1 MB) or Multibus-based process I/O and peripheral controllers can be added. Three different CCM packaging alternatives offer various numbers of Multibus expansion slots. Each CCM is powered independently.

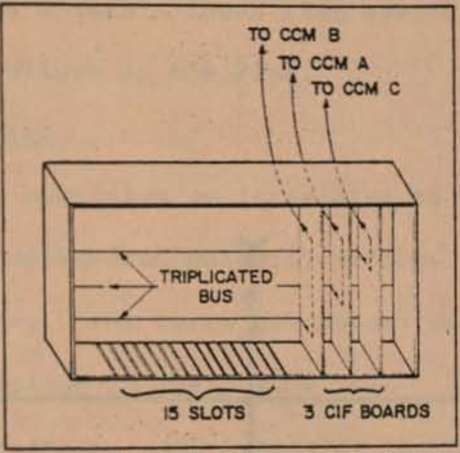
The process interface modules, PIMs, (**Exhibit VI-2**) are card cages containing a triplicated, backplane-implemented bus, three computer interfaces (CIFs), and 15 slots available for process I/O boards. Up to 15 PIMs may be accomodated in a system. The logical flow of the incoming and outgoing signals in the PIM is also outlined in the exhibit. Note the voting circuit on the output board.

The robustness of the voting circuits themselves is clearly a key issue. Luckily, a simple circuit is available which will continue to function correctly even when one of its components is faulty. In this circuit (**Exhibit VI-3**), the signals from the three CCMs, dubbed A, B, and C, drive gates which, in effect, form three AND gates ORed together, yielding the function Y = AB + BC + AC. This function will be TRUE or FALSE only when <u>any two</u> of the processors agree. The failure of any one of the six gates will not affect the circuit, as long as the processors themselves are functioning correctly. If both a processor failure and a voting circuit gate failure correspond, the voting circuit may give the wrong result. It is therefore essential to perform periodic tests on the voting circuits.

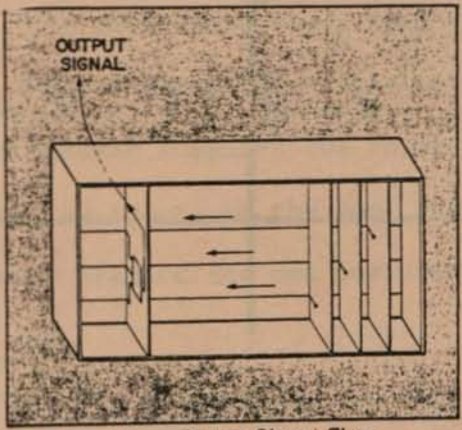
The CCMs can interface directly with the process through Multibus-based

EXHIBIT VI-2

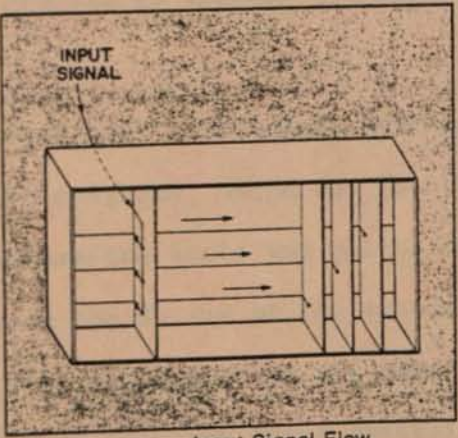
PROCESS INTERFACE MODULES (PIMs)



PIM BUS and Computer Interface.



Output Signal Flow.

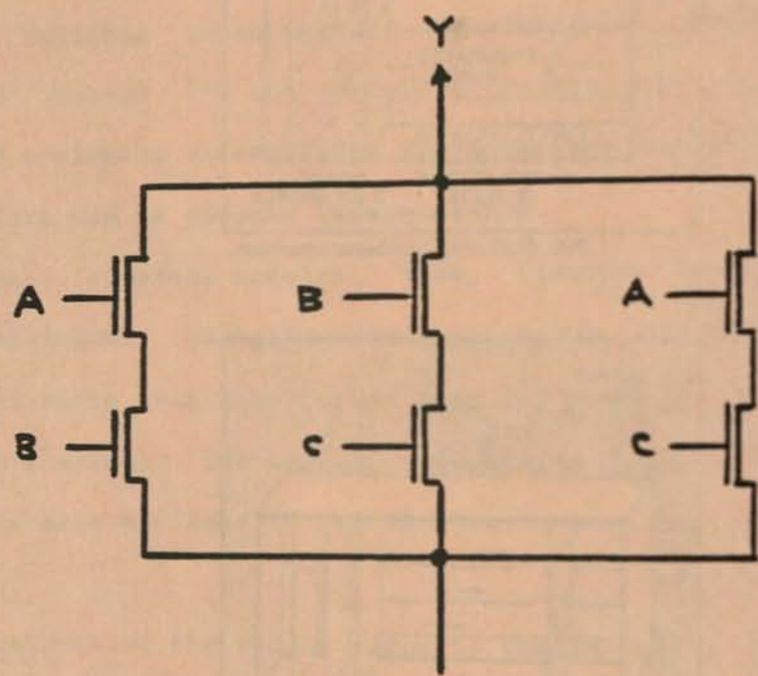


Input Signal Flow.

Source: August Systems

EXHIBIT VI-3

FAULT TOLERANT VOTING CIRCUIT



Y = AB + BC + AC

Source: August Systems

process I/O modules. By triplicating these modules, and interconnecting them in a particular fashion, the effect of majority voting can be achieved. This method could be used to obtain a lower cost system, or as a backup to guard against a catastrophic failure in the PIMs.

2. Recovery Strategies

The main recovery mechanism as it relates to the CCMs is, as outlined earlier, the software-implemented majority voting. At the end of each iteration or computational step, the three processors deposit values for all "state variables" in known locations in their memories. State variables, declared by the user during initialization, are typically the necessary inputs to the next iteration. Just before the next iteration is launched, typically upon receiving a clock interrupt, the three processors read the locations containing the state variables in each other's memories. This is accomplished over the read-only link. Then each processor compares the three values, and uses those upon which two processors agree as inputs to the next iteration. Note that this may dictate that a processor discard its own computed data in favor of values determined by the other two.

If a processor is "dead", or produces too many wrong outputs, the other two processors will notice this and post this fact. The hardware design of the system is such that a CCM can be removed and inserted without affecting the rest of the system.

How does the repaired processor regain synchronism with the other two? First, it must recover its programs, which may have been lost either because of a memory failure, or because the board was pulled out for repair. This is not a trivial problem, because the design of the system intentionally prevents any processor from writing into the memory of any other processor. Hence, it is not possible to effect this recovery under control of one of the surviving processors. The same difficulty also arises when the system is first initialized. August suggests three ways to handle this:

- o Store all programs in non-volatile PROMs.
- o Attach a backup disk, containing the running programs, switchable or dedicated to each processor, and have a disk bootstrap program stored in non-volatile PROMs.
- o Have a "copy" program in non-volatile PROMs which will copy the running programs, over the read-only link, from one of the functioning processors.

The option of storing all programs in PROM is not as far-fetched as it might appear, because in the process control environment, these programs are often quite small, and, once debugged, are rarely changed.

The second option requires that each processor have its own backup disk, resulting in a triple-disk configuration, or at least access to one switchable disk. In addition, loading can also be accomplished from the PCS 300 programmer or an Intel Microprocessor Development System (MDS).

The third method, dubbed "cross loading", is utilized by August in internal development activities. The processor being initialized or reinitialized reads programs from a running processor over the read-only link. The running processor experiences only memory cycle-stealing interference.

The PROM option appears the most desirable, and is apparently being accepted by the company's clients.

Once a processor has regained its programs, it will automatically synchronize itself at the next voting point by discarding its own meaningless operational and clock data and adopting the data produced by the other two processors. August refers to this process as the "education" of the repaired processor by the two functioning ones.

Process I/O boards, like the CCMs, can be removed and inserted on-line under power. A "tuning-fork and blade" connector system is used for reliability, and proper sequence of power, ground, and signals is assured by special power-on circuit on each board, which keeps the board disabled until power and ground have become stable.

Input boards, which are in effect triplicated (they fan the input signals through the three CIFs) are voted on by the CCMs, and consistently faulty ones can be so detected. Critical output boards can be monitored by feeding their output back through an adjacent input board. If an output board needs replacing, the following sequence is followed:

- o A new output board is inserted instead of the monitoring board.
- o The serviceman generates a "maintenance interrupt" which tells the system that the address of the newly-inserted board should be substituted for the one of the failed board.
- o A new monitoring board is plugged instead of the failed output board.

As pointed out earlier, the CCMs can support Multibus-based process I/O boards as a possible back-up for the PIMs, and August offers several such boards, in addition to the usual array of analog and digital PIM boards.

3. Software

The August operating system is RTTS (for Real Time Task Scheduler). Users can develop applications tasks in any language that is capable of producing 8086 executable code which is loadable according to the conventions established by Intel.

As its name suggests, RTTS is mainly concerned with the real time scheduling of tasks. RTTS is also responsible for implementing the software voting scheme of the SIFT concept, and for logging and reporting any errors or failures. Each of the three processors has a private copy of RTTS.

The scheduling algorithm used is apparently a variant of the "relative urgency" scheme, reported by Fineberg and Serlin in 1967. At each periodic clock interrupt (the period can be set by the user at initialization time), the scheduler assigns the CPU to waiting tasks so that those tasks whose deadlines are nearest get first crack at the CPU. The mathematical background for this scheme was provided by Serlin in 1972.

Application tasks can be scheduled to run periodically, every n time units, or on the occurrence of particular events, such as hardware interrupts, software interrupts, requests from other tasks, specific date-time combination, or the lapse of a certain time from an event.

At system start-up time, the user can specify the clock-interval value, and define the characteristics of all application tasks. The question of how these tasks get into the system is treated in the above discussion of the recovery strategies.

RTTS has extensive error detection schemes. Errors classified as arising from improper operation (e.g., arithmetic overflows, accesses to non-existent memory, etc.) are reported to the user via an interrupt and a status code. Errors which appear to be caused by hardware faults or synchronization failures are logged in special tables. These tables are scanned periodically by a scheduled system task, and their contents can be displayed on a user specified device (CRT, printer).

Additional software is available with the PCS 300, which implements a specialized process control software development facility based on relay ladder logic technology. In this system, the user specifies the control operations as if designing anetwork of relay coils, contacts, and such elements as timers and limiters. The PCS 300 allows interactive development of such networks, which are subsequently downloaded to a Can't Fail 300 system, which emulates the relay network. The PCS 300 can be used as a graphics operator interface.

The Control and Data Acquisition System (CDAS) provides application task definition and operator interface through a color graphics terminal. This package covers all commonly used control and data acquisition techniques.

In addition to the August-supplied software, standard Intel software packages, such as PLM, ASM, Fortran, and Pascal can be used via an Intel MDS.

F. ASSESSMENT

August is addressing its fault-tolerant systems to a market that is far more sensitive to the availability issue than even the transaction processing environment being pursued by Tandem, Stratus, and Synapse.

Up to now, these applications were handled by custom-designed systems, typically and predominantly based on a shared-memory, dual computer system, with one processor ready to take over should the primary processor fail. These solution suffer from a great many limitations, including the fact that shared memory represents a single point of failure, and that the switchover mechanism is usually partially or entirely manual. These defficiencies are responsible, for example, for the limited role that computerized control systems are permitted to play in power-plant environments, especially nuclear.

But the worst feature of the "conventional" back-up schemes is their ad hoc nature. Each system is custom tailored to a particular situation.

August, much like Tandem in the transaction processing environment, is the first to have devised a practical, generalized fault-tolerant solution to the industrial control and monitoring requirements.

However, the industrial control market is presently severely impacted by the current recession; and even in good economic conditions, its growth is not nearly as spectacular as the transaction processing one. While August will probably not be able to reproduce the phenomenal success of Tandem, it clearly has the potential for a better-than-average growth curve.

On the negative side, the company has so far been slow to "get going". Its product concept, while adequate for many fixed-mission applications, is not as flexible as one would wish, especially in terms of expansion.

The concentration on end-user business could also be questioned. While such business carries inherently higher margins, it also requires great resources for sales, service, and customer support. One wonders whether August would not be better off by cultivating vertical markets system integrators, who can build industry-specific applications on the August foundation and provide customer support.

We estimate that August is running at an annualized expenditure rate of around $4 million. At that rate, its funding will probably run out by year end 1982. A fifth financing round may very well be necessary before significant revenues begin to be realized from product shipments.

CHAPTER VII

OTHERS

A. COMPUTER CONSOLES

1. General

Computer Consoles, Inc. (CCI), founded in May, 1968, is headquartered in Rochester, NY. The company reported over $50 million in revenues in 1981 ($28.6 million in the six months ended June 30, 1982), and had 846 employees at year end 1981. Herman A. Affel, Jr., is president and treasurer. He has a physics degree from MIT; in the late '50s, he led the development of the Philco 2000 large-scale computer series. Just prior to assuming the CCI's presidency in 1971, he was for five years in the computer leasing business; previous to that, he spent a five year stint as vice president and technical director of Auerbach Corp., a leading computer industry information provider.

Other key officers are: Gary D. Haynes, v.p. marketing; Jeffrey Tai, sr. vp for operations; William F. Deller, vp of engineering; and Robert L. Brorein, vp of manufacturing. The company's stock became listed on the American Stock Exchange in mid-1981 (symbol CCS).

Since 1973, CCI has been specializing in providing high-availability computer systems for directory assistance ("information" operator support) applications in the Bell operating companies and some independents. CCI claims that it is the leading supplier of such systems to the U.S. telephone industry, with some 75 systems installed as of mid-1982. Interestingly enough, IBM is the next major supplier to this market.

Because of the nature of the application, high-availability is important, and therefore the systems designed by CCI, although they are based on standard DEC minicomputers, have a strong fault-tolerant flavor. In addition, the system can handle a large number of operators at remote terminals, and provides a very rapid response time (typically under 1 second) while maintaining a very large data base (typically millions of records).

Recently, the company has been broadening its market orientation in two directions. First, it is moving into the office automation marketplace with a system called Office Power™. This product, based on the Zilog System 8000 as the central computer, with Zentec terminals, was developed by RLG Corporation of Reston, VA, a company acquired by CCI in early 1981. Office Power, with software based on RLG's YARD ("Yet Another Relational Database"), is said to be "the most comprehensive office automation software package available today".

A second thrust of the diversification plan involves the upgrading of the directory assistance system to more powerful hardware, more general system software, and the expansion of its marketing scope to include general-purpose on-line transaction processing applications, outside the telephone industry.

2. The PerpetualProcessing™ System

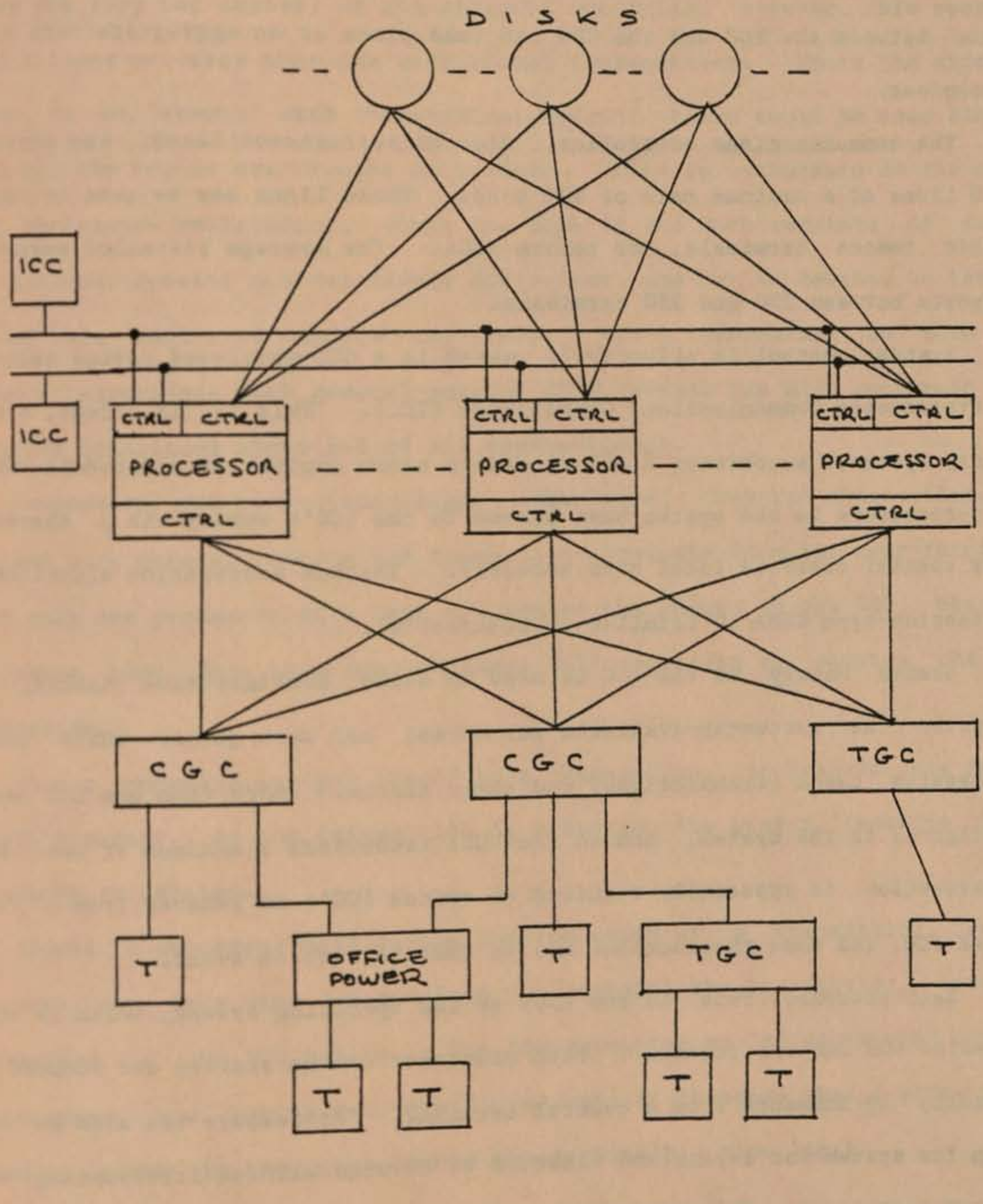
A typical DAS/CCI (Directory Assistance System), recently renamed PerpetualProcessing™, consists of up to eight processors, up to 16 disk drives, and up to eight terminal or communications controllers. Exhibit VII-1 is an approximate representation of this system.

The processors, which are currently DEC PDP 11 series minicomputers, are equipped with CCI-developed and manufactured disk controllers, each of which can access up to 16 drives. The drives, currently available in capacities of either 300MB or 600MB (450MB planned), are equipped with multi-access controllers that can support up to eight ports. These multiport controllers are also CCI products. Each processor can therefore access multiple disks, and each disk can be accessed by multiple processors. The average installed configuration contains more than 7 processors and more than 12 disk drives.

At the front (terminal) end, each processor is equipped with a CCI-developed interface that allows it to access up to eight Terminal Group Controllers

EXHIBIT VII-1

CCI DAS ARCHITECTURE



Source: ITOM International Co.

(TGCs) or Communications Group Controllers (CGCs), also CCI-developed. These controllers are multi-ported; each can attach to four processors.

The terminal controller, which utilizes from three to seven Intel 8085 microprocessors, can support up to 16 local CRT/keyboard terminals. Communications between the TGC and the CPU can take place at an aggregrate rate of 250 Kbytes/sec.

The communications controller, also microprocessor based, can support up to 8 lines at a maximum rate of 50K baud. These lines may be used to support either remote terminals, or remote TGCs. The average installed system now supports between 250 and 350 terminals.

System control is effectively vested in a CCI-developed device called the Interprocessor Communications Coordinator (ICC). This is, in effect, a shared memory system, supporting 512KB of memory under control of a Motorola 68K MPU. All processors in the system have access to the ICC's memory via a shared, 10 Mbps coaxial cable (a local area network). The bus arbitration algorithm is a contention-type CSMA/CD (similar to Ethernet's).

Shared memory in the ICC is used to store configuration tables, which describe the currently-available resources; and work queues which describe processing tasks (transactions) and their status. More than one ICC can be configured in the system, and in fact CCI recommends a minimum of two. Manual intervention is apparently required to switch ICC's to recover from a failure of an ICC, and some transactions may be lost in such an event.

Each processor runs its own copy of the operating system, which is specialized to the DAS application. Each processor can be started and stopped individually by commands from a control terminal. Processors can also be removed from the system for repair and returned to service without interrupting normal system operations. This is not true of the terminal and communications controllers, however.

Multiple copies of the data base, and the operating system, are kept on separate disk drives. In normal operation, a sort of disk mirroring scheme is maintained. A processor selected to execute an update transaction will also update the copy (or copies) of the affected record(s); however, this operation is of a lower priority than the operational transactions. Hence the mirroring action is not "atomic" with the original update; there could be some time lag until all the copies are brought up to date. This is acceptable in the directory assistance environment, where the bulk of the work consists of inquiry transactions; updates are relatively infrequent, and may be batched on tape, or entered via dedicated update terminals. (It's interesting to note that Tandem's experience with general-purpose OLTP systems has also confirmed that inquiries constitute about 80% of all transactions).

Processors are self-dispatching. When idle, they run diagnostics, and scan the work queues, looking for transaction requests from the user terminals. Since only one processor at a time can access the queues in the ICC, there is no danger that more than one processor will undertake to service the same transaction.

Once a processor assigns itself to a transaction, it records this fact in the ICC's memory. As the transaction is executed, its status, recorded in the ICC memory is updated.

Should a processor fail during the execution of a transaction, another processor can take over and complete (or restart) the transaction, based on information in the ICC tables. The ICC maintains an "aging watch" on the transactions, and begins recovery action when it detectes that a given transaction is "stuck" in the queue beyond the permissible time limit.

3. Future Plans

CCI plans to expand its market horizons to include general purpose on-line transaction processing, now pursued by Tandem and several newcomers, discussed elsewhere in this report.

To support this thrust, CCI is following a staged development process. Initially, the company will offer a system very similar to the existing PDP-11 based DAS system. However, a new processor, based on the Motorola 68K MPU, currently under development, will replace the PDP-11s. The terminal and communications controllers are also being redesigned to incorporate the 68K.

With this new hardware, a general-purpose OLTP operating system, PERPOS™, will also be introduced. PERPOS™ (for PerpetualProcessing Operating System) is coded in "C", like UNIX, and supports all UNIX system calls, including those relating to the hierarchical UNIX file system. PERPOS adds a number of features useful in the transaction processing environment, including contiguous files that allow access to large quantities of data in one I/O command, and file security.

The similarity to UNIX will allow customers to develop their own applications, or obtain third-party software, rather than be dependent on CCI to provide a turnkey system, as is the case now with DAS. This system is expected to be announced in October, 1982.

The next development stage was launched with the 1981 acquistion of an Israeli firm, The Time Machine Ltd. Time Machine is developing a 32-bit processor, expected to yield about twice the performance of the DEC VAX-11/780. This processor, dubbed TM600, will be apparently oriented to executing "C" code directly. Therefore only a minimal conversion effort will be required to adopt PERPOS to the TM600. The system is expected to be announced around June, 1983.

4. Assessment

CCI begins with a solid base and good continuing prospects in the telephone industry. It has recently been selected to develop the next generation of DAS systems for AT&T.

The experience the company has gained in the DAS environment is largely applicable to the general-purpose transaction processing market.

The company has in place a nationwide sales, support and service organization.

These are all excellent credentials, which should be of significant benefit to CCI in its quest to become a factor in the general OLTP market.

On the negative side, the restructuring of AT&T following the January, 1982 consent decree may affect CCI adversely, in that the blessings of AT&T will no longer carry the same weight with the independent Bell operating companies. This could jeopardize CCI's DAS market.

The company, which is as yet an "unkown quantity" in the general OLTP market, will have to make several significant adjustments in philosophy and operations. The AT&T experience (long qualification cycles followed by assured orders for many years) does not apply to the fiercely competitive OLTP market, where customer loyalty is hard to maintain. Also, the company's present heavily lease-oriented posture will need some adjusting.

The CCI FT design is not as consistent as some of the others, because it is based on a scheme for using essentially off-the-shelf systems (PDP-11s). Thus, should an ICC fail, the system does stop operating until a backup CCI (if present) is switched in, with possible loss of transactions. It is not clear what facilities, if any, are provided to assure data base consistency and recoverability.

The development tasks undertaken by CCI (68K processor, PERPOS, new 32-bit processor, plus Office Power) may tax the comapny's engineering capabilities.

On balance, however, ITOM believes that the positives far outweigh the negatives, and that, given the size of the potential market and, CCI's prospects are excellent.

B. CTL

Founded in 1966, Computer Technology Ltd. is the senior member of the Information Technology Ltd. (ITL) group, which also includes Network Technology Ltd. (broadband local area nets) and Office Technology Ltd. (executive workstations). Total revenues for the group amounted to 8.7 million pounds (approximately $14.8 million) and pre-tax profits were 604K pounds (about $1 million) in the year ended March, 1982.

CTL, headqaurtered at Hemel Hempstead, Hertfordshire, England, does not release financial data, but is believed to be the principal contributor to ITL's revenues and earnings. CTL has increased its revenues and profits in each of the past six years, culminated in a 30% revenue growth accompanied by a 50% increase in net earnings for the year ended March, 1982. Managing director (chief executive) is Bob Finch.

CTL designs, manufactures, markets and supports a line of computers dubbed the Series 8000. In addition, CTL is the exclusive U.K. distributor (via TRW) for the Convergent Technologies line. A third CTL activity is the Applied Systems Div., a systems house.

All three Series 8000 models apparently use the same basic CPU, which appears to be bus-oriented and microprocessor-based. The main features of each model are as follows:

	8026	8046	8066
Memory Range, Kbytes	128-512	<-- 256-1,024 -->	
Maximum formatted disk capacity, MB	100	<-- 2,000 -->	
Maximum no. of comm. lines	4	16	64
Max. no. of terminals	20	50	75
Transactions/hour	400	800	1600

The transaction throughput figures are based on a CTL benchmark in which a transaction is defined as a 4-line interactive order entry involving 32 fields CRT I/O, validation, processing, and 15 indexed file reads and updates.

Software offered includes the MODUS operating system, data management, transaction processing, text processing, eight languages including Cobol, Fortran, Basic and Pascal, a general business package, and six vertical markets applications packages.

In November, 1981, CTL announced MOMENTUM, a transaction processing system based on the Series 8000 hardware and software, expandable into a "fault-tolerant" configuration. First delivery occurred in March, 1982.

Exhibit VII-2 depicts the block diagram of a two-processor MOMENTUM system. A single processor system is nominally available, but with far more limited fault-tolerant capability, of course. The system is composed primarily of standard Series 8000 hardware and software, modified slightly, and complemented by a peripheral switching unit and by one or more interprocessor links.

The DMS 8000 data management system supports file and record locking. With the "fast recovery" option, DMS recognizes an "atomic" transaction string via a user-issued "checkpoint" call at the beginning of such a string. Following this call, DMS maintains "before" images of all updated records. Should the updating process fail, DMS notes this and "undoes" the partially-completed transactions, and releases all locks held by the failed process.

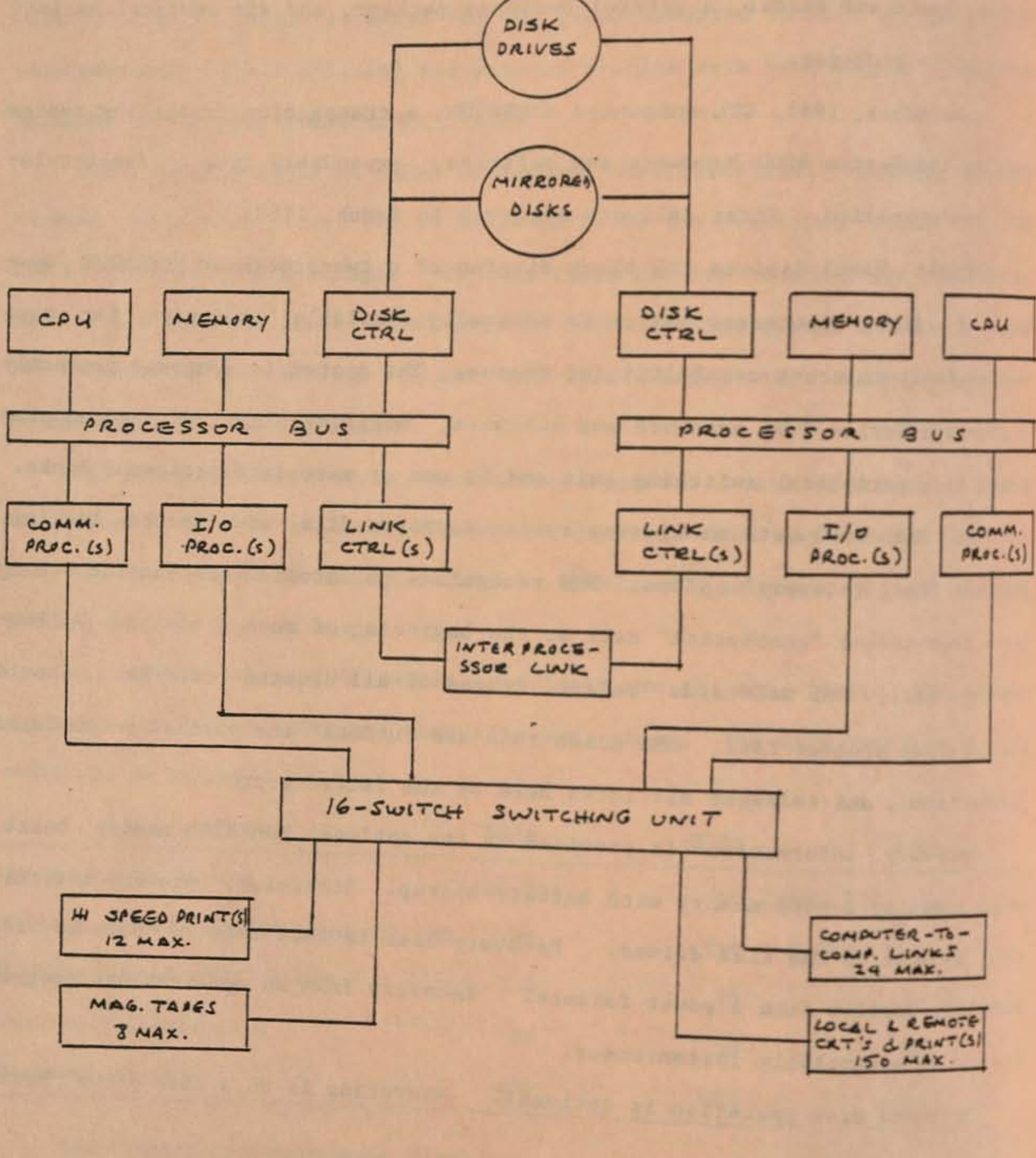
Recovery information is provided in the optional MOMENTUM memory board, which contains a 64KB memory with battery backup. Otherwise, recovery information is kept on the disk drives. Recovery time is less than 90 seconds for acomplete restart from a power failure. Recovery from an applications program failure is essentially instantenous.

Mirrored disk operation is optional. Mirroring is on a disk drive basis only.

The interprocessor link is used mainly by the two DMS copies to keep each

EXHIBIT VII-2

CTL MOMENTUM ARCHITECTURE



Source: CTL

other informed of the progress of transactions. Should one processor fail, the other is then capable of "undoing" the effect of incomplete transactions.

The transaction processing software, TAD, handles terminals in the foreground and passes transactions, via a disk-resident "log file", to the lower-priority "middleground", which handles data base accesses. Information about these log files is exchanged between the two TAD copies via the interprocessor link. Thus one TAD copy can be in charge of processing both log files. Should one processor fail, the TAD in the surviving processor can complete processing the failed processor's log file.

The peripheral switch houses power supplies and 16 individual relay switches, which can be used to automatically switch peripherals from one computer to the other.

Each communications line is supported by a 6809 MPU based I/O processor with 64KB memory. The protocol handlers running in these processors are coded in a high-level interpretive langauge, not in microcode. Up to 64 I/O processors can be attached to a Series 8000 CPU.

A 2-CPU system could support some 100 terminals with response time of under two seconds. Concurrent support of 12 high-speed communications lines with different protocols reduces on-line terminal performance by only about 10%, due to the I/O processors.

A basic, single CPU system with MOMENTUM features is arounf 45K pounds. A full dual-CPU MOMENTUM configuration starts at about 75K pounds.

C. DOSC

1. Background

DOSC, Inc. (Albertson, NY) was established in 1978. The name is an acronym which stands for Digitron Optical Scanning Corp. The company's original and main business is in designing, manufacturing and marketing computer-controlled optical scanning devices for banking applications.

In April, 1982 the company employed 62. It occupies a leased, 13,000 sq. ft. plant on Long Island, NY. Data on revenues is lacking, but is believed to be around $3 million. In August, the privately-held company was trying to raise additional capital to finance continued operation. As this report is being readied for the press, company staffers indicate that an agreement on the new financing is imminent.

DOSC is headed by president Paul Kucik. VP of marketing is William Dietz.

The DOSC entry in the fault-tolerant field is based on an earlier, distributed processing system developed by DOSC for Correspondence Resources, Inc., a Citicorp subsidiary. This predecessor system, dubbed MoneyFacts, is being used by Citicorp as a proprietary financial services product that is leased to smaller banks.

The new product, trade marked DOSC FailSafe™, was introduced in 1981. The first, and so far only shipment occurred in December, 1981. The customer was Citicorp.

2. Product Concept and Market Orientation

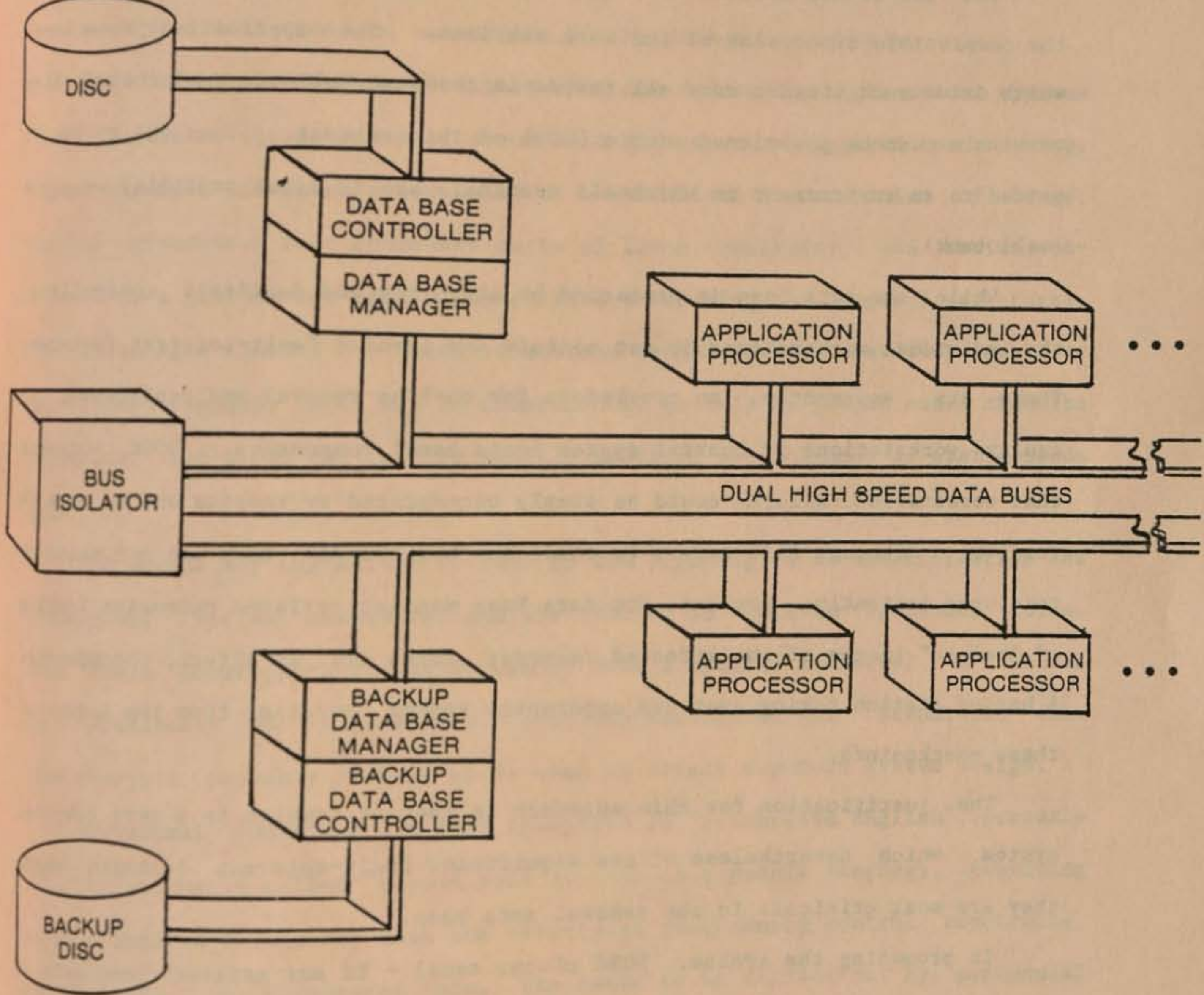
The company evidently hopes to maximize the return on its investment in the development of MoneyFacts by generalizing the system and offering it directly to end users.

The product is, in effect, a collection of up to 32 workstations, each with its own dedicated microprocessor (Intel 8085). All workstations share access to a central data base, which employs duplexed data base managers, disk controllers, and disks, and uses the disk mirroring technique, discussed elsewhere in this report, to protect the data base from disk and/or controller failures. Exhibit VII-3 depicts the system configuration.

Communications between the workstations and the data base is effected via

EXHIBIT VII-3

DOSC FAILSAFE™ ARCHITECTURE



Source: DOSC

the Multibus, which is duplicated mainly in order to accomodate the full complement of workstations. A bus isolator serves both to prevent faults in one bus from affecting the other, and to effect automatic switching of both buses from one data base to the other in case of failures.

The use of the Multibus for interprocessor communications severely limits the permissible dispersion of the work stations. The "application processors" which drive each station must all reside in the same cabinet, and the display terminals must be positioned within 1000' of this cabinet. Thus the system is suited to an environment in which all terminals are in close proximity (e.g., a small bank).

While the data base is protected by mirroring and duplicate controllers, the individual workstations do not contain any special fault-tolerant features. There are, apparently, no provisions for on-line removal and replacement of faulty workstations or central system (data base) components. DOSC suggests that workstation failures could be simply accomodated by keeping one or more in reserve. Although DOSC refers to these as "hot spares", they are not meant to take over instantly. Instead, the data base manager performs extensive logging of "before" images of the affected records; these are, in effect, checkpoints. A backup station taking over can apparently resume operation from the latest of these checkpoints.

The justification for this approach is that it results in a very low-cost system, which nevertheless offers significant fault-tolerant features where they are most critical: in the central data base.

In promoting the system, DOSC places equal - if not greater - emphasis on its software and productivity features. There are three key software components:

o Main operating system, runs in the DB Manager computer.

- o Workstation single-user operating system.
- o FailSafe Software Development System (FSDS).

These are described more fully in the Software section below. Briefly, FSDF has two key elements:

- o Reliance on, and automatic enforcement of, the precepts of the so-called "structured methodologies".
- o Simplification and automation of the production of code.

FSDS is meant to be a generalized tool for developing applications systems that conform to the precepts of structured design and structured programming. These precepts consist essentially of hierarchical decomposition of large, complex structures into component parts of lower complexity, and strict adherence to a limited set of program control (branching and looping) structures. The advantages claimed for these structured techniques are that they result in more robust designs, which can be comprehended quickly by people other than the designers, and which can be more readily modified and enhanced as user demands grow.

The second key ingredient in FSDS is the high degree of simplification and automation. System specifications are created on fill-in-the-blanks forms. From these forms (potentially by use of DOSC's optical scanners), a central data dictionary (DD) is generated, possibly automatically. Structured data flow analysis (probably Jackson's) is used to create top-down system design.

Procedural functions are then specified in "Structured English" (probably PDL, occasionally called "pseudo code"). It is a pidgin language, combining natural English vocabulary with the structured programming control constructs, to describe, in structured form, the tasks to be carried out by procedural code. These Structured English specifications are automatically translated into program code (actually, p-code). System- and user-documentation are automatically output from this translation. The system automatically checks on the use of all variables, and changes to variable definitions are automatically propagated throughout the system.

DOSC has identified a large number of potential applications in a number of industries for its FailSafe system, which, as noted earlier, is intended to support multiple terminals within the confines of a single office or plant:

INDUSTRY SEGMENT	APPLICATION
Banking & Securities	On-line retail banking operations Front end processor for real time banking applications On-line letter-of-credit preparation Interactive portfolio management On-line securities trading Securities clearance
Manufacturing	Factory management systems Factory automation and process control Distributed data collection
Insurance	Customer account maintenance Interactive policy generation Invoicing and remittance processing Interactive policy rating On-line claims processing
System Houses & OEM's	Proprietary products Intelligent workstations Turn-key applications
General Business	Management report generation On-line general ledger Interactive billing & accounting Labor reporting and payroll On-line financial planning Multi-terminal word processing and data base access
Distribution and Purchasing	On-line order entry Paperless purchasing office Inventory management Distribution management
Retail sales	Point-of-sale terminals Credit card processing

A minimal system which includes two 20 MB disks, duplexed disk controllers and data base managers, and one supervisor workstation, carries a quantity 10 price of $29,000. With two 80 MB disks, duplexed disk controllers and data base managers, one printer and one workstation, list price is $58,000, or $46,000 in quantity 10. A configuration including the duplexed data base managers and controllers, with two 80 MB disks, two 16MB cartridge disks (for backup), two 200 cps printers, and two workstations lists for $79,400. Each 8085-based workstation is $2,500.

3. Product Overview

a. Hardware

The heart of the DOSC FailSafe system is the data base complex, which consists of the following elements, each of which is duplexed:

- Data Base Manager computer.
- Intelligent Data Base Controller.
- Disk Drive.

In addition, the Bus Isolator, duplexed Multibus, and the power supplies are logically part of the central system.

The Data Base Manager, like the individual workstations, is based on the Intel 8085A-2 8-bit MPU, a single-chip, faster version of the 8080. It can execute a few register instructions in 800 ns, but most instructions take many more cycles; DOSC's claim that this is a 1.25 MIPS processor should not be taken too literally.

The Data Base Manager computer is the key component in the system. It runs the DOSC FailSafe operating system. It provides controlled access to the data base, supporting indexed sequential (ISAM) and sequential file organizations. In addition, it is responsible for the mirrored disk operation, and for effecting an automatic switchover to the backup Data Base Manager should the primary disk or disk controller fail. The switchover can also be instituted manually, which overrides the automatic selection. The Data Base Manager is also responsible for polling the applications processors (workstations) for activity.

The intelligent data base controller, rated by DOSC as a 5 MIPS processor, is actually a disk controller which can support two disk drives. It is apparently based on a proprietary, bit-slice design; DOSC provides few details here. The controller features automatic diagnostics, auto read-after-write to verify all writes, auto retry with track offset adjustment, CRC checking with auto error correction, complete error logging, and automatic alternate track assignment for bad tracks.

The disk drive is a CDC CMD (Cartridge Module Drive) with 80 MB fixed and 16 MB removable capacity for a total of 96 KB. Other capacities offered are 16, 32, and 64. Optionally, a 20 MB CDC SMD (Lark) drive is offered. SMD disks can be had in up to 300 MB capacity.

The Bus Isolator contains the circuitry to support the two Multibuses, prevent bus errors detected on one bus from affecting the other, and switching both buses to either one of the Data Base Manager computers. Two independent power supplies complete the central configuration.

The applications processor is the heart of the workstation. At least one workstation (the Supervisor) must be present, in order to control the duplexed Data Base Manager computer. Up to 31 other workstations are available for applications programs.

The applications processor is a single board CPU, based on the 8085A-2 MPU. The 64KB address space is divided into a 16KB EPROM, which contains a p-code interpreter, and 48KB of RAM. In addition, a 2KB CRT buffer is provided. The video generator produces RS170 compatible, coaxial-cable output, so the 24 line x 80 character, 10" monitor can be up to a 1000' away from the equipment cabinet. The 'remote' keyboard is attached via serial current loop interfaces. An 8-bit parallel, Centronics-compatible printer interface is also included. Communications with the Data Base Manager computer over the Multibus takes place at a maximum of 200 KB/sec.

In addition to the choice of disks (outlined above), the peripheral complement includes either a 200 cps matrix printer, 30 cps Diablo character printer, or a CDC line printer in 300, 600, or 900 lpm speed. Nonstandard peripherals offered include a Financial Application Terminal and an optical caharcter reader. These require specialized controller boards. A Cipher streaming tape drive (25/100 ips) and an 8", IBM-compatible floppy disk are also attachable via specialized interface boards.

b. Recovery Strategies

Other than providing for mirrord disk operation, and the ability to automatically or manually switch over to the backup disk/controller/DB manager combination, no specialized hardware fault-tolerant mecahnisms are incorporated in the DOSC system. Recovery from a workstation failure apparently consists of simply using a an available, idle back up workstation, and attempting to roll-back from the last good checkpoint. Some action on part of the supervisory station is probably required; e.g., to change the address of the workstation, or to allocate to it the data base access privileges of the failed workstation.

c. Software

DOSC considers its software features and capabilities as more significant than the hardware fault-tolerant mechanism. The software has three main componnets:

- o The operating system, running in the DB Manager Computer.
- o The workstation operating system.
- o The FailSafe Software Development System (FSDS).

The operating system, which runs in the Data Base Manager computer, provides the following:

- o Manages and controls access to the data base.
- o Supervises the mirrored disk operation, and effects automatic switchover should a disk or a disk controller fail.
- o Supports sequential and ISAM indexed-sequential file organizations with variable-length records and automatic record compression.

- o Allows keyed access to individual records with up to five levels of keys.
- o Allocates and deallocates file space dynamically.
- o Supports automatic record lockout for shared files.
- o Detects and prevents "deadly embrace" (deadlock) situations.
- o Maintains "Before" images of updated records to facilitate roll-back to the last good point in a transaction, should a workstation fail.
- o Provides a "cold start" procedure for recovery from failures which wipe out part or all of the data base.
- o Controls Multibus arbitration by sequential polling of each workstation for data base activity.

The single-user operating system for the applications processors is apparently a modified UCSD p-system. More recently, DOSC began offering CP/M as well. No peripherals are apparently meant to be attached to the workstation; the central disk facility is evidently where all programs and data reside. One application workstation can be equipped with a spooler software, which allows it to act as a shared "print server" for the other workstations. A p-code interpreter is in EPROM in each applications processor.

The FailSafe Software Development System (FSDS) is probably the most notable feature of the DOSC system. It combines structured design concepts, a centralized data dictionary (DD), and automatic code generation to provide improved productivity and maintenability. It runs primarily in the applications processors.

Simple paper forms are used to define all system inputs and outputs. These forms are simple enough to be filled directly by the end users. A central data dictionary (DD) is generated automatically when the variable definition forms are entered into the system. This could conceivably be done through the DOSC optical scanner, though there is no indication that this has been achieved.

The structured data flow analysis technique is then used to generate the top-down, hierarchical data flow diagram (bubble chart) for the application. Data flow analysis is a particular structured design technique, in which the charting of data flows precedes the design of procedures.

To describe the functions of the procedural sections of the design, a scheme called "Structured English" (probably Caine & Farber's PDL) is used. This is a pidgin language, which combines natural English vocabulary with the structured control mechanisms (if-then-else, do until). It allows a readable, flexible definition of the procedures, while adhering to the structured design concept, which restricts branching logic to a few cases (specifically excluding go-to). **Exhibit VII-4** is an example of a procedure written in Structured English.

The Structured English specifications are then automatically translated into p-code by a specialized compiler. This compiler also generates well-indented listings, which are used for both system- and user-documentation. The compiler refers to the data dictionary and performs global checks on variables.

Changes to variable definitions are propagated semi-automatically throughout the system. That is, it is not necessary to redefine each variable in each program; but it is necessary to recompile all programs.

In addition, a dialect of Pascal is available, as is an 8085 assembler.

4. Assessment

DOSC is going after a specialized low-end of the on-line, high-integrity transaction processing market defined so far by Tandem. Its product strategy is rather intriguing:

- o Offer a very low cost product.
- o Use off-the-shelf MPUs (8085).
- o Offer fault-tolerant features only where they are critical, i.e. in the central data base.

The product does suffer from the limitation that all user terminals must

EXHIBIT VII-4

STRUCTURED ENGLISH

Messages

• All displayed messages are maintained in a centralized message file.

• These messages are displayed automatically by the system the next time any screen is displayed.

Data Entry From Screen

• This single statement initiates an automatic sequence that causes the system to read all data fields from the screen, edit the data using both standard and specialized edits, display incorrect data fields and loop until all entered data is correct. This simplifies the data entry process and prevents contamination of the data base.

• Alphanumeric constants may be used instead of literals to clarify the operation being performed.

Recovery Procedures

• Log activates the recovery mechanism. Any record that is updated has its "before" image saved until the transaction is complete.

• Log completion signals completion of the transaction and removes the "before" image records from the file. If the transaction does not complete, warm start recovery backs out the uncompleted transaction.

```
PROCEDURE GENERAL_LEDGER_DIRECT_POSTING USING ('CUSTOMER_NUMBER')
   DO THE FOLLOWING UNTIL 'OPERATION' IN 'G_L_DIRECT_POSTING' IS EQUAL TO 'EXIT'
      MESSAGE # 1440 "GENERAL LEDGER DIRECT POSTING (ENTRY/PRINT)"
      MESSAGE # 1450 "ENTER OPERATION. (EXIT=0, POST=1, PRINT=2)"
      PROTECT ALL FIELDS IN 'G_L_DIRECT_POSTING'
      UNPROTECT 'OPERATION' IN 'G_L_DIRECT_POSTING'
      DISPLAY 'G_L_DIRECT_POSTING' AND WAIT FOR DATA
      PROTECT 'OPERATION' IN 'G_L_DIRECT_POSTING'
      SELECT 'OPERATION' IN 'G_L_DIRECT_POSTING' AS FOLLOWS
         CASE 1 IS 'EXIT'
            MESSAGE # 2050 "GENERAL LEDGER DIRECT POSTING COMPLETED"
         CASE 2 IS 'POST_TRANSACTION'
            LOG TRANSACTION STARTED
            PERFORM TRANSACTION_POSTING USING (SCREEN 'G_L_DIRECT_POSTING')
            IF RETURNCODE IS NOT EQUAL TO 'SUCCESSFUL'
            THEN
               MESSAGE # 2070 "TRANSACTION POSTING ABNORMALLY TERMINATED"
               THIS PROCEDURE HAS FAILED
               EXIT GENERAL_LEDGER_DIRECT_POSTING
            ENDIF
            LOG TRANSACTION COMPLETE
         CASE 3 IS 'PRINT_DIRECT_POSTINGS'
            BEGIN REPORT 'DIRECT_POSTING_REPORT'
            READ RECORD FROM 'POSTFIL' USING 'CUSTOMER_NUMBER' AND 'ITEM_NUMBER'
            IF RETURNCODE IS EQUAL TO 'SUCCESSFUL'
            THEN
               DO THE FOLLOWING UNTIL 'CUSTOMER_NUMBER' IN 'POSTFIL' IS NOT
                                      EQUAL TO 'CUSTOMER_NUMBER'
                  PRINT LINESET 'DIRECT_POSTING_DETAIL_LINE' ON REPORT
                                      'DIRECT_POSTING_REPORT'
                  READ NEXT RECORD FROM 'POSTFIL'
                  IF RETURNCODE IS NOT EQUAL TO 'SUCCESSFUL'
                  THEN
                     IF RETURNCODE IS NOT EQUAL TO 'END_OF_FILE'
                     THEN
                        MESSSAGE # 9910 "I/O ERROR WHILE READING POSTING FILE"
                        THIS PROCEDURE HAS FAILED
                     ENDIF
                  ENDIF
               ENDDO
            OTHERWISE
               MESSAGE # 9910 "I/O ERROR WHILE READING POSTING FILE"
            ENDIF
            END REPORT 'DIRECT_POSTING_REPORT'
      ENDSELECT
   ENDDO
   EXIT GENERAL_LEDGER_DIRECT_POSTING
   ENDPROCEDURE GENERAL_LEDGER_DIRECT_POSTING
```

File Access

• Record is read using a concatenated key composed of a variable identifying the customer and a variable specifying the desired data item.

• System requires RETURN CODE testing on all procedure calls and Input/Output operations.

Print Report Operations

• The Print operation is greatly simplified through the use of a centralized file of print report descriptions, header and trailer descriptions and report data line descriptions.

• The user is not required to perform the data movement operation.

• The system automatically counts lines and controls pagination.

Source: DOSC

reside in close proximity, i.e., no support for remote terminals hooked over switched or dedicated communications lines. This does limit the appeal of the product in many applications. On the other hand, there are undoubtedly numerous other applications, such as small banks (with which DOSC is particularly familiar), where the product fits very well.

The emphasis on the productivity and software issues may be a tactical necessity, perhaps, because the fault-tolerant aspect is not as extensive as in the Tandem, Stratus, Synapse and August offerings. One wonders, however, whether DOSC is not making too much of these. It dubbs its approach to system design and coding "revolutionary", whereas in fact neither data dictionaries nor structured English ("pseudo code") are particularly new. The ideas of structured programming (later expanded to cover general design, not just coding) have been around since 1966; despite initial glowing expectations that these would revolutionize the production of EDP systems and procedures, structured techniques so far have met severe resistance by both line personnel and corporate management. One wonders whether DOSC is undertaking to "re-educate" the world.

The marketing strategy, which currently appears to be aimed at end-users directly, can certainly be effective initially, especially if coupled with self-discipline in carefully defining limited geographical target areas. However, since the applications which fit the product specifications are very fragmented both geographically and in terms of industry segment classification, it would seem that sooner or later, DOSC will have to identify and nurture several vertically-oriented, local system houses.

By far, corporate viability and credibility is now the primary issue for DOSC. In the absence of any significant market performance so far, the company clearly needs either a substantial infusion of capital, or a known corporate entity as a backer. Should it succeed in obtaining sound financial backing, DOSC has an interesting product and a promising marketing strategy. Given the size of the potential market, the company should do very well.

D. PARALLEL COMPUTER

Parallel Computer Systems, Inc. (Englewood Cliffs, NJ), was founded in October, 1980 by Emanuel ("Manny") Wittels, previously VP of development at Wordstream (which was disbanded after being acquired by MAI). Earlier, he was involved in some of the early fault-tolerant military systems, including SAGE and BMEWS. He is chairman of the board and acting head of development for Parallel.

President of Parallel is Rick Martin, formerly planning manager for IBM in the System/370 138 and 148 and the 4331 programs. He served with IBM for 13 years in a variety of sales, marketing and planning responsibilities.

Vice president of marketing is another ex-IBMer, Thomas Garvey. He spent 22 years with IBM in a variety of posts, including sales, systems engineering, field management, and marketing support management.

Aldo T. Benenati, a Parallel cofounder, is vice persident for administration. He was previously with Wordstream.

Philip Messinger, also a cofounder, serves as vice president for finances and treasurer. Since 1975, he has been active in investments and venture capital.

Wittels, Martin, Benenati and Messinger are also members of the board. Other directors are Evelyn Berezin, Solomon Manber, and Timothy Horne.

In February, 1981, the company secured about $2.2 million in seed capital from Aleph Null Corp. of New York, and private investors. In early August, 1982, the company was reportedly close to concluding a second, $6 million financing round. Employment at that time stood at about 40.

Current plans calls for prototype availability in 3Q82, official announcement in 1Q83, and general availability in 3Q83.

Parallel has not released any product details so far. However, ITOM believs that the hardware product concept employs up to 32 processing "clusters", communicating over a high-speed, 32-bit wide, duplexed bus system. Each cluster contains up to three, 68000-based processors, up to 12 I/O controllers, and up to 8MB of RAM, implemented with 64Kbit chips. One of these processors acts as the cluster's "supervisor": it performs operating system functions, allocates applications work (to itself and the other cluster processors, if any), and supports the interface to the bus for inter-cluster communications. The cluster processors continuously check themselves by always running diagnostics, except when preempted by system functions or user tasks.

A minimum configuration apparently consists of two clusters. In a multiple cluster configuration, some clusters are specialized, for example to control the data base. The maximum configuration is said to be able to attach over 9,000 terminals.

Mirrored disk operations are supported. The disk management algorithms are said to be especially fast.

Perhaps the most interesting aspect of the system is the software. Parallel plans to use UNIX as its operating system. The internals will be modified to improve the system's efficiency in servicing transaction processing applications, and to support fault-tolerant operations in the context of the specific Parallel hardware architecture. The aim is to make the fault-tolerant mechanisms transparent to the user. The UNIX user and applications interfaces will be left intact, both in order to appeal to users already familiar with this operating system, and to allow them to take advantage of the emerging market in third-party supplied, UNIX-based applications packages.

This is important not only because applications software availability makes the system more attractive to prospective customers, but also because Parallel hopes that such third-party supplied software will obviate the need to develop such products in house. The company is already moving aggressively in this direction, by planning to purchase rather than develop its relational data base offering. This is believed to be a product similar to IBM's SQL/DS.

Cobol, Pascal, and "C" are planned initially, with Fortran, PL/1, and Basic to be added later. An ambitious networking support is believed to be part of the planned software, with the user able to access data in remote Parallel or non-Parallel systems.

Parallel has done an analysis which supports its belief that, in realistic, medium-sized configurations, it could maintain a price/performance advantage relative to Stratus and Tandem through 1987.

Not enough details are known about the Parallel hardware, software, and fault-tolerant features to permit an intelligent assessment. However, the basic concept of creating a UNIX-based fault-tolerant design is intriguing, due to the increasing popularity of this Bell Labs' developed operating system. However, some knotty problems, for example the interface between the UNIX file system and that of the selected DBMS, remain to be worked out.

E. PARALLEL COMPUTERS

Parallel Computers of Santa Cruz, CA (not related to the similarly-named New Jersey company discussed above), is headed by brothers Scott and Mark Pine, who are also engaged in another joint venture, Digimedics. Founded in 1974, Digimedics is a supplier of turnkey systems for hospital and other medical applications, both administrative and clinical. Digimedics' revenues are said to be running at approximately $3 million (annualized rate). The company employs about 20 and has delivered a number of systems so far, mainly based on

Digital Microsystems' hardware, and Digimedics' own vertical applications software.

Parallel Computers, which is currently capitalized by its founders, has 7 employees. It is in the process of developing a fault-tolerant, UNIX-compatible system based on the Intel 432 MicroMainframe™. Scott Pine is handling the business end, while Mark Pine, a graduate of UCSD (where he participated in the UCSD Pascal project) and a software engineer by education, is developing the system with another of the founders.

Parallel hopes to raise venture capital by year-end 1982, and intends to unveil its product line in 2Q83. While the company is reluctant to discuss product details, it has provided ITOM with some information. The following description is based on that information.

Parallel feels strongly that software and data integrity are as important to computer system reliability as hardware fault-tolerance. The iAPX 432 was selected mainly because its object-oriented architecture, unlike the "flat" architecture of conventional MPUs, provides hardware protection mechanisms that permit detection and isolation of software faults.

Another reason for the choice of the 432 is the graceful growth ("transparent multiprocessing") capability, facilitated by the self-dispatching feature of the 432 processors.

Despite some early problems with the Intel chip set, Parallel (unlike Synapse and Modcomp) does not plan to abandonand the 432. The company believes these problems are typical of the early development stage of the 432, and expects to receive production units in 4Q82. Meanwhile, software development proceeds using an in house VAX 11/730.

The Parallel system is composed of two logically separate processing subsystems. The central processing subsystem, which consists of a minimum of two 432 GDPs and 512KB of ECC memory, performs all processing functions. It utilizes the 432 System Bus for communications between the GDPs.

All I/O functions are localized in the I/O subsystem, which supports a standard Multibus at the peripherals end while attaching to the System Bus at the other end.

An entry-level system will support multiple 5-1/4" Winchester disk drives, with floppy disks or a streaming tape for backup. Larger systems may use 8" Wincheters and may include up to 5 GDPs.

UNIX System III will be the operating system, because of its increasing popularity with users, and because of the growing availability of standardized, third-party-supplied applications software. In addition, Parallel plans to offer a proprietary software product that addresses the programming productivity issue.

Initial market focus will target system integrators with vertical markets applications packages. Digimedics can be expected to be an early user.

F. SEQUOIA

Sequoia Systems, Inc. (Natick, MA) was founded in September, 1981 by Allen Burgess, Richard Karp and Jack Stiffler.

Allen Burgess, president, was previously senior vice president for engineering and development at Nixdorf Computer Corp. of Burlington, MA. Earlier, he was director of processor development for Data General, and held engineering management and design posts with Raytheon and Honeywell.

Dr. Richard Karp, vice president for software, was previously a computer science consultant and a lecturer at Stanford University, where his doctoral dissertation dealt with verification of operating systems. He also did work in secure and reliable transmission protocols.

Dr. Jack J. Stiffler, vice president for hardware, was previously a consulting engineer with Raytheon, where he was involved in the development, of the SERF fault-tolerant spaceborne computer for the USAF, and a NASA reliability study, among other projects. He holds a patent for the Rippler Circuit, a key component of the SERF computer, and authored a book on synchronous communication theory, published by Prentice Hall in 1971.

In September, 1981, the company raised approximately $2 million in seed capital from Arscott, Norton & Associates of San Francisco, and private investors. Employment in April, 1982 stood at 14. Sequoia has declined to provide any further details of its funding, organization, or product, claiming that such details are pending the filing of a patent, expected to occur sometime in the summer of 1982.

ITOM believes that the Sequoia product is a fault-tolerant system based on multiple 68000 MPUs. The operating system will apparently present UNIX-compatible interfaces at the applications and user levels, while the kernel (system internals) will be modified to support the fault-tolerant hardware.

Graceful upgrading will be provided so that the system's capability can be increased from 20 to as many as 30,000 terminals, according to the company. In terms of CPU power, capacity can grow from around 0.7 MIPS (generally regarded as the CPU power of a single 68000 MPU) to about 40 MIPS, suggesting that up to 64 MPUs can be supported.

An especially fast disk management algorithm, supported by special hardware, is believed to be an important part of the design (the patent application mentioned earlier is in connection with this hardware).

In addition to the operating system, software plans call for Cobol, Pascal, and "C"; a real-time "event manager"; text editor; word processing; a data base management system (to be acquired from an external source); and X.25 and SNA interfaces. Software development is proceeding on an in-house VAX

11/750.

The system will apparently be aimed not only at the "VAX/UNIX market", but also the factory automation and possibly process control environments. For this purpose, an IEEE 796 (Multibus) interface will be provided, along with controllers for factory data collection devices. The CPU scheduling algorithm will permit tasks to occupy a procssor as long as they can do useful work, in contrast with time-slicing systems. This is apparently in response to the DEC VMS system for the VAX line, where excessive roll-in/roll-out prevents efficient execution of real time or batch jobs.

Better fault-tolerance than in the Tandem system is claimed, apparently through self-checking implemented by hardware pairs and "exotic coding algorithms", according to one company staffer. In particular, transient failures will be identified and logged, after which the failed nodule is returned to service. The fault-tolerant mechanisms are said to be entirely transparent to the applications level user. The system is said to be able to sustain multiple and consecutive failures without "crashing", and to have no single point-of-failure.

The diagnostic system will also be able to pinpoint throughput bottlenecks, to aid in planning for system growth.

Present schedule calls for product announcement in September, 1982. The company claims to have already secured three firm orders as of April, 1982, each for a system in the $250,000 price range. Two of these came from Fortune 100 accounts, while the third is from a Fortune 500 company. Beta site testing is planned for around April, 1983, with general availability scheduled for 2Q83.

The company is expected to assume an end-user orientation, setting up its own service and support organization. The main market target appears to be not Tandem but the DEC VAX and UNIX users. They are expected to be weaned from DEC primarily on the strength of Sequoia's modular growth, better system scheduling algirthms, and fault tolerance features.

The lack of officially-released detail prevents any rational assessment of this entry. It appears that the company is still in the capital raising stage.

G. SYNTECH

Syntech International, Inc. (Dallas, TX) was established by Gordon T. Graves in June, 1981, by melding together a manufacturer of microprocessor boards and desk top microcomputers, SDSystems, with Graves' own operation, now called Multigame Ventures, which was engaged in marketing turnkey systems to the gaming and state lottery marketplace, based on SDSystems microcomputers. At the time these two operations were combined, the new organization went public (it is traded OTC under the symbol SYNE).

The company leases a 35,000 sq. ft. plant and employs about 100. SDSystems products, sold through a network of over 180 dealers internationally, accounted for all of the $6 million in revenues Syntech reported in 1981. Earnings for that period were less than $50K.

Early in 1982, the company announced that it "tentaively" won an $11 million contract from the state of Michigan to computerize the state lottery system with some 24 of Syntech's Marathon NonFail™ systems.

The NonFail system consists of two or more SDSystems' microcomputers, interconnected via MARS/net, a local area network scheme. Few technical details have been released. ITOM believes that the basic product concept is a sort of a "loosely coupled" self-checking scheme, under which two microcomputers run identical programs, with a third performing comparisons, and probably taking over if a mismatch is discovered.

The concept of using networked microcomputers to provide fault-tolerance (or reduce the need for it) is interesting and potentially of great appeal to the low-end transcation processing market. However, Syntech is yet to install such a system. The company also faces a significant writeoff from the cancellation of a contract with the New York State Lottery, which could wreak havoc on the bottom line.

H. SYNTREX

Syntrex Incorporated (Eatontown, NJ) was founded in 1979 by Dan Sinnot and Jim Bruno, who were also the founders of Interdata in the mid-1960s, and by Jim Folts, a former Interdata executive (Interdata was later acquired by Perkin Elmer). Sinnot is chairman and president, Bruno is exec vp, and Folts is vice president. Financial backers included Ampersand III; Bessemer Venture Partners; Welsh, Carson; Olivetti Realty; private investors; and the principals.

Syntrex went public in March, 1982 with a 1.6 million share offering which raised about $16 million. Its stock is traded OTC under the symbol STRX. For the six months ended April 30, 1982, Syntrex reported $16 million in revenues and $1.6 million in net income ($0.21/share). It operates in an 88,000 sq. ft. plant, with 9 sales and services offices in the U.S. Other areas are served by 35 dealers.

Olivetti, which holds about 19% of the stock (through a subsidiary) takes more than half of the product, and has exclusive European manufacturing and distribution rights.

Syntrex set out initially to develop an 8086-based, stand-alone word processing system whose main attraction was its ability to use an IBM electronic typewriter as the I/O device. The product, dubbed Aquarius, now also supports the Olivetti electronic typewriter, which Syntrex calls Aries.

Despite what appeared to be devastating competition from IBM's Displaywriter, introduced simultaneously with the Syntrex product, Aquarius has done extremely well.

Syntrex next set out to develop Gemini, an 8086-based, fault-tolerant file server, which Syntrex prefers to call an "electronic file cabinet", capable of storing 120,000 pages and of supporting up to 14 Aquarius stations. Polaris, the latest product, is a reduced version of the Gemini; it can support up to 6 Aquarius stations, and makes do without the fault-tolerant features.

Stations attach to the "file cabinet" in a star configuration, with the communications links running at 320 Kbps. A recently-introduced local area network scheme, dubbed SYNNet, which can connect up to eight Gemini or Polaris clusters, is an Ethernet-like contention bus (coaxial cable).

The Gemini product, which was announced with the Aquarius in June, 1980, but did not begin shipping until the quarter ended April 1982, creates a fault-tolerant environment, dubbed Always Up™. Internally, it consists of two identical halves (Exhibit VII-5).

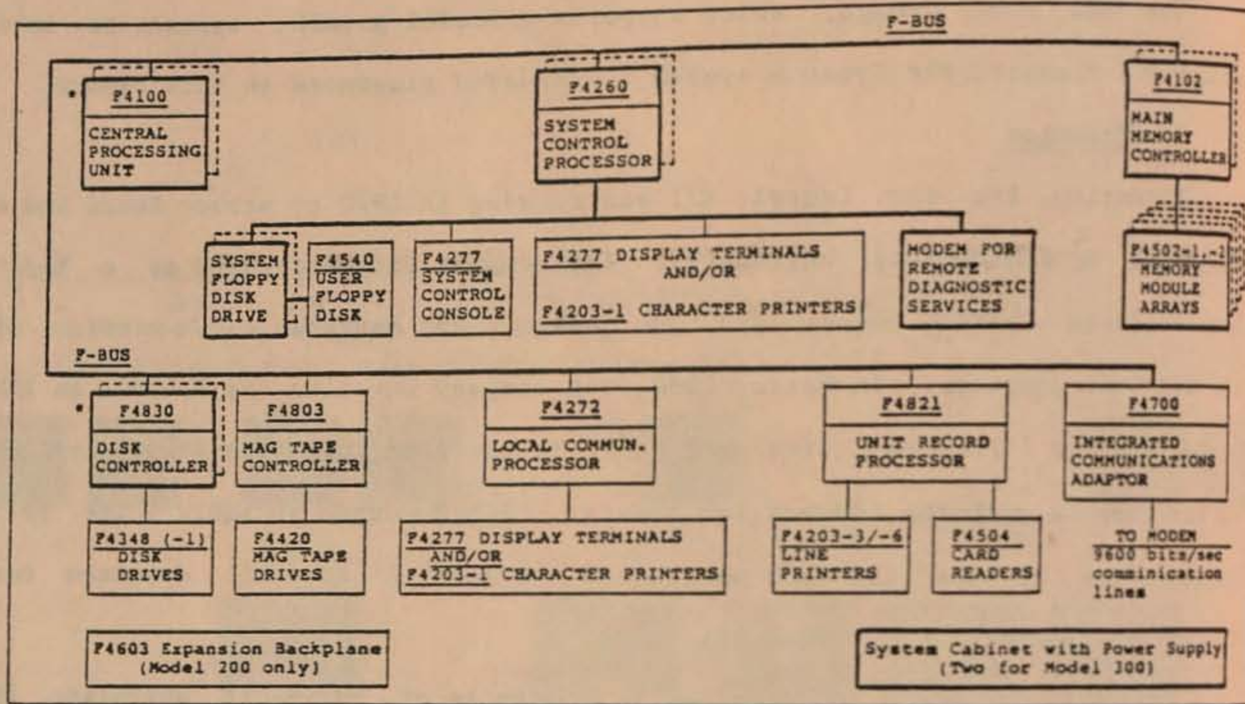
Each separately-powered half contains an 8088-based interface to the workstations, a 128KB 8086-based file management processor, one 14" Winchester disk drive of up to 150MB, and an automatic dialer dubbed Service Genie™. One half is intially designated "master"; the other half "shadows" the master and maintains its disk so as to mirror the master disk. Should the master fail, the other half takes over and continues to support system operation.

The Service Genie is a nice touch. The surviving half automatically dials the toll-free Syntrex service center number to inform it that a malfunction has occured, and to report the results of the internal diagnostics at the time of failure. This facility assures that a failure will not go unnoticed.

Despite its fine features, Gemini has not had the acceptance the company had hoped for. The Polaris, which is essentially one half of the Gemini, was developed as a response. Nevertheless, some segments of the word processing

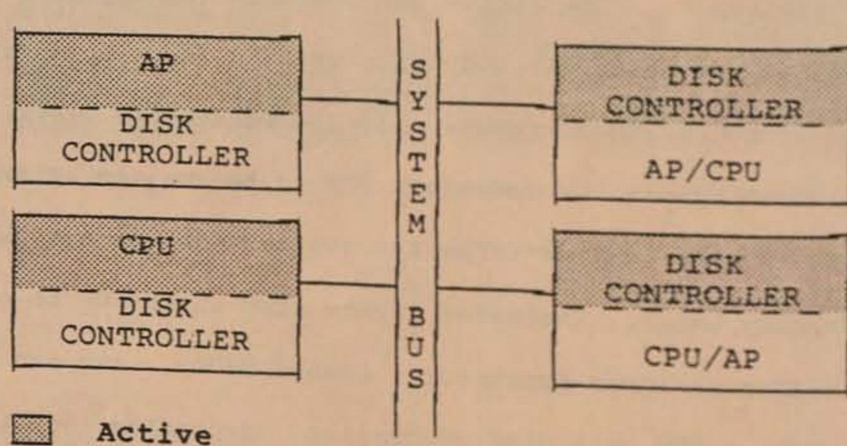
EXHIBIT VII-7

FORMATION F/4000 ARCHITECTURE



KEY:

- MODEL 100 — Components for entry level system (see *).
- MODEL 200 — Model 100, plus separate CPU and Disk Controller via Expansion Backplane.
- MODEL 300 — Components added to Model 100 via second System Cabinet.
- OPTIONAL EQUIPMENT that can be added to any F/4000 model to enhance its performance capabilities and improve its reliability.
- * CPU and DISK CONTROLLER share the same electronics (Model 100 and 300).



Source: Formation

controller can continue operating by sharing the surviving MPU29. When the SCP determines that a particular MPU29 has failed, it re-IMPLs the system, reconfiguring the remaining MPU29 to operate in the shared mode.

The main difference between the F/4000 Models 100, 200, and 300 is that the entry level Model 100 provides the shared MPU29 exclusively; the Model 200 provides independent MPU29s for the CPU and disk controller; and the Model 300 provides the independent CPU and disk controller, and supports the automatic reconfiguration for MPU29 sharing option, described above.

In May, 1982, Formation announced the availability of the Attached Processor (AP) option, under which a Model 300 can be equipped with up to four MPU29s, operating as a main CPU, an attached processor (AP, a concept supported by a number of IBM operating systems, including VM, which is supported by Formation), and two disk controllers. In normal operation, the AP enhances throughput by executing applications tasks; however, all I/O is handled exclusively by the primary CPU. As shown in the exhibit, each MPU29 can have a primary and a secondary mission, designated in the floppy-disk-based system configuration table, which the SCP uses to control reconfiguration upon discovering a failure.

Two memory controllers are provided in the Model 300, each supporting up to 4 boards of either 256KB or 1 MB each (16Kbit and 64Kbit chips, respectively). Should a hard memory failure be detected, the SCP re-IMPLs the system, while reconfiguring it to disconnect the affected memory controller and reassign (if necessary) memory address zero to the surviving memory space.

Disks may be dual-ported and electronically switched between two controllers. The local communications processor, mag tape controller, and unit record processor can be duplicated to enhance performance; upon failure, the SCP automatically reconfigures out the failed controller. DC power supplies are optionally duplicated when the expansion cabinet is added to the main system cabinet. Each set of supplies supports the equipment in its own cabinet. Upon failure, the SCP automatically reconfigures the system to exclude the components in the failed cabinet (this requires, of course, that two sets of all the minimally required modules are present, one set in each cabinet). Automatic reconfiguration typically takes about 5-10 minutes.

The Formation fail-soft concept is not unlike that offered by Synapse (see elsewhere in this report), although Formation is clearly limited by the need to maintain IBM operating system compatibility.

4. High Integrity Systems

High Integrity Systems Ltd. (Sawbridgeworth, Hertfordshire, England) is a consultancy and systems house, specializing in Motorola 68000 and Intel 432 based designs.

In November, 1982, HIS plans to begin offering a two-board microprocessor as a standard product. One of the Multibus boards carries Intel 432 3-chip set, clock, bus arbiter, and memory controller. The second board carries 1/2 MB of memory, and an intelligent I/O channel implemented with four 2901 AMD bit slice chips and supported by 32KB of "I/O memory", and a Multibus interface.

This board set can be extended by plug-ins to systems which include up to five 432 engines, up to 2 I/O channels with up to 128KB of I/O memory each, and up to 2 MB of main memory (with a planned 1 MB memory board).

Although the company's name is suggestive of fault-tolerant ambitions, and the choice of the 432 further reenforces this suggestion, the company says it has no current plans to enter the fault-tolerant systems market.

5. Modcomp

Modular Computer Systems (Ft. Lauderdale, FL), was founded in 1970 by Ken Harple and a group of engineers who left SEL (now a Gould subsidiary). Modcomp grew very rapidly, but ran into some trouble in 1977; ever since, the company's performance has varied; in January, 1980, the company received a much needed infusion of capital ($30 million) from the giant German electronics concern AEG Telefunken (AEG itself is reorganizing in receivership as this report is being readied for the press). Since 1977, Modcomp suffered a number of management shakeups which first saw Harple ousted, followed by the resignation of Alexander Giles, his successor. The company is now led by Gabriel Rosica.

The company specializes in minicomputers for process control and industrial automation applications. Like most other mini makers, Modcomp has attempted to break out of the limitations of its 16-bit architecture in a number of ways. Its present Classic computers are "hybrid" 16/32 bit machines, with internal 32 bit processing capability and limited forms of extended addressing.

One recent attempt to switch to a 32-bit architecture was centered around the Intel 432 chip set. However, that effort was dropped when, in February, 1982, Modcomp concluded a "technology transfer" agreement with Control Data Corp. Under this agreement, Modcomp received the commercial marketing rights to a 32-bit computer design that CDC began developing in 1972 for a variety of military applications. CDC received 90,000 Modcomp common shares, representing about 2% of the outstanding stock, and valued at the time at some $630,000.

As part of the agreement, Modcomp took on Benjamin Harrison as senior vp and John Griffith as director of business development. They previously ran a start up company called Continuous Computer Corp., which originally had the license to the CDC machine,

Modcomp has released no details of the product. ITOM believs, however, that this microprogrammed, Schottky TTL machine will be in the upper range of the "supermini" class; it will have substantially better throughput than the VAX 11/780 and Modcomp's present Classic line, which boasts an 8 Mbyte/sec I/O system. The product will probably compete with the SEL 32/87.

The very high performance of the machine will permit Modcomp to increase its penetration of the communications market, and enable it to address the scientific computation market, in which it has no significant presence now.

One of its main attractions for Modcomp is that it will be able to emulate present Modcomp Classic architecture to run current Modcomp 16-bit software. In addition, it will have a native 32-bit architecture, with a large address space and support for a large amount of physical memory.

The basic product concept is that of a tightly-coupled multiprocessor, with all processors executing code from the shared memory, although processors could also have private memory. One processor is nominally the "master", assigning tasks to the other processors, either on a pool basis, or as specified by the user. Should the master fail, one of the remaining processors automatically assumes its role. Processors exchange "I'm alive" messages via the shared memory; failures can also be detected by extensive, microprocessor-based diagnostic subsystems built into the processors and IOPs. Remote diagnostics are also supported.

Redundant power system with on-line remove/reinsert capability will apparently be supported, as are dual-ported controllers and mirrored disk operations. Because of the company's present control and real-time orientation, the product is not likely to have significant data base consistency/recoverability features, at least initially. Product unveiling is expected in late 1983 or early 1984.

6. <u>National Semi</u>

The Systems Division of National Semiconductor Corp. (Santa Clara, CA) supplies the Datachecker® supermarket POS system and is the second largest supplier of such systems, with about 30% of the market (NCR leads with about 34%).

In July, 1982, the division concluded an OEM agreemnet with Dynabyte (Milpitas, CA), under which National would purchase between $3.5 and $6 million worth of Dynabyte computers, especially the Monarch desk-top system, which employs both a Z80B and an 8086.

National evidently plans to market the Monarch as a "store computer", to support the POS terminals; but it is also possible that it would offer the unit as a general-purpose business computer.

Although the company has not realesed any details, its System Division has been known to have a strong ineterest in fault-tolerant systems to support its POS terminals. There is some speculation that National might upgrade the Monarch to offer some fault-tolerant features.

APPENDIX

SUPPLIERS LIST

(Last line in each entry is the telephone number: area code/number)

August Systems
2757 19th Street SE
Salem, OR 97302
503/364-1110

BTI Computer Systems
870 West Maude Ave.
Sunnyvale, CA 94086
408/733-1122

Computer Consoles, Inc.
97 Humboldt Street
Rochester, NY 14609
716/482-5000

Computer Technology Ltd.
Eaton Road, Hemel Hempstead
Hertfordshire HP2 7LB, England
0442/3272

DOSC, Inc.
175 I.U. Willets Road
Albertson, NY 11507
516/621-6640

Formation Inc.
823 East Gate Drive
Mt. Laurel, NJ 08054
609/234-5020

High Integrity Systems Ltd.
41 Bell Street, Sawbridgeworth
Hertfordshire CM21 9AR, England
0279/725030

Intel Corp.
3585 SW 198th Avenue
Aloha, OR 97007
503/642-8421

Modcomp
POB 6099
Ft. Lauderdale, FL 33310
305/974-1380

National Semiconductor
2900 Semiconductor Drive
Santa Clara, CA 95051
408/721-5000

Parallel Computer Systems, Inc
210 Sylvan Avenue
Englewood Cliffs, NJ 07632
201/894-0620

Parallel Computers
POB 1187
Santa Cruz, CA 95061
408/429-1338

Sequoia Systems, Inc.
1085 Worcester Road
Natick, MA 01760
617/655-9020

Stratus Computer, Inc.
17 Strathmore Road
Natick, MA 01760
617/653-1466

Synapse Computer Corp.
801 Buckeye Court
Milpitas, CA 95035
408/946-3191

Syntech International, Inc.
POB 28810
Dallas, TX 75228
214/340-0379

Syntrex Incorporated
POB 657
Eatontown, NJ 07724
201/542-1500

Tandem Computers Inc.
19333 Vallco Parkway
Cupertino, CA 95014-2599
408/725-6000

BIBLIOGRAPHY

The purpose of this short annotated bibliography is to point the reader to a number of readily-accessible publications that treat the subject of fault-tolerant computing systems in more depth, primarily in the conceptual and theoretical senses. Most items listed here contain extensive bibliographies.

Siewiorek, Daniel P. and Swarz, Robert S.: THE THEORY AND PRACTICE OF RELIABLE SYSTEM DESIGN, Digital Equipment Press, 1982.

This invaluable compendium is a "must" for anyone serious about FT. The book contains extensive discussions of the concepts of fault tolerance, reliability, availability, maintainability, evaluation criteria, and financial considerations. In addition, the book includes reprints of many of the landmark papers on actual FT systems, including Tandem, the Intel 432, the Bell Labs ESS processors, STAR, SIFT, FTMP, c.vmp, and Pluribus, as well as RMA aspects of the Univac 1100/60, VAX, and IBM System/360 & 370. An extensive appendix on error correcting codes ia also included, as is a summary of the MIL-HDBK-217B reliability model.

Hopkins, Albert L. Jr.: FAULT-TOLERANT SYSTEM DESIGN: BROAD BRUSH AND FINE PRINT, in IEEE Computer magazine, March 1980.

A very fine survey of the state of the art. Hopkins was involved in the design of FTMP and has a firm grasp on the concepts ("broad brush") as well as the nitty-gritty realities ("fine print"). The entire issue, by the way, is dedicated to fault-tolerance, including a rather comprehensive survey of error correcting codes by Pradhan and Stiffler (Stiffler is now associated with Sequoia, see body of the report).

Randell, B. et. al.: RELIABILITY ISSUES IN COMPUTING SYSTEM DESIGN, ACM Computing Surveys, June 1978.

Another excellent "must", providing an overall conceptual and practical view of the entire subject. The same issue also contains an important piece by Verhofstad on recovery techniques for database systems.

Denning, P.J.: FAULT TOLERANT OPERATING SYSTEMS, ACM Computing Surveys, December, 1976.

This entire issue of the Surveys is dedicated to the subject of fault-tolerant software. The two other papers are by Hecht, on FT software for real time applications, and by Linden, on operating system structures to support security and reliable software, focusing on small protection domains and extended-type objects.

Kohler, Walter H.: A SURVEY OF TECHNIQUES FOR SYNCHRONIZATION AND RECOVERY IN DECENTRALIZED COMPUTER SYSTEMS, ACM Computing Surveys, June 1981.

The entire issue is dedicated to the subject of data base integrity and consistency. The other two papers in it are on concurrency control in distributed database systems, by Bernstein and Goodman; and on the recovery manager of the IBM System R, by Jim Gray (now at Tandem) et. al.