

ADDRESS BY
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GOOD MORNING, IT'S A PLEASURE TO BE IN PARIS THIS WEEK AND TO HAVE AN OPPORTUNITY TO PRESENT MEMOREX TECHNOLOGY DIRECTION TO SOME OF THE LEADERS OF EUROPE'S INDUSTRY.

IF YOU FIND ME SPEAKING TOO SWIFTLY, JUST RAISE YOUR HAND AND SAY "VOUS PARLAIS TROP VITE, PARLAIS L'INCOMPREHENSIBLE".

BLANK
MRX TECH EVOL

MEMOREX TECHNOLOGY EVOLUTION

I. INTRODUCTION

THE TECHNOLOGY ADVANCES IN JUST THIS PAST YEAR HAS BEEN OUTSTANDING. A COMPLETE NEW INDUSTRY WAS BORN AROUND THE EIGHT-INCH DISC TECHNOLOGY.

WITH TECHNOLOGICAL BREAKTHROUGHS IN LSI, THE RANDOM ACCESS MEMORY PRICING RULE OF 1/2 REDUCTION EVERY TWO YEARS, WHICH HAS BEEN IN EFFECT OVER A DECADE, IS NO LONGER VALID.

A SINGLE-DISC STORAGE FILE HAS BEEN ANNOUNCED WITH NEARLY FIVE TIMES THE CAPACITY OF THE LARGEST MAGNETIC DISC FILE .

BIG BLUE MADE AN UNPRECEDENTED LEAP IN TECHNOLOGY TO ANNOUNCE THE MOST POWERFUL PRICE/PERFORMANCE COMPUTER IN THE HISTORY OF DATA PROCESSING.

A COMPUTER HAS BEEN TESTED AT NEARLY 1,000 TIMES THE SPEED OF A 370/158 PROCESSOR.

A NEW MEDIA TECHNOLOGY HAS EMERGED THAT PERHAPS WILL REVOLUTIONIZE THE FLEXIBLE MEDIA EQUIPMENT PRODUCTS IN THE NEXT FIVE YEARS.

SO, ALL OF YOU ARE AWARE, OURS IS A DYNAMIC, FAST-CHANGING, HIGH-TECHNOLOGY ENVIRONMENT. THIS MORNING I WILL DISCUSS THE TECHNOLOGY EVOLUTION, HOW IT IS CURRENTLY APPLIED AT MEMOREX, AND WHERE WE SEE IT TAKING US IN THE FUTURE.

III. PRODUCT OVERVIEW

**WRX INFO STOR
& COMM**

LET'S TAKE A LOOK AT THE ENVIRONMENT IN WHICH OUR PRODUCTS OPERATE.

THIS IS A SNAPSHOT OF MEMOREX PRODUCTS IN THE OVERALL DATA PROCESSING ENVIRONMENT, SHOWING SOME OF THE MARKETS WE SERVE.

AS A MATTER OF FACT, MEMOREX PRODUCTS TODAY SERVE MORE OF THE TOTAL INFORMATION STORAGE AND COMMUNICATIONS MARKETPLACE THAN THOSE OF ANY OTHER INDEPENDENT MANUFACTURER. THESE RANGE FROM THE LARGE STORAGE HIERARCHICAL DATA SYSTEMS TO THE SMALL DISTRIBUTED DATA BASE PRODUCTS. WE SEE LOCAL FILE SYSTEMS INTERCONNECTED VIA COMMUNICATIONS PROTOCOLS SUCH AS SDLC AND BYSYNC, OVER SUCH NETWORKS AS TELENET, ARPANET, OR HIGH SPEED SATELLITE NETWORK SYSTEMS IN THE FUTURE.

GREEN AREAS HERE REPRESENT EQUIPMENT MANUFACTURED BY MEMOREX, WHILE GOLD AREAS REPRESENT STORAGE MEDIA PRODUCED BY MEMOREX.

AND MEMOREX IS CONTINUALLY ANALYZING NEW OPPORTUNITIES TO BETTER SERVE THE COMPLETE SYSTEMS ENVIRONMENT.

R&D SPENDING

[MEMOREX] HAS EXPERIENCED RAPID GROWTH IN THE PAST FEW YEARS, AND WE ARE COMMITTING TO RESEARCH AND DEVELOPMENT AND FUTURE INVESTMENTS IN EVER-INCREASING AMOUNTS.

FOR INSTANCE, IN THE PAST FOUR YEARS OUR ENGINEERING MANPOWER HAS DOUBLED; OUR ENGINEERING SPENDING HAS TRIPLED, AND OUR ENGINEERING TECHNOLOGY-RELATED SPENDING HAS INCREASED 7.5 TIMES.

MRX PROD CHART

[THIS] CHART REPRESENTS MEMOREX'S PRODUCT PROGRESSION OVER THE YEARS. WE HAVE CONTINUALLY DIVERSIFIED THROUGH THE YEARS, ADDING NEW PRODUCT LINES ACROSS THE BOARD IN MEDIA, STORAGE, EQUIPMENT, AND COMMUNICATIONS, AND HAVE DEVELOPED A STRONG INTERNATIONALLY BASED OPERATION TO DEVELOP, MARKET, AND MAINTAIN THESE PRODUCTS ON A WORLDWIDE BASIS.

**MRX INFO STOR
EQPMT (LSSG)**

[THE] NEXT TWO SLIDES REPRESENTS THE RAPID EVOLUTION OF MEMOREX STORAGE PRODUCTS FOR OEM AND END-USER - STARTING WITH THE ORIGINAL [DISC]DRIVES AND MOVING TO TODAY'S 3652 DOUBLE-DENSITY DISC DRIVE.

**MRX INFO STOR
EQPMT (GSG)**

IN FACT, MEMOREX HAS INTRODUCED FOUR TIMES MORE STORAGE EQUIPMENT PRODUCTS IN THE PAST THREE YEARS THAN IN THE PREVIOUS 10 YEARS COMBINED.

**MRX DATA COMM.
EQPMT.**

THE FASTEST GROWING PRODUCT GROUP AT MEMOREX [TODAY], OUR COMMUNICATIONS GROUP, HAS EXPANDED RAPIDLY SINCE 1970, THIS GROUP IS NOW TAKING THE FIRST STEP TOWARD A MODULAR CONCEPT: INTELLIGENT MULTI-PROCESSOR CAPABILITY WITH FUTURE INTELLIGENT CONTROLLERS AND TERMINALS.

ENGINEERING IN COMMUNICATIONS TODAY IS 40% HARDWARE OREIENED AND 60% SOFTWARE, WITH STRONG EMPHASIS ON FUTURE SOFTWARE DEVELOPMENT.

MEMOREX IS ONE OF THE FEW DATA COMMUNICATIONS COMPANIES OFFERING THE COMPLETE SYSTEM, INCLUDING THE FRONT-END PROCESSORS, THE TERMINALS, AND THE TERMINAL CONTROLLERS AND PROTOCOLS FOR COMMUNICATION LINK TO THE HOST CPU.

INFO STOR MEDIA

[MEMOREX] MEDIA HAS GROWN RAPIDLY AS WELL. IN THE PAST THREE YEARS WE HAVE DEVELOPED MORE MEDIA PRODUCTS THAN IN THE PREVIOUS FIFTEEN YEARS.

MEMOREX IS ONE OF THE FEW COMPANIES MANUFACTURING BOTH THE COMPUTER STORAGE EQUIPMENT AND THE COMPUTER MEDIA USED ON THAT EQUIPMENT.

FOR INSTANCE, MEMOREX IS ONE OF ONLY TWO INDEPENDENT COMPANIES THAT MANUFACTURES THE COMPLETE DISC DRIVE - THE HEADS, THE MEDIA, AND THE ELECTRONICS. THIS IS BECOMING INCREASINGLY IMPORTANT WITH THE ADVENT OF THIN FILM HEADS AND MEDIA.

AND OF COURSE, MEMOREX TODAY IS THE NUMBER ONE COMPUTER MEDIA SUPPLIER IN THE WORLD.

WHILE MEMOREX IS ONE OF THE WORLD'S LARGEST COMPUTER PERIPHERAL MANUFACTURERS, ASK THE MAN ON THE [STREET] ABOUT MEMOREX, AND HE'LL SAY: "SURE - THEY MAKE THE TAPE THAT SHATTERS THE GLASS."

SHATTERED GLASS

MEMOREX CONSUMER AND BUSINESS MEDIA GROUP IS KNOWN PRIMARILY FOR ITS "SHATTERED GLASS" ADVERTISING WHICH ASKS "IS IT LIVE, OR IS IT MEMOREX."

AT THE RECENT CONSUMER ELECTRONICS SHOW, IN FACT, MEMOREX AUDIO TAPE WAS ACKNOWLEDGED AS THE HIGHEST QUALITY AUDIO TAPE IN THE INDUSTRY, EXCEEDING EVEN HERETOFORE LEADERS: MAXELL AND TDK.

CONSUMER &
BUSINESS MEDIA
CHART

BUT AS YOU CAN [SEE] AUDIO TAPE IS JUST ONE OF THE PRODUCTS OF THE CONSUMER AND BUSINESS MEDIA GROUP. OUR VIDEO TAPES ARE RECOGNIZED AS THE #1 QUALITY LEADER IN THE BROADCAST FIELD TODAY. AND OUR WORD PROCESSING PRODUCTS ARE WIDELY USED IN OFFICE ENVIRONMENTS.

MEMOREX IS THE ONLY EQUIPMENT MANUFACTURER WITH THE FULL COMPLEMENT OF MEDIA PRODUCTS: DIGITAL, AUDIO, AND VIDEO.

THIS GIVES US A MAJOR OPPORTUNITY IN TECHNOLOGY SYNERGY IN MEDIA AND EQUIPMENT PRODUCTS.

MICROGAP RCDG

THE ADVANCES THAT ARE IMMINENT IN THE MICRO-PARTICLE FLEXIBLE MEDIA TODAY COULD REVOLUTIONIZE INFORMATION AND STORAGE EQUIPMENT IN THE NEXT FIVE YEARS. FOR EXAMPLE, FULLY EXPLOITING THE POTENTIAL OF THIS TECHNOLOGY COULD POSSIBLY YIELD:

- A 50-MEGABYTE FLEXIBLE DISC
- INSTEAD OF 50 THOUSAND CHARACTERS ON A MAGNETIC CARD, BETTER THAN 60 MILLION CHARACTERS ON A WALLET SIZED CREDIT CARD.
- POSSIBLY A STANDARD 100-MEGABYTE TAPE DRIVE STORAGE ON 26 INCHES OF TAPE.
- YES, AND BETTER THAN TWO HOURS OF AUDIO RECORDING MESSAGE ON A POSTAGE STAMP - AND THAT'S A U. S. - SIZE STAMP, NOT A FRENCH STAMP.

THE RAPID PROGRESS OF MEMOREX PRODUCT DEVELOPMENT HAS HAD ONE PURPOSE: SUPERIOR VALUE TO OUR CUSTOMER. PRODUCT INNOVATIONS, IDEAS, AND TECHNOLOGIES ARE PRIMARILY AIMED AT PROVIDING INCREASED VALUE OVER OUR COMPETITION. AND MEMOREX HAS BEEN BLESSED WITH MAGNIFICENT COMPETITION—COMPETITION THAT KEEPS OUR ENGINEERING RESOURCES AND ENGINEERING ACTIVITIES ON THEIR TOES. TO ACHIEVE PRODUCT LEADERSHIP IN THE INDUSTRY, WE MUST MAINTAIN THE HIGHEST LEVEL OF TECHNICAL EXCELLENCE IN OUR ENGINEERING ORGANIZATION.

MEMOREX FELLOWS

AND IN OUR EFFORTS TO FOCUS ON OUR FUTURE TECHNOLOGICAL REQUIREMENTS, MEMOREX RECOGNIZES THE IMPORTANCE OF [PEOPLE] - SCIENTISTS, ENGINEERS, AND RESEARCH-ORIENTED TECHNOLOGISTS.

TO PROMOTE THIS AT MEMOREX, WE HAVE ESTABLISHED THE MEMOREX FELLOWS PROGRAM, RECOGNIZING INDUSTRY-WIDE LEADERS AND MAJOR CONTRIBUTORS AT MEMOREX.

TODAY WE HAVE THREE MEMOREX FELLOWS: FRANK SORDELLO, MANAGER OF OUR RECORDING TECHNOLOGY CENTER AND HOLDER OF 26 PATENTS IN DISC STORAGE PRODUCTS; ERIC DANIEL, MANAGER OF OUR MAGNETIC CHEMICAL TECHNOLOGY CENTER AND WORLDWIDE AUTHORITY ON MEDIA

TECHNOLOGIES; AND DR. JOHN SCOTT, PRESIDENT OF OUR MINI-DISC DRIVE COMPANY, DEVELOPER OF MEMOREX'S 8" DRIVES, AND AUTHORITY IN RIGID **MEDIA**.

PRDT INNOVAT.

FROM ITS BEGINNING, MEMOREX HAS CONTINUALLY INCORPORATED INNOVATIONS INTO OUR PRODUCTS. IN FACT, MEMOREX HAS LED INDUSTRY STANDARDS IN MANY AREAS.

WE WERE THE FIRST COMPANY, FOR EXAMPLE, TO INTRODUCE THE CROSSLINK BINDER IN DIGITAL COMPUTER TAPES, WHICH ESTABLISHED US AS THE LEADER IN THE INDUSTRY IN THE EARLY 1960'S.

MEMOREX SET THE STANDARD FOR WIDE-BAND RECORDING ON MEDIA INSTRUMENTATION RECORDING TAPE.

MEMOREX WAS THE FIRST COMPANY TO INTRODUCE THE VOICE COIL MOTOR, WHICH REVOLUTIONIZED THE DISC DRIVE PRODUCTS. THE COMPLETE INDUSTRY, INCLUDING IBM, SWIFTLY FOLLOWED.

MEMOREX LED THE INDUSTRY WITH MANGANESE ZINC FERRITE HEAD DEVELOPMENT. MEMOREX WAS THE FIRST COMPANY TO MANUFACTURE AND TO MARKET OEM FLEXIBLE DISC DRIVES. MEMOREX WAS THE FIRST TO SPIN-COAT

SIMULTANEOUSLY ON BOTH SIDES OF RIGID DISCS, AND MEMOREX WAS THE FIRST WITH A UNIQUE DESIGN COMPUTER TAPE SUPERREEL TO IMPROVE DATA INTEGRITY.

AND GUESS WHO INTRODUCED TO THE INDUSTRY THE INTELLIGENT DUAL PORT INTERFACE AND THE REVOLUTIONARY DISC CACHE SUBSYSTEM TO IMPROVE THROUGHPUT BY REDUCING ACCESS CONTENTION AND ACCESS TIME FOR LARGE DATA BASE SYSTEMS

8" DRIVE

AND MEMOREX IS THE ONLY INDEPENDENT MANUFACTURER TO MANUFACTURE THE COMPLETE 8" DISC DRIVE, INCLUDING HEADS, MEDIA, AND ELECTRONICS.

LIEGE

FROM ITS [BEGINNING] MEMOREX HAS BEEN ORIENTED TOWARD THE WORLD MARKET. WE BEGAN DOING BUSINESS IN EUROPE, THE FAR EAST, AND LATIN AMERICA IN 1965. WE STARTED MANUFACTURING IN LIEGE, BELGIUM, IN 1969; AND TODAY WE HAVE ADDITIONAL INTERNATIONAL SUBSIDIARIES OPERATING 60 SALES AND SERVICE OFFICES IN FIVE CONTINENTS. WE ALSO HAVE APPROXIMATELY 100 INDEPENDENT DISTRIBUTORS AND AGENTS FOR VARIOUS PRODUCTS AROUND THE WORLD. MANY OF THEM IN COUNTRIES NOT SERVED BY OUR SUBSIDIARIES. MEMOREX'S INTERNATIONAL REVENUES ARE ABOUT 47% OF TOTAL REVENUES.

OUR COMMITMENT TO THE INTERNATIONAL MARKETPLACE IS ENHANCED BY OUR RECENT INTERNATIONAL INVESTMENTS. THESE INCLUDE THE ACQUISITION OF TELEX EUROPE, CONSTRUCTION OF A MANUFACTURING PLANT IN IRELAND, EXPANSION OF MANUFACTURING OPERATIONS IN MEXICO AND BELGIUM, AND EXPANDED SALES AND SERVICE OFFICES AND DISTRIBUTORS WORLDWIDE.

**WORLDWIDE
TECH iBASE**

MEMOREX'S TECHNOLOGY IS STRENGTHENED BY OUR RELATIONSHIPS AND AFFILIATIONS WITH COMPANIES THROUGHOUT THE WORLD. OUR ENGINEERING RESEARCH CENTERS ARE ESTABLISHED WORLDWIDE TO MAINTAIN

INTERNATIONAL STANDARDS - SUCH AS ECMA STANDARDS, INTERNATIONAL SAFETY CODES, AND OTHER INTERNATIONAL REQUIREMENTS.

I I I . TECHNOLOGY OVERVIEW

TECHNOLOGY CHART

AS I MENTIONED [EARLIER], OURS IS A FAST-CHANGING, HIGH-TECHNOLOGY INDUSTRY. A BROAD SPECTRUM OF INFORMATION STORAGE AND EQUIPMENT TECHNOLOGIES EXISTS TODAY—SOME PROVEN, OTHERS STILL EMERGING.

HERE I HAVE SEPARATED THE STORAGE AND RETRIEVAL TECHNOLOGIES INTO FOUR MAJOR CATEGORIES: MAGNETIC; MECHANICAL; ELECTRONIC; AND OPTICAL. EACH OF THESE CATEGORIES INCORPORATES A WIDE RANGE OF TECHNOLOGIES. THESE TECHNOLOGIES ARE EITHER CLOSELY MONITORED OR ARE UNDER VARIOUS LEVELS OF DEVELOPMENT IN OUR RESEARCH CENTERS.

THE LATEST TECHNOLOGIES IN THE MAGNETIC STATIC AREA—INCLUDING BUBBLE AND CROSS-TIE MEMORIES—ARE RECEIVING MORE ATTENTION TODAY THAN ARE THE OLDER CORE, DOMAIN-TIP PROPAGATION, AND MICRO-BIT TECHNOLOGIES.

THE MAGNETIC TAPE AREA INCLUDES BOTH ANALOG AND DIGITAL TECHNOLOGIES, FROM AUDIO AND VIDEO ANALOG TO HIERARCHICAL STORAGE DIGITAL TAPE SUBSYSTEMS,

THE ROTATING MAGNETIC TECHNOLOGIES INCLUDE FLEXIBLE AND RIGID DISCS. THESE RANGE FROM THE BERNOULLI DISC, A NON-CONTACT FLYING HEAD FLEX DISC, TO THE RIGID, FIXED, *AND MOVING HEAD DISC DRIVES.

USE OF THE MECHANICAL TECHNOLOGIES, WITH CARDS AND PAPER TAPE, CONTINUE IN A BROAD NUMBER OF DATA PROCESSING APPLICATIONS TODAY.

THE ELECTRONIC TECHNOLOGIES RANGE FROM THE PICO-SECOND ACCESS TIME JOSEPHSON JUNCTION—A NONVOLATILE SEMICONDUCTOR MEMORY THAT REQUIRES CRYOGENIC COOLING —TO THE LOWER SPEED, LOWER COST, CHARGE-COUPLED DEVICES.

THE RANDOM-ACCESS MEMORIES INCLUDE A COMPLETE SPECTRUM OF TECHNOLOGIES SUCH AS TTL AND I^2L . THE ELECTRONIC BEAM MEMORY IS ALSO A DERIVATIVE OF SEMICONDUCTOR TECHNOLOGY, AS IS THE PROGRAMMABLE READ-ONLY MEMORY FAMILY.

THE OPTICAL TECHNOLOGIES INCLUDE MICROFILM, LASER AND HOLOGRAPHIC, AMONG OTHERS.

AS THESE TECHNOLOGIES CHANGE, SO DO THE PROJECTIONS FOR THEIR ULTIMATE SUCCESS OR FAILURE IN THE MARKETPLACE. MANY OF THEM—LIKE THE DOMAIN-TIP PROPAGATION AND MICRO-BIT TECHNOLOGIES—HAVE COME AND GONE. BUT SEVERAL STAND OUT AS EXCELLENT POTENTIAL ACCESS GAP FILLER TECHNOLOGIES. (THE TERM ACCESS GAP REFERS TO THE TECHNOLOGY GAP BETWEEN MOVING HEAD DISC FILES AND HIGH-SPEED, RANDOM-ACCESS MEMORY.) LET'S LOOK AT A FEW OF [THESE]

BUBBLE

BUBBLE MEMORY TECHNOLOGY CONTINUES TO EVOLVE RAPIDLY, CHANGING DIRECTION NOW AND AGAIN IN SEARCH OF THE KEY TO SUCCESS. EARLY PREDICTIONS POINTED TOWARD THE PERMALLOY BAR FILE. THIS WAS REPLACED IN PRIORITY BY THE BUBBLE LATTICE FILE, WHICH IN TURN HAS BEEN OUTPACED BY THE CONTINUOUS DISC FILE. AND NOW CURRENT ACCESS AND WALL DOMAIN BUBBLES ARE BEING EXPLORED.

CCDs

A DIRECT [DERIVATIVE] OF RAM SEMICONDUCTOR TECHNOLOGY, CHARGE-COUPLED DEVICES OFFER THE ADVANTAGE OF BEING A PROVEN TECHNOLOGY. HOWEVER, IT MAY BE THIS SIMILARITY THAT HOLDS BACK THE BROADER APPLICATION OF CCDs. THE PRESENT PRICE DIFFERENCE BETWEEN

CCDs AND RAMs MAY NOT BE ENOUGH, IN MOST CASES, TO OFFSET THE 1000-TO-ONE DIFFERENCE IN ACCESS TIME - AT LEAST IN TERMS OF A FULL MIGRATION TO CCD TECHNOLOGY.

ELECTRON
BEAM

[THE ELECTRON] BEAM MEMORY OFFERS LOW ACCESS TIME WITH HIGH DATA RATE, AND PROponents PREDICT HIGH AREAL DENSITIES WITH POTENTIALLY LOW COSTS. TECHNICAL PROBLEMS, HOWEVER, ARE CONTINUING TO SLOW DOWN ITS INTRODUCTION INTO THE MARKETPLACE.

CROSS-TIE
MEMORY

[THE CROSS-TIE] MEMORY IS EXTREMELY SLOW IN MATURING PAST THE BREADBOARD STAGE. THE HIGH AREAL DENSITIES AND DATA RATE, ALONG WITH THE RELATIVELY SIMPLE CONSTRUCTION, HOWEVER, SUGGEST A POSITIVE POTENTIAL FOR THIS TECHNOLOGY.

OPTICAL
DISC
STORAGE

[ONE OF THE] SWIFTEST DEVELOPING TECHNOLOGIES IS THE OPTICAL STORAGE TECHNOLOGY, WHICH RECENTLY ANNOUNCED BETTER THAN 2,500 MEGABYTES OF STORAGE ON A SINGLE SURFACE, WITH NEARLY TWO ORDERS OF MAGNITUDE GREATER AREAL DENSITY THAN PRESENT MAGNETIC STORAGE SYSTEMS.

HOWEVER, THE PRESENT READ/ONLY LIMITATION WILL LIMIT ITS FULL ACCEPTANCE INTO THE DATA STORAGE ENVIRONMENT.

MEMOREX AND OTHERS ARE CURRENTLY WORKING ON DEVELOPMENTS IN OPTICAL STORAGE TECHNOLOGIES TO DETERMINE THEIR APPLICABILITY TO THE OVERALL DATA PROCESSING INDUSTRY.

DIGITAL
STORAGE

THE [RAPID] GROWTH OF THE VARIOUS STORAGE TECHNOLOGIES IS ILLUSTRATED HERE. IN EVALUATING COMPETING TECHNOLOGIES, THERE ARE TWO VITAL PARAMETERS. ONE IS SYSTEM PRICE, SHOWN ON THE VERTICAL SCALE AS CENTS-PER-BIT OF STORAGE, AND THE OTHER IS DATA ACCESS TIME. THIS IS SHOWN ON THE HORIZONTAL SCALE, IN SECONDS.

IT IS OBVIOUS THAT THE FASTEST TECHNOLOGIES ARE ALSO THE MOST EXPENSIVE.

WE CAN READILY SEE THE LARGE GAP BETWEEN THE HIGHER SPEED SEMICONDUCTOR MEMORIES AND THE MOVING HEAD DISC.

THIS HAS LED TO THE GROWTH OF THE GAP FILLER TECHNOLOGIES MENTIONED EARLIER. MOVING FROM 1979 TO 1984, WE ANTICIPATE THE SAME RELATIVE MAGNITUDES, AS ALL TECHNOLOGIES REDUCE THE COST OF STORAGE WHILE INCREASING PERFORMANCE.

**COMPARISON OF
AREAL DENSITIES**

IN [ANALYZING] THE PROGRESS OF THE ANALOG SYSTEM SHOWN HERE IN BLUE AND DIGITAL STORAGE SYSTEMS SHOWN IN YELLOW, WE SEE THE MOST RAPID ADVANCES IN DIGITAL BEING THE RIGID DISC TECHNOLOGIES. INCREASES IN AREAL DENSITY BY GREATER THAN THREE ORDERS OF MAGNITUDE HAVE BEEN ACHIEVED SINCE 1957.

ANALOG SYSTEMS SUCH AS AUDIO TAPE, CASSETTE, AND BROADCAST TV HAVE INCREASED MORE SLOWLY IN CAPACITY, MOTIVATED MORE BY QUALITY THAN CAPACITY. IN THIS LAST DECADE, HOWEVER, VIDEO SYSTEMS—BOTH HOME VIDEO AND VIDEO DISCS—HAVE JUMPED TO BETTER THAN 100 MILLION BITS-PER-SQUARE-INCH AREAL DENSITY.

THIS COMPARISON OF DENSITIES POINTS OUT TWO ORDERS OF MAGNITUDE IN AREAL DENSITY FROM THE HIGHEST DENSITY DIGITAL STORAGE SYSTEM—MEMOREX'S MODEL 2652 DISC FILE OR EQUIVALENT—AND THE ANALOG STORAGE SYSTEM, THE VIDEO DISC.

THE CHALLENGE TODAY IS TO MERGE THESE TECHNOLOGIES, TAKING ADVANTAGE OF THE LARGE STORAGE CAPACITY OF THE VIDEO TECHNOLOGIES, WHILE AT THE SAME TIME RETAINING THE READ/WRITE FLEXIBILITY AND ACCURACY OF THE LARGE STORAGE DISC FILES.

LET'S REVIEW THE PROGRESS THESE HAVE MADE OVER THE YEARS.

EVENT
CHART

[THIS CHART] DEPICTS THE CONTINUAL CHANGES IN TECHNOLOGY FOR THE DISC FILE FROM THE ORIGINAL RAMAC DEVELOPED IN 1957 BY ONE OF OUR COMPETITORS.

HERE WE SEE THE TECHNOLOGIES REMAIN FAIRLY CONSTANT FOR THE FIRST DECADE, THEN INNOVATIONS WERE INTRODUCED BY MEMOREX WITH THE VOICE COIL MOTOR, WHILE CHANGES OCCURRED IN COATING, CLOCKING METHODS, AND MAGNETIC HEADS. THOSE TECHNOLOGIES REMAINED CONSTANT AGAIN FOR APPROXIMATELY ANOTHER DECADE.

TODAY, WE ARE READY FOR THE NEXT DECADE OF TECHNOLOGICAL EVOLUTION OF THE DISC FILES. THE VOICE COIL WILL PROBABLY CONTINUE FOR A WHILE, THEN GIVE WAY TO NEW AND MORE PRECISE TECHNOLOGIES AND ACTUATOR CONCEPTS, WHILE EMBEDDED SERVO CONCEPTS WILL BE IMPROVED.

THE MFM CODING WILL BE CHALLENGED BY NEW CODE COMPRESSION TECHNIQUES. THE VFO WILL CONTINUE BUT

WILL IMPROVE IN SPEED AND PERFORMANCE. THE ERROR CORRECTION CODE WILL BE EXPANDED TO EXTENDED ERROR CORRECTION.

AND, OF COURSE, THIN FILM HEADS AND MEDIA WILL PROVIDE FOR A TREMENDOUS INCREASE IN FUTURE AREAL DENSITIES.

CAPACITY
PER SPINDLE

[THE CAPACITY] INCREASES RESULTING FROM THESE TECHNOLOGICAL INNOVATIONS GREW RAPIDLY ON THE EARLY SYSTEMS, WHICH USED 24-INCH DISCS AND FIXED MEDIA.

WITH THE ADVENT OF REMOVABLE MEDIA, INCREASES CONTINUED AT A SLOWER RATE TO OUR PRESENT DISC FILE CAPACITY. AS EMERGING TECHNOLOGIES ARE DEVELOPED, I BELIEVE THIS GROWTH TREND WILL CONTINUE, PROVIDING GREATER THAN 4000 MEGABYTES-PER-SPINDLE BY 1985.

AREAL
DENSITY

[AREAL] DENSITIES, TOO, INCREASED RAPIDLY ON THE EARLY SYSTEMS, RESULTING IN TODAY'S HIGH-CAPACITY DRIVES. I EXPECT THIS TREND TO CONTINUE TO GREATER THAN 50 MILLION BITS-PER-SQUARE-INCH BY THE MID-1980'S.

BITS PER
INCH

[THE INCREASE] IN BITS-PER-INCH FOLLOWED THE SAME TREND. WITH DEVELOPMENT OF THIN FILM TECHNOLOGIES, THIS

TREND WILL CONTINUE TO GREATER THAN 25 THOUSAND BITS-PER-INCH BY 1985.

TRACKS PER
INCH

[DEVELOPMENTS] IN TRACKS-PER-INCH MARK AN INTERESTING STRAIGHT LINE ON A LOG SCALE, AS INDICATED HERE. HAVING INCREASED STEADILY, THEY SHOULD CONTINUE TO GREATER THAN 2000 TRACKS-PER-INCH BY 1985.

DATA RATE

[AS THE PACKING] DENSITY CONTINUES TO INCREASE, THE DATA RATE WILL OF COURSE IMPROVE, AS SEEN HERE. THIS WILL REQUIRE AN INCREASE IN CHANNEL CAPACITY, AND, POSSIBLY, IN ACCESS METHODS.

HEAD TECH
PROJECTIONS

[GIVEN] ALL THE ADVANCEMENTS IN THESE TECHNOLOGIES AS WELL AS THE IMPROVEMENTS IN SUCH AREAS AS AREAL DENSITY, BITS-PER-INCH, AND TRACKS-PER-INCH, WE MIGHT WELL ENVISION DISC FILES IN THE MID-1980'S OFFERING TOO MEGABYTES-PER-SPINDLE, 25 THOUSAND BITS-PER-INCH, 2000 TRACKS-PER-INCH, AND 50 MEGABITS PER SQUARE INCH.

MEMORY TECH
COST DYNAMICS

[WHEN WE] COMPARE MOVING HEAD DISCS WITH BUBBLE, CCD, AND RAM, WE SEE PRICE-PER-BIT PROJECTIONS FOR DISC FILES DROPPING TO LESS THAN 100 MICROCENTS-PER-

BIT (LESS THAN 4 MILLIONTH OF A FRANC PER BIT) WITHIN A DECADE. THIS IS APPROXIMATELY 33 FRANCS PER MEGABYTE.

AS SEMICONDUCTOR TECHNOLOGIES CONTINUE TO IMPROVE WITH ELECTRON BEAM AND X-RAY LITHOGRAPHY, I SUSPECT THAT THESE PRICE CURVES OF SEMICONDUCTOR STORAGE WILL CONTINUE DOWNWARD.

THE BUBBLE TREND IS MUCH MORE SPECULATIVE. IT WILL DEPEND, TO A LARGE EXTENT, ON THE QUANTITY DEMAND FOR THESE DEVICES, WHICH WILL IN TURN RELATE TO COST, AND HENCE TO POSSIBLE TECHNICAL BREAKTHROUGHS IN THE SUBMICRON BUBBLE.

IT IS ANTICIPATED THAT THE RESULTANT COST-PER-BIT CURVE OF THE DISC FILE, AS COMPARED TO CCD, RAM, AND BUBBLE, WILL MAINTAIN ITS RELATIVE POSITION THROUGH THE 1980's, NARROWING SLIGHTLY.

THE DYNAMIC CHANGES TAKING PLACE IN INFORMATION STORAGE AND RETRIEVAL MAKE ACCURATE PREDICTION EXTREMELY DIFFICULT. HOWEVER, PERFORMANCE TRENDS ESTABLISHED BY TWO DECADES OF CONTINUALLY INCREASING PERFORMANCE OF DIGITAL AND ANALOG MAGNETIC STORAGE SYSTEMS, ALONG WITH TECHNOLOGICAL EVOLUTIONS EVIDENT IN INDUSTRY RESEARCH CENTERS, SUGGEST A CONTINUING IMPROVEMENT IN PERFORMANCE.

AS I MENTIONED, THE LARGE STORAGE DISC FILES ARE READYING FOR THE NEXT DECADE OF TECHNOLOGY EVOLUTION. NEW MEDIA, NEW HEADS EMPLOYING THIN FILM CONCEPTS, NEW ELECTRONICS, AND NEW ARCHITECTURE WILL HIGHLIGHT THE NEXT DECADE.

THE FUTURE DISC FILES WILL BE COMBINED WITH CACHE CONCEPTS TO PROVIDE LOWER COST, FASTER ACCESS, HIGHER SPEED MEMORY PERFORMANCE TO REMAIN THE PREDOMINANT MASS STORAGE DEVICE THROUGH THE 1980'S.

ALONG WITH THE TECHNOLOGICAL ADVANCES IN MEMORY SYSTEMS WILL COME THE INEVITABLE CHANGES IN COMPUTER SYSTEMS ARCHITECTURES IN BOTH SOFTWARE AND FIRMWARE; NEW ACCESS METHODS, AND DIRECT ATTACH METHODS WHICH WILL TAKE ADVANTAGE OF THESE INNOVATIONS.

**MODULAR PROCESSING
SYSTEMS**

THERE ARE MANY [SCENARIOS] AT THIS POINT. NO, THIS ISN'T AN ANNOUNCEMENT OF THE NEXT AMDAHL MACHINE ARCHITECTURE. INSTEAD, IT IS A SCENARIO DEVELOPED A YEAR AGO ON THE FUTURE PROCESSING SYSTEMS THAT WILL TAKE ADVANTAGE OF THE PERFORMANCE OF HIGHER SPEED, HIGHER CAPACITY STORAGE SYSTEMS. THESE WILL HAVE PARALLEL PROCESSING CAPABILITIES EXTENDING TO ARRAY PROCESSING, WITH POSSIBLE ARRAY PROCESSORS AND CONTENT ADDRESSABLE MEMORY SYSTEMS WITH WIDER BAND CHANNELS.

**FUTURE DP
SYSTEMS**

ONE CAN ENVISION A MODULAR CONCEPT WITH DEDICATED FRONT-END PROCESSORS, BACK-END DATA BASE MANAGEMENT PROCESSORS, A COMPUTATION PROCESSOR, AND A CONTROL PROCESSOR... ALL LINKED VIA A HIGH SPEED, MULTI-ACCESS DATA BUS, WHERE THE DATA MANAGEMENT FUNCTION WILL BECOME THE FOCAL POINT AND PROCESSORS WILL PLAY MORE OF THE PERIPHERAL [ROLE].

**HIGH SPEED
BUS LINK**

OBVIOUSLY, TODAY'S SOFTWARE SYSTEMS HAVE NOT SOLVED ALL OF THE CONCURRENCY AND OTHER RELATED PROBLEMS. [HOWEVER] SUCH A SYSTEM WOULD ALLOW DIRECT ATTACH FEATURES FOR HIGH SPEED DATA HANDLING AND EFFICIENT DATA MIGRATION AND PAGING CAPABILITY, TAKING ADVANTAGE OF THE COMPLETE RANGE OF INFORMATION STORAGE

TECHNOLOGIES. FROM CACHE TO HIERARCHICAL STORE TO ALLOW A TREMENDOUS PRICE-PERFORMANCE ADVANTAGE TO THE [END USER].

BLANK

IV. RESEARCH AND DEVELOPMENT AT MEMOREX

SO, MEMOREX CONTINUES TO ANALYZE THE RELEVANT TECHNOLOGIES TO MAXIMIZE OUR POSITION AS PRODUCT LEADER.

MRX BLDG.

[IN] EARLY 1978, WE ESTABLISHED THREE MAJOR RESEARCH CENTERS AT MEMOREX: THE RECORDING TECHNOLOGY CENTER, THE MAGNETIC AND CHEMICAL TECHNOLOGY CENTER, AND THE COMMUNICATIONS TECHNOLOGY CENTER. THESE CENTERS CONTAIN MANY ADVANCED RESEARCH LABORATORIES.

MRX R&D FACS.
ADV. TECH
R&D LABS

THE RECORDING TECHNOLOGY CENTER WAS ESTABLISHED TO [FOCUS] ON ADVANCED RECORDING CONCEPTS INCLUDING THIN FILM HEADS, THIN FILM MEDIA, AND TO ANALYZE THESE AND OTHER EMERGING TECHNOLOGIES REQUIRED FOR FUTURE STORAGE PRODUCT LEADERSHIP. HERE MEMOREX HAS ESTABLISHED A THIN FILM HEAD TECHNOLOGY AND CAPABILITY SECOND TO NONE IN THE INDUSTRY.

RTC SLIDE

PHOTO THIN
FILM HEAD

[MEMOREX] TESTED ITS FIRST THIN FILM HEADS IN DECEMBER 1978. THESE HEADS WERE NEARLY IDENTICAL TO THOSE LATER REQUIRED FOR IBM'S 3370, ANNOUNCED THIS YEAR. FUTURE THIN FILM HEADS FOR THE CONVERSION BEYOND THE 3370 ARE NOW BEING TESTED.

R&D WITH MCTC
HILITE

MCTC PHOTO

MCTC PHOTO

R&D WITH COMM.
HILITE

COMM. PHOTO

LSI SLIDE HILITE

LSI PHOTO
CAD

ARTWORK DESIGN

BLANK

[THE] MAGNETIC AND CHEMICAL TECHNOLOGY CENTER WAS ESTABLISHED PRIMARILY TO FOCUS ON ADVANCED FLEXIBLE MEDIA TECHNOLOGIES TO [SUPPORT] OUR AUDIO, VIDEO, WORD PROCESSING, AND COMPUTER TAPE PRODUCT LINES - TO [ADVANCE] THE STATE OF THE ART IN CHEMICAL FORMULATIONS AND PROCESSES FOR MEDIA PRODUCTS. [THE] COMMUNICATIONS TECHNOLOGY CENTER PROVIDES FOCUS FOR [ADVANCED] COMMUNICATIONS CONCEPTS AND FUTURE TECHNOLOGY.

[LARGE] SCALE INTEGRATED CIRCUITS WILL PLAY A KEY ROLE IN FUTURE COST-EFFECTIVE, HIGH PERFORMANCE PRODUCTS.

MEMOREX [CURRENTLY] HAS INTERNAL COMPUTER AUTOMATED LSI DESIGN CAPABILITY. AND WE ARE CURRENTLY [DEVELOPING] LSI PROTOTYPES, FABRICATION, AND TESTING CAPABILITIES BOTH INTERNALLY AND THROUGH OUTSIDE AFFILIATIONS.

[WE'RE] CURRENTLY DEVELOPING THESE TECHNOLOGIES TO ACHIEVE CHIP DENSITIES EVEN HIGHER THAN THOSE ANNOUNCED BY IBM.

[NOW,] LET'S TAKE A SECOND TO WALK THROUGH SOME OF THE RESEARCH CENTERS AT MEMOREX,

(PAUSE)

SAM

RCT WAFER

WAFER PROBE

THIN FILM MASK/OSBORN

ELECTRON MICROSCOPE

PRESSURE PROFILE SIMULATOR

VSM

SEM

X-RAY ANALYZER

X-RAY DISPLAY

FAST FOURIER TRANSFORM ANALYZER

VIDEO TEST LAB

LIQUID CHROMATOGRAPH

THIN FILM FORMULATION

DISC PROTOTYPE LAPPING

MEDIA DEFECT ANALYZER

AUDIO SLITTER

TECHNICAL COMPUTER CENTER

v. CONCLUSION

TITLE [WELL,] I HOPE I HAVE SHED A BETTER LIGHT ON MEMOREX'S OVERALL TECHNOLOGY CAPABILITY IN THIS DYNAMIC, FAST-CHANGING, HIGH TECHNOLOGY ENVIRONMENT OF WHICH WE'RE ALL AN INTEGRAL PART. I HAVE ATTEMPTED TO POINT OUT THE INCREASING IMPORTANCE OF COMBINING MEDIA TECHNOLOGY WITH EQUIPMENT TECHNOLOGY TO TAKE ADVANTAGE OF THE TREMENDOUS INNOVATIONS IN THESE AREAS.

TECHNØLØ6Y AT MEMOREX IS DIRECTED NOT ONLY TOWARD
FUTURE DEVELOPMENTS, BUT ALSO TOWARD THE
ENHANCEMENT OF OUR PAST PRODUCTS TO EXTEND THE
RESIDUAL VALUES OF YOUR EXISTING EQUIPMENT——
TO PROVIDE A LASTING SUPERIOR VALUE TO OUR
CUSTOMERS.

**STEVEN H. PUTHUFF
SICOB SHOW
PARIS, F R A N C E
SEPTEMBER 19-22, 1979
SLIDE SEQUENCE**

1. BLANK
2. TECHNOLOGY EVOLUTION AT MEMOREX
3. MEMOREX INFORMATION STORAGE AND COMMUNICATION
4. R&D SPENDING
5. MEMOREX PRODUCT CHART
6. INFORMATION STORAGE EQUIPMENT
7. INFORMATION STORAGE EQUIPMENT
8. INFORMATION STORAGE EQUIPMENT-DATA COMMUNICATION EQUIPMENT
9. INFORMATION STORAGE EQUIPMENT-INFORMATION STORAGE MEDIA
10. SHATTERED GLASS
11. CONSUMER AND BUSINESS MEDIA
12. MICROGAP RECORDING
13. MEMOREX FELLOWS
14. PRODUCT INNOVATIONS
15. 8" DRIVE
16. LEIGE
17. WORLDWIDE TECHNOLOGY BASE
18. TECHNOLOGY CHART
19. BUBBLE
20. CCD'S
21. ELECTRON BEAM
22. CROSS-TIE MEMORY
23. OPTICAL DISC STORAGE
24. DIGITAL STORAGE
25. COMPARISON OF AREAL DENSITIES BPI

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- 25 . EVENT CHART
- 27 . CAPACITY PER SPINDLE
- 28 . AREAL DENSITY
- 29 . BITS PER INCH
- 30 . TRACKS PER INCH
- 31 . DATA RATE
- 32 . HEAD TECHNOLOGY PROJECTIONS
- 33 . MEMORY TECHNOLOGY COST DYNAMICS
- 34 . BLANK
- 35 . MODULAR PROCESSING SYSTEMS
- 36 . FUTURE DP SYSTEMS
- 37 . HIGH SPEED BUS LINK
- 33 . BLANK
- 39 . MEMOREX BULIDINGS (SAN TOMAS)
- 40 . MEMOREX FACILITIES (ADV. TECH F&D LABS RTC HILITES)
- 41 . RTC SLIDE
- 42 . PHOTO THIN FILM HEAD
- 43 . ~~R&D~~ WITH MCTC HILITES
- 44 . MCTC PHOTO
- 45 . MCTC PHOTO
- 46 . ~~R&D~~ WITH COMMUNICATIONS HILITES
- 47 . COMMUNICATIONS PHOTO
- 48 . LSI HILITE
- 49 . LSI PHOTO
- 50 . CAD

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- 51 . ARTWORK DESIGN**
- 52 . BLANK**
- 53 . SAM**
- 54 . WAFER FOR THIN FILM HEAD**
- 55 . WAFER PROBE**
- 56 . THIN FILM MASK**
- 57 . ELECTRON MICROSCOPE**
- 58 . PRESSURE PROFILE SIMULATOR**
- 59 . VSM**
- 60 . SEM**
- 61 . X-RAY ANALYZER**
- 62 . X-RAY DISPLAY**
- 63 . FAST FOURIER TRANSFORM ANALYZER**
- 64 . VIDEO TEST LAB**
- 65 . LIQUID CHROMATOGRAPH**
- 66 . THIN FILM FORMULATION**
- 67 . DISC PROTOTYPE LAPPING**
- 68 . MEDIA DEFECT ANALYZER**
- 69 . AUDIO SLITTER**
- 70 . TECHNICAL COMPUTER CENTER**
- 71 . MEMOREX LOGO**