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287-5526

Evgeni Evtushenko

* * *

Halves are no use to me! I scorn half measures!
Give me the whole sky! Lay the whole earth bare!
Mountains and rivers, seas and all their treasures
Are mine! And these with no one shall I share!

Life, do not fawn on me and grudge your favours.
Give me full weight! My shoulders they are strong.

I do not want a joy, a smile that wavers,

Nor do I want half griefs in a sad song.

There's but one half I welcome—half the pillow
Where, pressing tenderly against the cheek,
A golden ring is glowing on your finger
And shooting stars are falling, helpless, weak.

Peter Tempest

DO THE RUSSIANS WANT A WAR?

To Mark Bernes

Say, do the Russians want a war?—
Go ask our land, then ask once more
That silence lingering in the air
Above the birch and poplar there.
Beneath those trees lie soldier lads
Whose sons will answer for their dads.
To add to what you learned before,
Say—Do the Russians want a war?

Those soldiers died on every hand
Not only for their own dear land,
But so the world at night could sleep
And never have to wake and weep.
New York and Paris spend their nights
Asleep beneath the leaves and lights.
The answer's in their dreams, be sure.
Say—Do the Russians want a war?

But we will
swim it; no
Ocean so great
it cannot become
an Eden!

63-110 NSN 7540-00-634-4018
U.S. GPO: 1966-181-246/40018
FPMR (41 CFR) 101-11.6
Prescribed by GSA
STANDARD FORM 63 (REV. 8-61)

Sure, we know how to fight a war,
But we don't want to see once more
The soldiers falling all around,
Their countryside a battle ground.
Ask those who give the soldiers life
Go ask my mother, ask my wife,
Then you will have to ask no more,
Say—Do the Russians want a war?

Tom Botting

THE COTTAGE

So again the fisherman's cottage
Welcomed me, a tardy guest,
And at once revived forgotten
Memories within my breast.

In a corner I lay quietly
Just as many years before
In my corner I slept lightly
On the rough familiar floor.

Here I felt at home, unshackled,
Cleansed, exalted through and through
By the scent of fish, tobacco,
Children, kittens, cabbage stew.

Snoring loudly was the fisherman
While the children with soft tread,
Clenching in their teeth hot fritters,
Climbed up on the oven-bed.

Only the woman was not idle,
Washing pots and scrubbing pans,
Wielding broom and fork and needle,
Never empty were her hands.

Angrily Pechora spluttered,
Suddenly kicked up a row.
"Up to tricks!" the woman muttered,
As if chiding her brown cow.

Blowing at the smoky taper,
Out she went and in the gloom
Washtub sounds of slopping-slapping
Carried from the other room.

"On a Skullworkers' Home"

Her eyes are ~~the~~ huge +
blue, 2 flustering draps
of that same Elba,

Our common Elba
- we must not let hang

Russia & America
swim close!

"We will embrace as
in the Maytime of '45,
and this time, I dare
believe for keeps!"

"True, there are oceans of
water between us.

True, the Great Ocean, the P,
is between us.

Ro / Carol Heidi

(Gilder/ARD)
May 9, 1988
4:00 p.m. S

PRESIDENTIAL ADDRESS: MOSCOW STATE UNIVERSITY
MOSCOW, U.S.S.R.
WEDNESDAY, MAY 25, 1988

Thank you all very much. [acknowledgements]

As you know, I've just come from meetings with one of your most distinguished graduates, General Secretary Gorbachev, who sends you his greetings and wishes you luck on your finals. It's a great pleasure to be here at Moscow State University, even though I know I wasn't your first choice. Unfortunately, Michael Jackson was busy.

It's also a great pleasure to once again have the opportunity to speak directly on this live broadcast to the people of the Soviet Union. As you may know, this speech is also being carried live back in the United States, where it is now 8 in the morning, and I imagine a lot of sleepy people are just tuning in.

So while I have you all together -- electronically, at least -- let me just say that before I left Washington for this summit, I received hundreds of letters and telegrams. Many contained a simple message that they asked I carry with me when I came here. A simple message, yes, but perhaps also some of the most important business of this summit -- it is a message of peace and goodwill and hope for a growing friendship and closeness between our two peoples. So let me just say, from America to the Soviet Union: [Russian for "God be with you."]

In this, our ^{fourth} ~~third~~ summit, General Secretary Gorbachev and I have spent many hours together, and I feel that we are getting to

know each other well. We have been very busy trying to solve the major problems that confront us: disarmament, world peace, and such. Now, I know you are very serious students, but if this were America, someone would ask me when we were going to get around to building a blue jeans factory in Moscow.

Seriously, our discussions, of course, have been focused primarily on many of the important issues of the day -- issues I want to touch on with you in a few moments. But first I want to take a little time from the business of politics and diplomacy and talk to you much as I would to any group of college students in the United States. I want to talk not just of the realities of today, but of the possibilities of tomorrow. I want, together with you, to extend our imaginations into the future, and try to discover what is in store there for your generation -- whether you live in the Soviet Union, or America, or anywhere in this world of ours.

Standing here before a mural of your revolution, I want to talk about a very different revolution that is taking place right now, one that has nothing to do with parties or politics. It is quietly sweeping the globe, without bloodshed or conflict. Its effects are peaceful, but they will fundamentally alter our world, shatter old assumptions, and reshape our lives.

It's easy to underestimate, because it's not accompanied by banners or fanfare. It's been called a technological, or information, revolution, and as its emblem one might take the tiny silicon chip. That chip, the basic component of today's new-age computers, is no bigger than a fingerprint, but one of

these remarkable inventions has the computing power of a roomful of old-style computers. Calculations that once took months, even years, are now completed in fractions of a second. One of these chips can store in its memory every word in every book in miles of library shelves. They would enable you to hold the entire contents of the Lenin Library in the palm of your hand.

And they're getting smaller and more powerful all the time. One scientist brings this all down to Earth by comparing the computer chip to cars. If automotive technology, he says, had progressed as fast as semiconductor technology in the past 20 years, a Zil would now cost less than 2 rubles, get 3 million miles-to-the-gallon, deliver enough power to drive an ocean liner, and 6 of them would fit on the head of a pin.

This is more than a productivity explosion. Operating in the mysterious world of quantum physics, today's computers signal a quantum leap in the world's economy. We are rapidly moving from the economy of the Industrial Revolution -- an economy feeding on and tied to the Earth's physical resources -- to, as one economist titled his book, The Economy In Mind, in which human imagination and the freedom to create are the most precious natural resources.

Think again of that little computer chip. Those chips, the driving force of the modern economy, are made from sand, one of the most common substances on Earth. Their value doesn't come from the material that makes them up, but from the microscopic architecture designed into them by ingenious human minds.

Or take the example of this speech, being broadcast live via satellite, around the world. That satellite -- the product of human invention -- replaces thousands of tons of copper mined from the Earth and molded into wire.

In the new economy of the technological revolution, human invention increasingly makes physical resources obsolete. We are entering an age where thoughts come before things; increasingly it is an age of mind over matter. We are breaking through the material conditions of existence to a world where the human imagination paints its own destiny. Even as we explore the most advanced reaches of science, we are returning to the age old wisdom of our culture, a wisdom contained in the first line of the Gospel of John, that in the beginning was the word, the ^{truth} ~~idea~~. And it was from this ^{truth and the ideas that stem from this truth} ~~idea~~ that the material abundance of creation issued forth.

There's a Russian story about two men who find the elevator in their high-rise isn't working, so they start to walk up the stairs. On the 50th floor, one of them turns to the other and says, "I've got good news, and I've got bad news. The good news is that we've only got one more floor to climb. The bad news is that I forgot the key."

We cannot forget the key. And the key to this new economic age is freedom -- freedom of thought, freedom of information, freedom of communication. The renowned scientist, scholar, and founding father of this University, Mikhail Lomonosov lived his life for the ideals of open inquiry, scrutiny of ones own ideas and independent judgement. "It is common knowledge," he said,

"that the achievements of science are considerable and rapid, particularly once the yoke of slavery is cast off and replaced by the freedom of philosophy." Any one of our Founding Fathers, George Washington, Thomas Jefferson, Benjamin Franklin might have said much the same thing.

And what is true for science is equally true for the economy, especially the new economy of the technological revolution. At any given moment in the United States there are a thousand economic experiments going on. Someone has an idea for a new product, or a new service, and he goes out and convinces others that it's a good idea and they should invest in it. We call these people entrepreneurs. Many times they have steady jobs that they quit, because they want to follow their own lights. Sometimes the only people that believe in them and their schemes are their own family, and often the going is pretty rough at first. Sometimes the business never takes off.

But these individuals, these small enterprises and their dreams are responsible for almost all of the economic growth in the United States. Entrepreneurs are the prime movers of the technological revolution. In fact, one of the largest personal computer firms in the United States was started by two college kids, no older than you, in the garage behind their home.

Some people, even in my own country, look at this riot of experiment and progress and see only waste. What of all the entrepreneurs that fail? Well, many of them do, particularly the successful ones. Usually several times. And if you ask them the secret of their success, they will tell you, it's all that they

learned in their struggles along the way -- yes, it's what they learned from failing.

That is why it's so hard for Government bureaucracies, no matter how big, ever to substitute for millions of individuals each living and breathing his scheme 24 hours-a-day; to substitute for the heart and soul of the entrepreneur, hoping beyond hope to make his impossible dream a reality?

Trying to drive a bureaucracy into the modern economy is like trying to put a jet engine on a horse and buggy. If you want to take flight, you must have wings.

The fact is, bureaucracies are pretty much the same around the world. There's an old anecdote about a town -- it could be anywhere -- with a bureaucrat who is known to be a good for nothing, but he somehow has always hung on to power. So one day, in a town meeting, an old woman gets up and says to him, "There is a folk legend where I come from that when a baby is born an angel comes down from heaven and kisses it on one part of its body. If the angel kisses him on his hand, he becomes a handyman, if he kisses him on his forehead, he becomes bright and clever. And I've been trying to figure out where the angel kissed you that you should sit there for long doing nothing."

We are seeing the power of freedom spreading around the world. Nations such as South Korea, Singapore, Taiwan, have vaulted into the technological era, barely pausing in the industrial age along the way. Low-tax, free-market agricultural policies in the sub-continent mean that India is now a net exporter of food. Perhaps most exciting are the winds of change

blowing over mainland China, where one quarter of the world's population is now feeling that first taste, that first thrill of freedom. How many entrepreneurs, how many great minds, will the new China contribute to the 21st century?

At the same time, the growth of democracy has become one of the most powerful political movements of our age -- in Latin America, where 90 percent of the population lives under democratic government; in the Philippines, in South Korea, and Taiwan, free, contested, democratic elections are the order of the day. Throughout the world, free markets are the model for growth; democracy is the standard by which governments are measured.

We Americans make no secret of our belief in freedom. In fact, it is something of a national pastime. Every 4 years is a Presidential election year, and 1988 is one of them. We are now in the midst of primary season, in which the American people, in votes and caucuses across the country, winnow down the candidates to the final few who will run in the national election. At one point there were 14 candidates running in the 2 major parties, not to mention the candidates of all the other parties, including the Communist and Socialist parties -- all vying for my job.

Every day on the television, four nationwide independent news organizations, and hundreds of locals stations, plus thousands of independent newspapers, report on the candidates, grill them in interviews, and bring them together for debates. When it's all over, a new President will have been chosen, and I

will stand with him on the steps of the Capitol building as he's sworn in by the Chief Justice of the Supreme Court.

But Freedom doesn't begin or end with elections. Go to any American town, to take just an example, and you will see dozens of churches, of dozens of denominations. In many places synagogues and mosques. Look in the telephone book of any big city, and you will see the names of every conceivable nationality -- they are living there together, side-by-side, working together in the same factories and businesses; their children attending the same Sunday School, growing up together, marrying, and raising families of their own.

Go into any courtroom, and there will preside a judge whose only responsibility is to the law; and there you will see a jury, usually of 12 men and women -- common citizens, they are the final arbiters of guilt or innocence.

Go into any schoolroom, you will see children being taught the self-evident truth, written in our Declaration of Independence, "that all men are created equal," and that they are endowed by their creator with certain unalienable rights, and that just governments are instituted among men only to secure and protect those rights.

But freedom is more, even than this: Freedom is the right to question, and change, the established way of doing things. It is the continuing revolution of the marketplace. The right of two young men in college to start a computer firm in their garage that out-competes its giant rivals. It is the right to put forth an idea, scoffed at by all the experts, and watch it catch fire

among the people. It is the right to be eccentric, to follow your imagination, or stick to your conscience, even if you are the only one in a sea of doubters.

Freedom is the belief that individual life is ~~infinitely~~ *intrinsically* precious; it is the recognition that no single person, no single authority or government has a monopoly on the truth, but that every one of God's creatures was put on this world for a reason and has something to offer. America is a nationality ~~made up of~~ ✓ hundreds of nationalities. Our ties to your land are more than good feelings; they are ties of kinship. In America, you will find Russians, Azerbaijanians, Armenians, Ukrainians, Estonians, Latvians, and Lithuanians: They come from every part of the Soviet Union, from every continent, to live in harmony, seeking a place where each is respected, each is valued for its diverse strengths and beauties and the richness it brings to our lives.

Freedom, it has been said, makes people selfish and materialistic, but Americans are one of the most religious peoples on Earth; because they know that liberty, just as life itself, is not earned, but a gift from God, they seek to share that gift with the world. "Reason and experience," said George Washington, in his farewell address, "both forbid us to expect that National morality can prevail in exclusion of religious principle... [and it is] substantially true, that virtue or morality is a necessary spring of popular government."

Democracy is less a system of government than it is a system to keep government small, unintrusive -- even, in some sense, ineffective: A system of constraints on power to keep politics

and government secondary to the important things in life, the true sources of value found only in family and faith.

But I hope you know, I go on about these things not simply to extol the virtues of my own country, but to speak to the true greatness of the heart and soul of your land. Who, after all, needs to tell the land that produced Dostoyevsky about the quest for truth, the country of Tolstoi about family and faith, the home of Scriabin about imagination. The great culture of your diverse land speaks with a glowing passion to all humanity. let me cite one of the most eloquent contemporary passage on human freedom; it comes, not from the literature of America, but from this country, from one of the greatest novels of the 20th century, Dr. Zhivago: "I think that if the beast that sleeps in man could be held down by threats -- any kind of threat, whether of jail or of retribution after death -- then the highest emblem of humanity would be the lion tamer in the circus with his whip, not the prophet who sacrificed himself. But... this is just the point -- what has for centuries raised man above the beast is not the cudgel but an inward music: the irresistible power of unarmed truth..."

The irresistible power of unarmed truth -- today the world looks expectantly to signs of change, steps toward greater freedom in the Soviet Union, because we know that such freedom in this land would mean a flowering and renaissance of humanity unparalleled in modern history.

We watch and we hope, as changes take place in the press, as some dissidents are released, some are allowed to travel abroad,

and there is discussion of abandoning article __ and allowing true freedom of worship to all creeds. We look forward to seeing these first steps turn into strides, to change that builds an unstoppable momentum, pulled along by that irresistible power of unarmed truth, the irresistible power of freedom.

Reform that is not irreversible will always be insecure. Such freedom will always be looking over its shoulder. A falcon on a tether, no matter how long the rope, can always be pulled back. That is why, in my conversation with General Secretary Gorbachev, I have urged him to look for ways to make irreversible change. And we have been talking together about one sad reminder of a divided world, the Berlin Wall.

And to bring down the barriers of misunderstanding between our peoples, I am proposing a massive exchange program, of 5,000 high school and undergraduate students a year between our countries. You have a wonderful phrase in Russian for this: [Russian phrase], and for those here who will no doubt understand my English better than my Russian: "Better to see something once than to hear about it a hundred times."

Just a few years ago, few would have imagined the progress our two nations have made together: The I.N.F. treaty, which General Secretary Gorbachev and I signed last December in Washington, the first true nuclear arms reduction treaty in history, calling for the elimination of an entire class of nuclear missiles. And just __ days ago, we saw events in Afghanistan that give us hope that soon the fighting may end and

the healing may begin, and that that suffering country may find self-determination, unity, and peace at long last.

It is my fervent hope that our constructive cooperation on these issues will be carried on to address together the continuing destruction of regional conflicts around the globe, and that the remarkable statesmanship and courage that led to the treaty in Afghanistan will lead to solutions in Africa, Asia, and Central America.

I have often said, nations do not distrust each other because they are armed, they are armed because they distrust each other. If this globe is to live in peace and prosper, if it is to embrace all the possibilities of the technological revolution, then nations must renounce, once and for all, the right to an expansionist foreign policy. Peace between nations must be an enduring goal -- not a tactical stage in a continuing struggle.

Americans seek always to make friends of old antagonists: A colonial revolution with Britain cemented for all ages the ties of kinship between our nations; after a terrible civil war between North and South, we healed our wounds and found true unity as a Nation. We fought two world wars in my lifetime against Germany, and a bloody Pacific conflict with Japan, but now those nations are two of our strongest allies and friends.

Some people point to the trade disputes between us as sign of strain, but they are the frictions of all families, and the family of free nations is a big and vital and sometimes boisterous one. I can tell you that nothing would please my heart more, than in my lifetime to see our diplomats grappling

with the problem of trade disputes between America and a growing, exuberant, exporting Soviet Union that had opened up to economic freedom and expansion.

Your generation is living in one of the most exciting, hopeful times in Soviet history. It is a time when the first breath of freedom stirs the air, and the heart beats to the accelerated rhythm of hope, when the accumulated spiritual energies of a long silence yearn to break free.

I am reminded of the mysterious, ambiguous passage near the end of Gogol's Dead Souls. Comparing his nation to a spreading troika, he asks what will be its destination. But he writes, "there was no answer save the bell pouring forth marvellous sound."

We do not know what will be the conclusion of this journey, we do not know if the promise of glasnost will be fulfilled. But in this Moscow Spring, this ^{May}~~April~~, 1988, we may be allowed to hope that freedom, like the fresh green sapling planted over Tolstoi's grave, will blossom forth at last in the rich fertile soil of your people and culture. We may be allowed to hope that the marvellous sound of a new openness will keep on ringing through [perezvon] leading to a new world of reconciliation, friendship, and peace.

Thank you all very much and [in Russian: God bless you].

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IN A STEELWORKER'S HOME

I love America,
the America who swam
the Maytime Elbe
holding aloft whiskey
with a tired right arm,
paddling with the left;
yes, and Russia swam to meet her in
the Maytime Elbe,
holding aloft vodka
with a tired left arm,
paddling with the right,
and vodka and whiskey—
neat!—without translation
understood
each other perfectly,
goddammit,
on the waters where victories met!

I love America,
the America who now
sits with me in the prefab ranch-house
of a steelworker.



(Gilder/ARD)
May 17, 1988
1:00 p.m.

PRESIDENTIAL ADDRESS: MOSCOW STATE UNIVERSITY
MOSCOW, U.S.S.R.
WEDNESDAY, MAY 25, 1988

Thank you all very much. [acknowledgements]

It's a great pleasure to be here at Moscow State University. And I want to thank you all for turning out. I know you must be very busy this week studying and you are all now taking your final examinations -- so let me just wish you [Nyah pooka nyeh peara].

[Did I hear something?] In America we might say "break a leg," which is just as untranslatable.

Nancy couldn't make it today because she is visiting Leningrad -- which she tells me over the phone is a very beautiful city -- but she, too, says hello and wishes you good luck.

Let me say, it's also a great pleasure to once again have this opportunity to speak directly on this live broadcast to the people of the Soviet Union. As you may know, this speech is also being carried live back in the United States. So while I have you all together -- electronically at least -- I want to tell you that before I left Washington I received many heartfelt letters and telegrams asking me to carry here a simple message. A simple message, perhaps, but also some of the most important business of + this summit -- it is a message of peace and goodwill and hope for a growing friendship and closeness between our two peoples.

As you know, I've just come from a meeting with one of your most distinguished graduates. In this, our fourth summit,

General Secretary Gorbachev and I have spent many hours together, and I feel that we are getting to know each other well.

Our discussions, of course, have been focused primarily on many of the important issues of the day -- issues I want to touch on with you in a few moments. But first I want to take a little time to talk to you much as I would to any group of college students in the United States. I want to talk not just of the realities of today, but of the possibilities of tomorrow.

Standing here before a mural of your revolution, I want to talk about a very different revolution that is taking place right now, quietly sweeping the globe, without bloodshed or conflict. Its effects are peaceful, but they will fundamentally alter our world, shatter old assumptions, and reshape our lives.

It's easy to underestimate, because it's not accompanied by banners or fanfare. It's been called the technological, or information, revolution, and as its emblem one might take the tiny silicon chip -- no bigger than a fingerprint, one of these chips has more computing power than a roomful of old-style computers, or the ability to store in its memory every word in every book in miles of library shelves. They would enable you to hold the entire contents of the Lenin Library in the palm of your hand.

As part of an exchange program, we now have an exhibition touring your country that shows how information technology is transforming our lives: replacing manual labor with robots, forecasting weather for farmers, or mapping the genetic code of D.N.A. for medical researchers. Micro-computers today aid the

design of everything from houses to cars to spacecraft -- they even design better and faster computers. They can translate English into Russian or enable the blind to read -- or help Michael Jackson produce on one synthesizer the sounds of a whole orchestra. Linked by a network of satellites and fiber-optic cables, one individual with a desktop computer and a telephone commands resources unavailable to the largest governments just a few years ago.

Like a chrysalis, we are emerging from the economy of the Industrial Revolution -- an economy confined to and limited by the Earth's physical resources -- into, as one economist titled his book, The Economy In Mind, in which there are no bounds on human imagination and the freedom to create are the most precious natural resources.

Think of that little computer chip. Its value isn't in the sand from which it is made, but in the microscopic architecture designed into it by ingenious human minds. Or take the example of the satellite relaying this broadcast around the world, which replaces thousands of tons of copper mined from the Earth and molded into wire.

In the new economy, human invention increasingly makes physical resources obsolete. We are breaking through the material conditions of existence to a world where man paints his own destiny. Even as we explore the most advanced reaches of science, we are returning to the age old wisdom of our culture, a wisdom contained in the first line of the Gospel of John in the New Testament: In the beginning was the word, the idea, and it

was from this idea that the material abundance of creation issued forth.

But progress is not foreordained -- freedom of thought, freedom of information, freedom of communication. The renowned scientist, scholar, and founding father of this University, Mikhail Lomonosov knew that. "It is common knowledge," he said, "that the achievements of science are considerable and rapid, particularly once the yoke of slavery is cast off and replaced by the freedom of philosophy."

You know, one of the first communications between your country and mine was a letter from the President of one of our oldest universities, to Michael Lomonosov, on a subject of scientific inquiry. And one of the first contacts was between Russian and American explorers. The Americans were members of Cook's last voyage, on an expedition searching for an arctic passage; on the island of Unalaska, they came upon the Russians, who took them in and together, with the native Indians, held a prayer service on the ice.

The explorers of the modern era are the entrepreneurs, men with vision, with the courage to take risks and faith enough to brave the unknown. These entrepreneurs and their small enterprises are responsible for almost all the economic growth in the United States. They are the prime movers of the technological revolution. In fact, one of the largest personal computer firms in the United States was started by two college students, no older than you, in the garage behind their home.

Some people, even in my own country, look at this riot of experiment that is the free market and see only waste. What of all the entrepreneurs that fail? Well, many do, particularly the successful ones. Often several times. And if you ask them the secret of their success, they will tell you, it's all that they learned in their struggles along the way -- yes, it's what they learned from failing. Like an athlete in competition, or a scholar in pursuit of the truth, experience is the greatest teacher.

That is why it's so hard for Government planners, no matter how sophisticated, ever to substitute for the heart and soul of the entrepreneur, workers might one day (?) make his impossible dream a reality. The fact is, bureaucracies are pretty much the same around the world. There's an old story about a town -- it could be anywhere -- with a bureaucrat who is known to be a good-for-nothing, but he somehow has always hung on to power. So one day, in a town meeting, an old woman gets up and says to him, "There is a folk legend where I come from that when a baby is born an angel comes down from heaven and kisses it on one part of its body. If the angel kisses him on his hand, he becomes a handyman, if he kisses him on his forehead, he becomes bright and clever. And I've been trying to figure out where the angel kissed you that you should sit there for so long and do nothing."

We are seeing the power of freedom spreading around the world. The Republics of Korea, Singapore, and Taiwan, have vaulted into the technological era, barely pausing in the industrial age along the way. Low-tax, free-market agricultural

policies in the sub-continent mean that India is now a net exporter of food. Perhaps most exciting are the winds of change blowing over mainland China, where one quarter of the world's population is now feeling first thrill of freedom.

At the same time, the growth of democracy has become one of the most powerful political movements of our age. In Latin America in the 1970's, only a third of the population now lived under democratic government -- today over 90 percent do. In the Philippines and South Korea, free, contested, democratic elections are the order of the day. Throughout the world, free markets are the model for growth; democracy is the standard by which governments are measured.

We Americans make no secret of our belief in freedom. In fact, it is something of a national pastime. Every 4 years the American people choose a new President and 1988 is one of those years. At one point there were 14 candidates running in the 2 major parties, not to mention all the others including the Communist and Socialist candidates -- all trying to get [poluchit] my job.

Over 1,000 local television stations, 8,500 radio stations, and 1,700 daily newspapers, each one an independent, private enterprise beholden in no way to the Government, report on the candidates, grill them in interviews, and bring them together for debates. In the end, the people vote -- they decide who will be the next President.

But freedom doesn't begin or end with elections. Go to any American town, to take just an example, and you will see dozens

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of churches, representing many different beliefs. In many places synagogues and mosques.(?) And you will see families of every conceivable nationality, worshipping together.

Go into any schoolroom, and there you will see children being taught they are endowed by their Creator with certain unalienable rights, among them freedom of speech, freedom of assembly, and freedom of religion, that no government can justly deny them.

Go into any courtroom, and there will preside an independent judge, beholden to no government power; and there will be a jury of usually 12 men and women -- common citizens, they are the ones, the only ones, who weigh the evidence and decide on guilt or innocence. In that court, the accused is innocent until proven guilty, and the word of a policeman, or a President, carries no more weight, than the word of the accused.

Go to any college campus, there you'll find an open, sometimes heated, discussion of the problems in American society and what can be done to correct them; turn on the television, and you'll see the legislature conducting the business of government right there before the camera, debating and voting on the legislation that will become the law of the land. March in any demonstration, you'll see policemen -- they are there to protect the demonstrators.

Go into any Union Hall, where the members know their right to strike is protected by law. As a matter of fact, one of the many jobs I've had before this one was being President of a

union, the Screen Actors Guild of America. I lead my union out on strike for higher pay -- and I'm proud to say, we won.

But freedom is more, even than this: Freedom is the right to question, and change, the established way of doing things. It is the continuing revolution of the marketplace. It is the understanding that allows us to recognize shortcomings and seek solutions. It is the right to put forth an idea, scoffed at by all the experts, and watch it catch fire among the people. It is the right [to be eccentric,] to follow your imagination, or stick to your conscience, even if you are the only one in a sea of doubters.

Freedom is the belief that every individual life is infinitely precious; it is the recognition that no single person, no single authority or government has a monopoly on the truth, but that every one of us was put on this world for a reason and has something to offer. America is a nation made up of hundreds of nationalities. Our ties to your land are more than ones of good feeling; they are ties of kinship. In America, you will find Russians, Armenians, Ukranians, people from all the Baltic and Central Asian republics: They come from every part of the Soviet Union, from every continent, to live in harmony, seeking a place where each is respected, each is valued for its diverse strengths and beauties and the richness it brings to our lives.

Recently, your government has been allowing a few individuals and families out to visit relatives in the West. We can only hope that it won't be long before many more are allowed to do so, and Ukrainian-Americans, Latvian-Americans,

Armenian-Americans, can freely visit their homelands, just as this Irish-American visits his.

Freedom, it has been said, makes people selfish and materialistic, but Americans are one of the most religious peoples on Earth; because they know that liberty, just as life itself, is not earned, but a gift from God, they seek to share that gift with the world. "Reason and experience," said George Washington, in his farewell address, "both forbid us to expect that National morality can prevail in exclusion of religious principle... [and it is] substantially true, that virtue or morality is a necessary spring of popular government."

Democracy is less a system of government than it is a system to keep government small, unintrusive: A system of constraints on power to keep politics and government secondary to the important things in life, the true sources of value found only in family and faith.

But I hope you know, I go on about these things not simply to extol the virtues of my own country, but to speak to the true greatness of the heart and soul of your land. Who, after all, needs to tell the land of Dostoyevsky about the quest for truth, the home of Kandinsky and Scriabin about imagination, the rich and noble culture of Alizheer Navoi about beauty and heart. The great culture of your diverse land speaks with a glowing passion to all humanity. Let me cite one of the most eloquent contemporary passage on human freedom; it comes, not from the literature of America, but from this country, from one of the greatest writers of the 20th century, Boris Pasternak, in the

Spell

novel, Dr. Zhivago: "I think that if the beast that sleeps in man could be held down by threats -- any kind of threat, whether of jail or of retribution after death -- then the highest emblem of humanity would be the lion tamer in the circus with his whip, not the prophet who sacrificed himself. But... this is just the point -- what has for centuries raised man above the beast is not the cudgel but an inward music: the irresistible power of unarmed truth..."

The irresistible power of unarmed truth -- today the world looks expectantly to signs of change, steps toward greater freedom in the Soviet Union, because we know that such freedom in this land would mean a flowering and renaissance of humanity unparalleled in modern history.

We watch and we hope, as we see positive changes taking place. We look forward to seeing these first steps turn into strides, to change that builds an unstoppable momentum, pulled along by that irresistible power of unarmed truth, the irresistible power of freedom.

There are some, I know, who look with a wary eye on the changes taking place in your society, fearful that change will bring only disruption and discontinuity -- that to embrace the hope of the future must mean a complete rejection of the past. But like a tree growing strong through the seasons, rooted in the earth and drawing life from the sun, so too, positive change must be rooted in traditional values -- in the land and culture, in family and community -- and it must take its life from the eternal things, from the source of all life, which is faith.

Such change will lead to new understandings, new opportunities, to a broader future in which the tradition is not supplanted, but finds its full flowering.

That is the future beckoning to your generation. At the same time, we should remember that reform that is not institutionalized will always be insecure. Such freedom will always be looking over its shoulder. A falcon on a tether, no matter how long the rope, can always be pulled back. That is why, in my conversation with General Secretary Gorbachev, I have urged him to look for ways to institutionalize change -- to put guarantees on reform. And we have been talking together about one sad reminder of a divided world, the Berlin Wall. It is time to remove the barriers that keep people apart.

I am proposing an increased exchange program of high school and other young people between our countries. You have a wonderful phrase in Russian for this: "Better to see something once than to hear about it a hundred times." I hope that eventually we could have thousands of such exchanges every year. [But not everyone can travel across the continents and oceans. Words travel lighter: That is why we would like to make available to this country more of our ___ thousand magazines and periodicals; and our television and radio shows, that can be beamed off a satellite in seconds.] Nothing would please us more than for the Soviet people to get to know us and our way of life.

Just a few years ago, few would have imagined the progress our two nations have made together: The I.N.F. treaty, which General Secretary Gorbachev and I signed last December in

Washington, the first true nuclear arms reduction treaty in history, *calling* for the elimination of an entire class of nuclear missiles. And just 15 days ago, we saw the beginning of your withdrawal from Afghanistan, which gives us hope that soon the fighting may end and the healing may begin, and that that suffering country may find self-determination, unity, and peace at long last.

It is my fervent hope that our constructive cooperation on these issues will be carried on to address together the continuing destruction of conflicts in many regions of the globe, and that the serious discussions that led to the Geneva accords on Afghanistan will lead to solutions in Africa, Asia, Southeast, and Central America.

I have often said, nations do not distrust each other because they are armed, they are armed because they distrust each other. If this globe is to live in peace and prosper, if it is to embrace all the possibilities of the technological revolution, then nations must renounce, once and for all, the right to an expansionist foreign policy. Peace between nations must be an enduring goal -- not a tactical stage in a continuing conflict.

I have been told that there is a popular song in this country -- perhaps you know it? -- whose evocative refrain asks the question, "Do the Russians want war?" In answer it says, "Go ask... the silence that lingers in the air, above the birch and poplar there/ Beneath those trees the soldiers lie.... Go ask those who gave the soldiers life/ Go ask my mother, ask my wife/ Then you will have to ask no more/ Do the Russians want a war?"

Voice of America
↓

Natasha Clarkson

But what of your one-time allies? What if we were to ask the the watery graves of the Pacific, or the European battlegrounds where Americans fallen were buried far from home. What if we were to ask their mothers, sisters, and sons: Do Americans want war? Ask us, too, and you will find the same answer, the same longing in every heart. People do not make wars, governments do -- no mother would ever willingly sacrifice their sons for territorial gain, for economic advantage, for ideology. A people free to choose, will always choose peace.

Americans seek always to make friends of old antagonists:
X After a colonial revolution with Britain, we have cemented for all ages the ties of kinship between our nations; after a terrible civil war between North and South, we healed our wounds and found true unity as a Nation. We fought two world wars in my lifetime against Germany, and one with Japan, but now those nations are two of our closest allies and friends.

Some people point to the trade disputes between us as sign of strain, but they are the frictions of all families, and the family of free nations is a big and vital and sometimes boisterous one. I can tell you that nothing would please my heart more, ^gthan, in my lifetime, to see our diplomats grappling with the problem of trade disputes between America and a growing, exuberant, exporting Soviet Union that had opened up to economic freedom and growth.

And as important as these official people-to-people exchanges are, nothing would please me more than for them to become unnecessary, to see travel between East and West become so

routine that college students in the Soviet Union could take a month off in the summer, and, just like students in the West do now, put a pack on their back and travel from country to country in Europe with barely a passport check in between. Nothing would please me more than to see the day that a concert promoter in, say, England could call up a Soviet Rock group -- without going through any government agency -- and have them playing in Liverpool the next night.

Is this just a dream? Perhaps, but it is a dream that it is our responsibility to make come true.

Your generation is living in one of the most exciting, hopeful times in Soviet history. It is a time when the first breath of freedom stirs the air, and the heart beats to the accelerated rhythm of hope, when the accumulated spiritual energies of a long silence yearn to break free.

I am reminded of the mysterious, ambiguous passage near the end of Gogol's Dead Souls. Comparing his nation to a spreading troika, he asks what will be its destination. But he writes, "there was no answer save the bell pouring forth marvellous sound."

We do not know what will be the conclusion of this journey, but we are hopeful that the promise of reform will be fulfilled. In this Moscow spring, this May, 1988, we may be allowed that hope -- that freedom, like the fresh green sapling planted over Tolstoi's grave, will blossom forth at last in the rich fertile soil of your people and culture. We may be allowed to hope that

the marvellous sound of a new openness will keep ringing through,
leading to a new world of reconciliation, friendship, and peace.

Thank you all very much and [in Russian: God bless you].

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In education, business, manufacturing, communications, scientific research, medicine, entertainment and the home, the changes wrought by the extraordinary innovation and proliferation of information technology have been swift, profound—and international. To cite only a few examples: Japan, along with a number of other Asian nations, is a leading developer of advanced electronic products for the world; Japan is also conducting research into Information-Age technologies as diverse as semiconductor chips and artificial intelligence. West Germany is among the world's first supplier of components for integrated digital networks, allowing data, voice and video to travel over the same communications lines. And Minitel, an innovative French videotex system, gives subscribers a vast electronic directory, with access to thousands of goods and services.

For the United States, as for many countries around the world, the industrial age that defined the first half of the 20th century is giving way to a new age of information that is effectively shrinking the world, compressing time and expanding the accessibility of vast realms of knowledge. This publication examines the impact of these transforming technologies on American life, and highlights some of the challenges and opportunities facing all of us as we join the global information revolution that is shaping the future for ourselves and our children. The

Information Age is an extraordinarily diverse phenomenon, one that encompasses videocassette recorders (VCRs) in the home, and such "cutting-edge" technologies as fiber optic communications and computer chips that

- ■ ■ *"The dramatic increase in computer power and accessibility, and the proliferation of telecommunications, have paralleled and reinforced each other."*

■ ■ ■ *“Americans have welcomed the revolution in information technology because it promotes the values of individual freedom and opportunity that are at the heart of an open, democratic society.”*

communication links, for example, computer operators can tap into distant electronic information sources or other computers. Telecommunication systems, in turn, use computers and microelectronics to manage the complex flow of data through their lines. The convergence of computers and telecommunications began in the 1950s when researchers developed devices that enable digital computers to talk to other computers over telephone lines. One computer network today links more than 1,000 scholars and researchers in 18 countries. With the advent of digital telephone systems, computer and telecommunication technologies have grown even closer together.

It is this convergence of electronics, computers and telecommunications that has established the technological basis for the Information Age.

Americans have welcomed the revolution in information technology because it promotes the values of individual freedom and opportunity that are at the heart of an open, democratic society. The new technology, by creating fresh sources of knowledge, supporting unfettered scientific inquiry and promoting individual opportunity, reaffirms ideals that were enshrined in the U.S. Constitution and Bill of Rights 200 years ago.

When ideas are free, they are abundant: the United States today has more than 9,100 newspapers, 11,300 periodicals, 10,000 radio stations, 940 commercial TV stations and another 300 noncommercial, publicly supported television stations. Each year, private U.S. publishers produce some 50,000 book titles. Equally important: not a single one of these publications or broadcast stations is government-owned or controlled.

Foreign publications are also plentiful. As one indicator, the Library of Congress (the nation's largest library) subscribes to more than 1,100 foreign newspapers, and a total of 60,000 U.S. and foreign periodicals.

The Information Age supports other deeply held American values as well: the availability of a wide range of goods and services, economic opportunity, and free and open competition. Individual freedom and economic opportunity are essential to the constant stream of innovations that

Computer and telecommunications systems are at the heart of the modern American economy. Above, computerized data center in Sacramento, California, receives and processes thousands of product orders each day for retail stores across the country. Simultaneously, computers print out the customer's order along with price stickers for each container. Top center, opposite page, "mega-bit" computer chip, smaller than a pen point, can hold more than one million bits of information. Developed by AT&T, the nation's largest telephone company, the chip is used in telecommunications switching equipment and information processing.

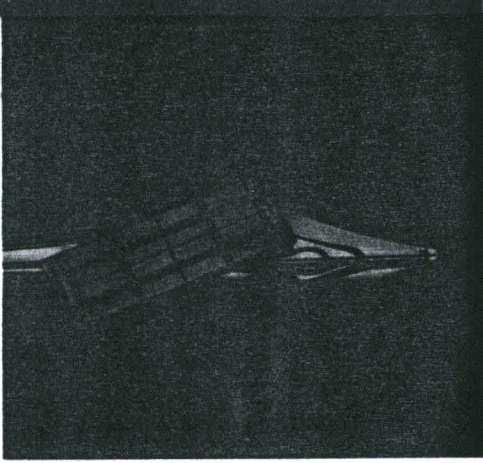
can hold one million "bits" of information. As one aid to understanding this phenomenon, you will find a glossary on page 64 that defines some of the technology, acronyms and high-tech terminology of the Information Age.

But first, how do we define the Information Age itself? The exchange of information, after all, defines civilization itself; and technology such as the telegraph, telephone, calculator and typewriter are inventions of the last century.

Part of the answer appeared in 1946, when scientists at the University of Pennsylvania completed the world's first general-purpose electronic computer, called ENIAC. ENIAC weighed 30 tons, filled the space of a two-car garage, contained 18,000 vacuum tubes, and at current prices, cost almost \$2.8 million. Today, as a result of a revolution in micro-electronics, the same amount of computer power is contained in a microprocessor—a silicon chip about the size of a child's fingernail that costs less than \$10.

A second part of the answer to the question, 'What is the Information Age?', came in 1963, when the United States launched the world's first geosynchronous-orbit communications satellite, inaugurating an era of global communications. Today, more than 140 geosynchronous satellites are in operation, and together with cable, microwave and fiber optic networks, they carry data, video and voice communications at ever-increasing rates.

The dramatic increase in computer power and accessibility, and the proliferation of telecommunications, have paralleled and reinforced each other. With modern



characterize the Information Age. Speaking in Paris in 1986, Secretary of State George Shultz said: "Any nation that wants to profit from the information revolution must understand where innovation comes from. In this era of rapid technological change, the pace of obsolescence is accelerating as never before. Innovation—and risk taking—are more than ever the engines of progress and success. This is true both in the economic marketplace and in the marketplace of ideas."

The Age of Information has also been the age of the entrepreneur. In 1950, for example, Americans created new businesses at the rate of 93,000 per year; by the 1980s, the rate was more than 600,000 per year—and many were in the expanding fields of information and communications. Although the failure rate for new businesses is always high, these entrepreneurs have nevertheless brought vitality, competition, and new ideas and new products to everything from computer equipment to TV entertainment programs.

Paralleling this economic expansion has been the creation of new jobs, belying the often-expressed fear that technology—notably computers and robots—would destroy jobs and create vast unemployment. Instead, the United States economy generated more than 42 million jobs from 1959 to 1985—in precisely the period that the nation made the transition from an industrial economy to one where the majority of workers are engaged in creating, using, storing and transmitting information.

Unquestionably, many American workers, especially in the manufacturing sector, have been displaced by new technology and have needed retraining for entirely new jobs. But overall, information technology, whether in the business office or factory, has boosted productivity, generated economic growth and thereby created new jobs. The number of assembly line workers has dropped, for example, but the demand for computer operators has jumped substantially. Indeed, in the contemporary, highly competitive global economy, the failure to innovate with new

technology means economic failure—and the loss of old jobs along with the prospects for new ones.

The impact of information technology is pervasive, affecting virtually every aspect of public life. Perhaps the most dramatic example is that of computers. Twenty years ago, computers were large, centralized machines tended by highly trained specialists. Today, thanks to a revolution in microelectronics, computers have evolved into small, powerful machines that provide unprecedented access to information and knowledge to individuals and organizations throughout U.S. society.

Americans today own more than 30 million computers, half of which sit in their homes or schools. Their range of applications extends to virtually any activity involving information: writing a report, analyzing statistics, helping teach school children, paying bills, conducting scientific and medical research, operating machine tools, monitoring air traffic, designing everything from newspaper pages to buildings, and hundreds of other activities.

Linked to telecommunications systems, the range and application of the computer is even greater: searching through massive amounts of information in one of almost 3,000 electronic libraries, or data bases; or tapping the massive computing power of larger computer systems. And with the advent of new lightwave communication systems, which use slender optical fibers and lasers, the capacity, quality and reliability of the global telecommunication network will experience a quantum increase.

Perhaps the most visible impact of the new information technology has been in the office, where more than half of all American workers are employed, and where experts predict that computer terminals soon will be as common as the telephone is today. By incorporating microelectronic components, familiar office equipment

■ Sound Machine

Using computer technology, the Kurzweil 250 digital synthesizer (below) can accurately recreate the sounds of a variety of musical instruments, including the human voice. With a range that allows it to sound like a symphony orchestra one moment and a rock band the next, the Kurzweil 250 is a favorite of such pop music composers and musicians as Stevie Wonder and Herbie Hancock. Its inventor, Raymond Kurzweil, earlier developed a reading device for the blind that scans words on a printed page, then reads them aloud in an artificial voice. Kurzweil's latest invention reverses the process: the Voice-Writer listens and recognizes an English vocabulary of 10,000 words, printing them out as fast as they are spoken.



Young student (below) learns computer skills with the help of a small robot called a "turtle." By entering simple commands into the computer, student can control movement of robot turtle on the floor, as well as create geometric patterns on the computer screen.



is taking on new or expanded functions. Typewriters acquire computer memory and become word processors that, in turn, become almost indistinguishable from personal computers. Telephone systems incorporate small computers, or microprocessors, and computers serve as communication devices. Through telecommunication networks, businesses can link computers with everything from data bases to printers, send mail electronically from headquarters to branch offices, and set up "teleconferences" among managers who are thousands of kilometers apart.

In factories, robots and computer-controlled systems are transforming the manufacture of goods ranging from automobiles to computer components themselves. On the farm, computers help predict the weather, analyze production costs, even determine the use of fertilizers and pesticides. Retail stores are able to control their inventory of goods and speed the sale of groceries and other merchandise carrying computerized codes. Whether in the office, farm, on the manufacturing line or at the store, the impact of these technological changes is the same: greater productivity, increased efficiency, more economic growth and new job opportunities.

In education, computers are becoming integrated into the curricula from the elementary school through the university. More than 85 percent of U.S. public schools have computers; a whole generation is growing up with the computer, taking it for granted, learning its language and using it with ease for everything from studying mathematics and history to writing reports. At the university level, computer "literacy" is now a degree requirement in many scientific and technical curricula. A number of universities even require that entering freshmen have a computer when they register for classes. At many universities, students can use local computer networks to exchange information, tap into data bases and conduct advanced scientific research.

Advanced technologies that enable scientists to see dramatic computer-enhanced images of Saturn and Uranus, thousands of millions of kilometers away, can also map the genetic composition of a human cell. Thousands of computer systems are at work in the health field in the United States,

monitoring patients, helping with diagnoses and treatments, and providing physicians with immediate access to a vast range of current medical information.

In the arts, computer graphics programs are creating startling new images, and music synthesizers are reproducing the instruments of the orchestra—as well as new, hitherto unheard sounds. Even the choreographed steps of the ballet dancer can be captured, reproduced and analyzed for future dancers and audiences with the aid of a computer.

Communications technology is bringing new choices and opportunities into the American home. As in the office, many familiar devices have changed and taken on enhanced functions. The phonograph record, for example, has a new rival in the remarkable sound reproduction of the compact disk, which is played with an enclosed laser beam instead of a stylus. Television is as ubiquitous as ever in the home, but now, through cable networks accessible to half of all American homes, viewers can select from 20 to 50 or more channels of entertainment, information and instruction.

The information revolution is a time of challenge and opportunity. Those who fail to master its challenges will be turning their backs on the future and on the vital flow of information that is the lifeblood of this new age. The future belongs to those with the freedom to question, explore, communicate and create through access to a worldwide, ever-increasing pool of information.

The challenge that confronts us as we enter the 21st century is to link information, knowledge and people so that we all can learn, grow and share in the bounty of the Information Age.



Computer components: above, a removable "floppy" disk that is used to store information outside the computer. Left, computer keyboard and monitor. Small "mouse" to right of monitor is used for entering commands into the computer.



Speed, volume, accuracy: three reasons why Americans have embraced computer technology. For insurance company manager Bob Hoppie, as for millions of other office workers, computers are the means by which they manage information and avoid an inundation of paperwork. Here, Hoppie, who works for the Sequoia Insurance Company in California, unfurls a long stream of claims forms that have been processed by the firm's computer systems—saving him and his staff countless hours of work filling out these forms by hand or on a typewriter.

..... E N G I N E E R S O F T H E

Our age is characterized by the need and ability to process large quantities of information in novel and intricate ways to solve the complex problems of modern life. To collect, store, use and disseminate such large amounts of information, one tool is indispensable: the computer. With the modern computer and the linkage provided by electronic communication, we have been able to expand our abilities, enhance our knowledge and enrich our lives.

By Arthur L. Norberg and William Aspray
The Charles Babbage Institute

In a single lifetime the computer has grown from a scientific curiosity to a fundamental tool of modern American life.

Three innovations made the computer possible and set it apart from earlier calculating technology: electronic switching, digital representation of information, and internally stored, automatically executed instructions.

Evolution

To appreciate the innovation of electronic switching, it is helpful to look back on earlier mechanical and electromechanical calculating devices. Calculating equipment can be traced back to the 17th-century adding machines of Pascal and Leibnitz. Its descendant, the 19th-century business adding machine, represented numbers by the position of toothed wheels and carried out addition by switching their position, rotating the wheels the appropriate number of teeth.

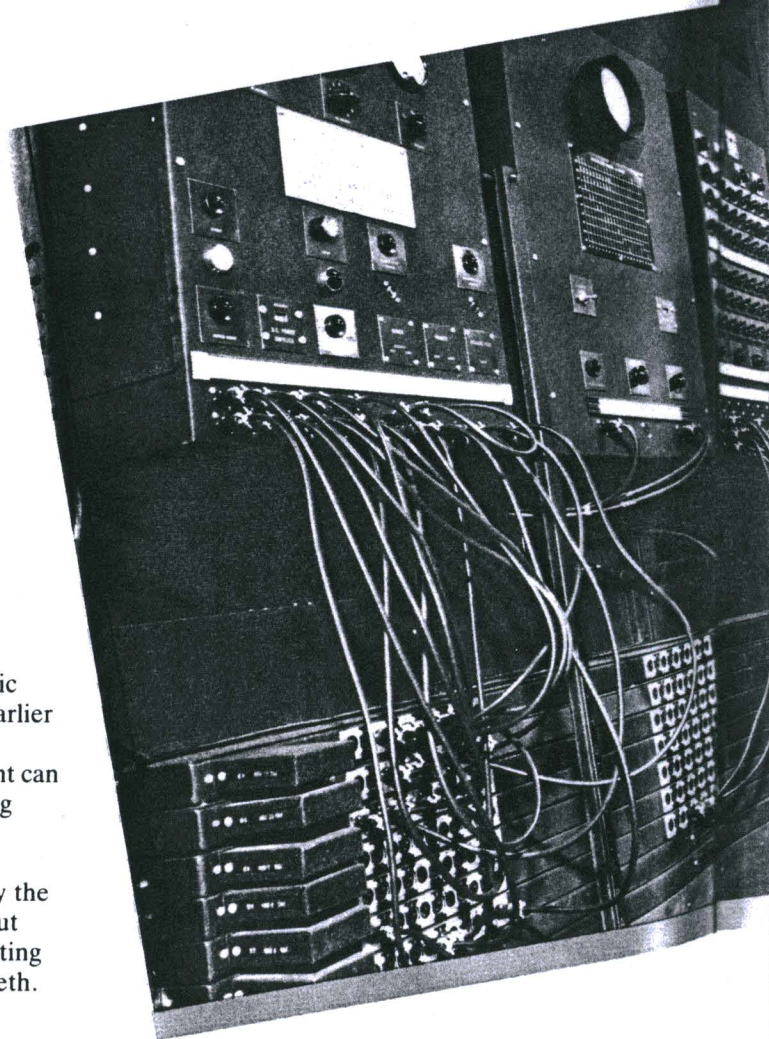
By the end of the 19th century, Herman Hollerith, the son of German immigrants to the U.S., had developed a revolutionary punched-card calculator for large statistical problems. Information was coded by punching holes in them in specific patterns. An electrical-mechanical device would sense the holes and send signals to the processor. Hollerith's calculator was so successful that the U.S. Census Bureau used it for the 1880 census.

Scientists and engineers also used analog calculating systems—that is, machines that use one kind of physical property, like movement or electrical resistance, to represent another. The moving hands of a clock, for example, are an analog for the passage of time.

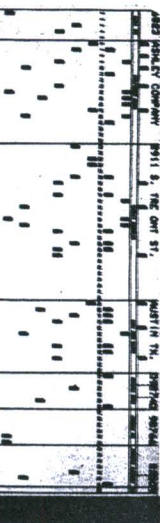
But two problems plagued analog systems. First, the range of applications was

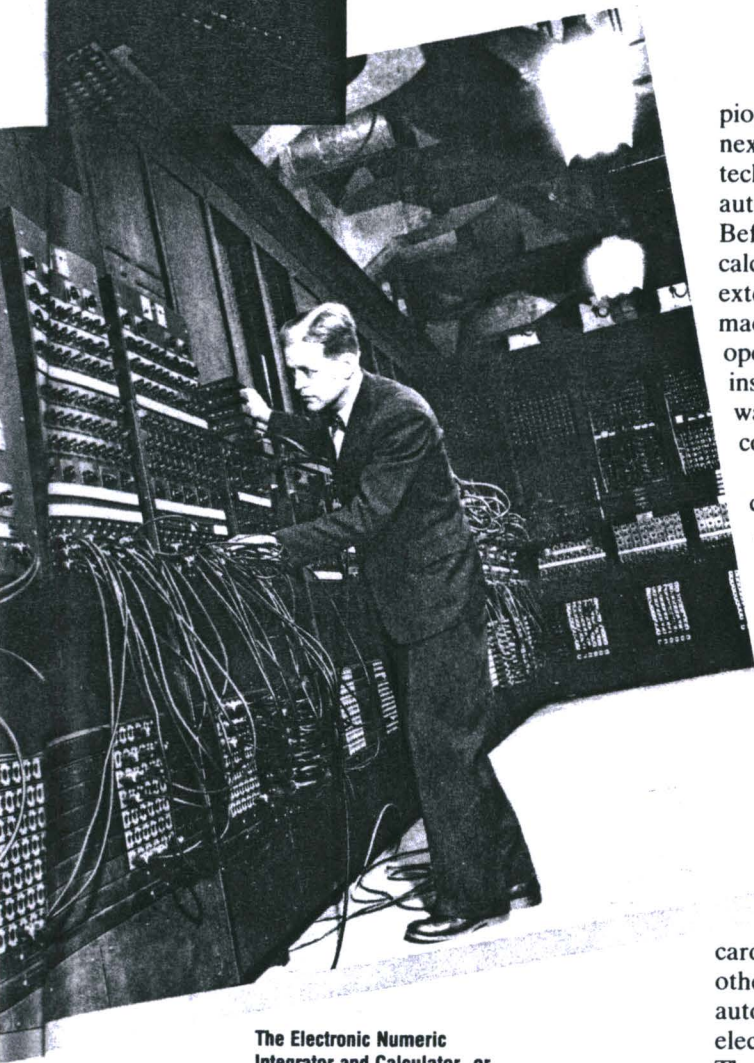
limited by the range of problems the analog device could model. Second, the precision of most of these machines was limited to .1 percent—suitable for many problems, but not all, and the cost of improving their precision grew exponentially.

In 1946 two University of Pennsylvania scientists—John Mauchly and J. Presper Eckert, Jr.—built the Electronic Numeric Integrator and Calculator, or ENIAC, a computer which used vacuum tubes instead of electromechanical relays. It was the largest machine to be built with vacuum tube technology. ENIAC, the first general-purpose electronic computer, was used for computing ballistic tables, weather



Above, sample "punch card," used by early calculating machines to store and process information. Numbers are represented by single holes punched in the card, letters of the alphabet by two holes. The machine then registers the holes electrically as the card moves across sensors.





The Electronic Numeric Integrator and Calculator, or ENIAC, the first general-purpose electronic computer.

predictions, atomic energy calculations, cosmic ray studies and wind tunnel designs.

Although a hulking dinosaur next to today's sleek desktop models, the pioneering ENIAC, like modern microcomputers, was based upon the same fundamental principle: digital rather than analog representation of information. Information was stored as numbers in the machine, and the machine did its processing by counting these numbers, rather than by measuring physical parameters.

In contrast to an analog device, computers face no serious practical limitation to the degree of precision with which they can operate. Doubling the precision requires storing perhaps twice as many digits, and adding extra processing time. This increase of precision widens the realm of application far beyond that of analog devices, without significantly increasing the cost.

John Von Neumann, a computer pioneer and mathematician, created the next major innovation in computer technology: internally stored, automatically executed instruction. Before the advent of the computer, calculating machinery had to be externally programmed. (With adding machines, for example, the operator manually entered each instruction and piece of data as it was needed during the computation.)

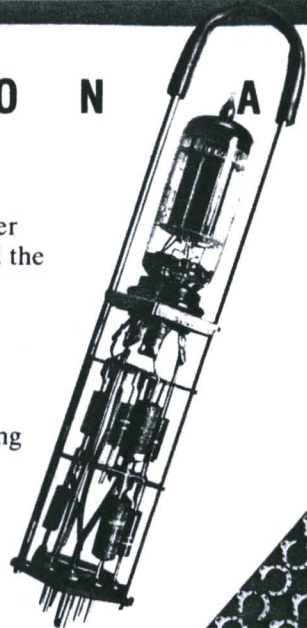
Early calculating machines could execute only one instruction at a time, and then store only one, or a very few intermediate results. It might take a day of plugging cables into electrical boards, setting banks of switches, or adjusting screws or levers to prepare a single problem for calculation. Operators then had to repeat the process for a new application.

By contrast, the modern computer has stored programming. The operator feeds instructions and data to the computer in a written code—most commonly through a keyboard, but also through punched cards, magnetic tape, telephone lines or other input devices. The computer automatically converts this code into the electronic pulses recognizable by the machine. The machine stores and executes instructions, and calls in data automatically as it is needed, without human intervention. In short, it controls its own operation, practically speaking, to any degree of complexity.

Heart of the Matter

An electronic, digital, stored-program computer is composed of three kinds of equipment: input-output devices, storage devices and a central processing unit.

The input-output devices provide a means for the computer system to communicate with the outside world, translating the electronic pulses that are sensible to its human operators—or to other equipment to which it is attached. (A computer, after all, can be part of a larger system, working as the "brain" in the



Early components and computers: top, computer industry's first "replaceable unit," an assemblage of electronic parts in a 1948 IBM machine that engineers could simply remove and replace with a new plug-in component. Above, banks of switches—420 in all—were set by hand in the Mark I, the first U.S. computer whose operations were controlled by internally stored programs.





inertial guidance system of an airplane or on an automated assembly line.)

Storage devices hold program instructions, initial data, intermediate results, commonly used functions and other information needed for the components of the computer system to operate and communicate with one another. Most computer systems have several different kinds of storage devices, usually within the central processing unit (CPU). Information that is not required frequently can be stored outside the computer on large magnetic tapes, lighter weight "floppy disks" or optical disks.

The central processing unit is the most critical component of the computer. It ensures that the various components operate as a system, and it is there that arithmetic and logical operations are carried out on data and instructions. All information in the computer, whether data or instructions, is coded in binary form (called "bits"), "0"s or "1"s, represented in the machine by the absence or presence of an electrical charge. Although seemingly simple, the system is extremely flexible. Symbols, such as numbers or the letters of the alphabet can be represented as sequences of these binary digits (strings of "0"s and "1"s called "bytes"). Simple, yet powerful rules have been devised for carrying out arithmetic operations (addition, multiplication, etc.) and logical operations (comparison, conjunction, negation, etc.) on these sequences. From these basic arithmetical and logical operations, one can build up solutions to problems of almost any complexity.

From Vacuum Tubes to Chips

Over the past four decades, technical innovations have shrunk computers to desktop size and smaller, and slashed their costs dramatically. Today, people with little or no knowledge of computer technology work happily with computers on a daily basis.

Two areas of innovation are especially worthy of note: switching components and software.

The earliest computers used vacuum tubes as the electrical switches for storing and

Transistor (right) is 1/200th the size of earlier vacuum tubes and used 1/100th of the power. The transistor functioned as an electrical switch in early generations of computers until it was replaced by the semiconductor circuit, which combined large numbers of transistors on a single silicon chip.



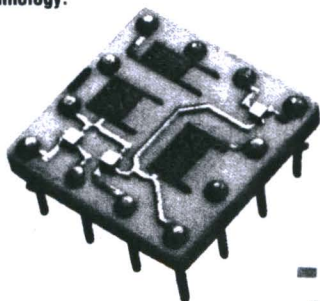
processing binary digits. However, vacuum tubes generated large amounts of heat (requiring extensive air conditioning units), consumed great amounts of power, and were bulky, expensive and unreliable.

William Shockley, John Bardeen and Walter Brattain resolved the problems caused by vacuum tubes when they invented the transistor at Bell Laboratories in 1947. The transistor functions similarly to the vacuum tube, but it makes use of the electrical properties of certain materials, called semiconductors, that eliminate the need for charged particles to travel through space. The result: less electrical power, less heat generated, and most important, smaller size. (The introduction of the transistor made it possible to build the first minicomputers and large-scale scientific computers.)

In the late 1950s, two U.S. engineers took the next major step in computer technology when they developed the integrated circuit. Working independently, Jack St. Clair Kilby of Texas Instruments and Robert Noyce, who later founded Intel Corporation, devised silicon chips that contained an entire circuit consisting of electrically connected transistors, resistors and capacitors. At first these integrated circuits contained only a few transistors each; but the technology rapidly improved so that tens and later hundreds of transistors could be placed on a single fingertip-sized piece of silicon—called a chip.

Intel was the setting for another crucial technological breakthrough: the 1969

First high-volume, mass-produced semiconductor circuit, built in the early 1960s by IBM. Twelve-millimeter-square chip was faster and required less power than older transistor technology.



"Technical innovations have shrunk computers to desktop size and smaller.... Today, people with little or no knowledge of computer technology work happily with computers on a daily basis."

development of the microprocessor—a single chip that incorporates an entire central processing unit. The microprocessor dramatically simplified the design of the computer, leading to further miniaturization and use of fewer chips.

The Computer Complex

Because of the rapid improvement in the technology, especially in microelectronics, it has become technically and economically feasible to build computers of many different sizes and performance characteristics. Growth has been especially active at the two ends of the spectrum, microcomputers and supercomputers.

Supercomputers are the largest computers in terms of size, speed, cost and complexity. They can carry out thousands of millions of operations each second and store several million pieces of information in primary memory. The demand for speed has required many innovations, such as the use of multiple processors working simultaneously to carry out a computation, or the development of

Anatomy Of a Personal Computer

With the development of semiconductor technology, the typical personal computer now contains an extraordinary amount of capacity and computing power in a few compact electronic components. Moreover, the development of non-technical software programs permits individuals with very little computer training or knowledge to operate today's computers with ease. Left, looking at the major components of a computer, clockwise from top left: small memory board with additional random access memory (RAM); main board that holds computer's microprocessor, or central processing unit (CPU), and RAM storage area; printer interface board; disk-drive interface board; disk-drive unit (with cord), which permits the computer to read and write data on magnetic disks; removable magnetic or "floppy" disk for information storage outside the computer; and keyboard and data entry. Video display terminal, or monitor, is at top left on the facing page.



Right, five-meter-square projection of advanced microprocessor chip. A single chip, which actually measures less than 38 millimeters on a side, incorporates 275,000 transistors and can handle more than four thousand million bytes of memory. It is, in short, a computer-on-a-chip.

■ ■ ■ *"Today the individual user has on his or her desk a computer that rivals, in ability and speed, the room-sized mainframe computers of the 1960s."*

The first integrated circuit (below), designed in 1958, became the prototype for today's microchip. The integrated circuit consists of miniature transistors and other circuit elements mounted on a single silicon chip.

■ ■ ■ faster integrated circuits using new materials like gallium arsenide. Supercomputers are used for controlling large time-sharing systems and for making vast numerical calculations very quickly—as in weather forecasting, or in modeling complex chemical reactions.

The next category of computer is the mainframe. These have traditionally been the work-horses of large and medium-sized businesses, government and large time-sharing systems like airline reservation, air traffic control or library catalogues.

Minicomputers, far less powerful and considerably less costly than "supers" or mainframes, are designed for use in small organizations such as the laboratories or business offices.

Unlike mainframe computers, they are designed primarily for use by individuals or small groups.

The microcomputer, or personal computer (PC), was made possible by the development of the microprocessor. These computers, ranging in price from a few hundred to a few thousand dollars, are capable of handling word processing, financial spreadsheets, relatively small engineering and scientific numerical calculations, small data bases and a large number of other specialized applications. They are so inexpensive that they are now found in millions of homes and offices.

The March of Technology

Today, advances on six technological fronts are having a dramatic impact upon the way Americans are using computers—and the

rapid spread of computerization throughout society. These innovations are: micro-processor and semiconductor technology, multiprocessing and multiprogramming, networking and communication, graphics, robotics and computer-aided manufacturing, and artificial intelligence.

Advances in microprocessor design—and in the materials from which they are constructed—are creating exponential advances in the speed, complexity and processing power of computers. For example, the capability of a single semiconductor chip increased from four kilobytes (or thousand bytes) of random access memory (RAM) in the early 1970s to 64 kilobytes in 1980. Recently, IBM developed a one-megabit chip that can hold a *million* bits of information, and experts foresee four-megabit chips in the near future. The parallel drop in costs has been equally dramatic: In 1953, the cost per 100,000 calculations on a computer was \$1.26; in 1980, the cost had dropped to \$0.0025 per 100,000 calculations—and is substantially lower today. These advances have brought about dramatic changes in miniaturization and increase in performance per unit price. Each year, microprocessors appear in more kinds of appliances and systems, and every year the desktop computer itself is more powerful and less expensive than the year before. Today, the individual scientist has on his desk a computer that rivals in ability the room-sized mainframe computers of the 1960s.

Scientists are also developing multiprocessing computers, machines with many independent central processing units capable of working on a number of different problems at once, or of breaking a complex problem into many parts and working on these parts simultaneously.

One example is a remarkable new computer, the Connection Machine, developed by Daniel Hillis, co-founder of the Thinking Machines Corporation in Cambridge, Massachusetts. The Connection Machine, which is contained in a 1.5-meter clear-plastic cube, can execute several thousand million instructions per second, rivaling much larger supercomputers in speed, but at a quarter of the cost. In one demonstration, the Connection Machine scanned 16,000 news stories in 120th of a



second and laid out the circuitry for a computer chip with 4,000 transistors in three minutes. The secret to its speed is that, instead of the single central processing unit (CPU) found in conventional computers, the Connection Machine contains more than 65,000 microprocessors, each with its own tiny memory bank. Moreover, each processor is directly or indirectly connected to every other unit, so that the circuitry can be electronically rearranged to suit the problem at hand.

Computer and communication technologies are rapidly converging. In addition to transmitting information, telecommunications enables computers to work together in carrying out a computation, and permits a network of users to share a major resource like a library's electronic data base.

Until recently, graphic output from computers was rudimentary—in most cases limited to simple charts and diagrams. Tremendous advances have been made in the past few years. It is now possible to use the computer to generate complex and multicolored business reports, perform electronic printing, execute sophisticated computer-aided designs for engineers and architects, produce works of art, and generate

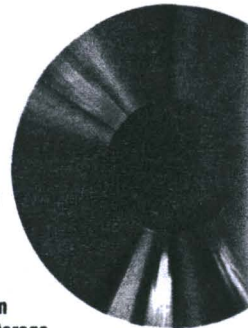
extraordinary special effects for live-action and animated films.

Computers are also entering manufacturing processes in significant ways, allowing complex continuous processes to be monitored automatically by the computer. Computerized robots are being employed as welders on automobile assembly lines, for example, and machine tools can be programmed through a computer to cut and lathe tools to any specification.

Research is under way in many areas of artificial intelligence (AI), although perhaps none is so promising as expert systems. These systems consist of one component capable of reasoning logically from hypotheses to conclusions and another with a data base of specialized information. They are intended for employment in fields where a narrow range of expert knowledge is required: Already, AI systems are at work in medical diagnosis, the analysis of seismic data and the design of computers themselves.

The computer has been the catalyst for many of the remarkable changes that have transformed life in the 20th century. Our reliance on this machine to solve problems and enhance our lives testifies to its importance. No other technology is as versatile. No other technology holds as much promise for the future. The computer stands at the center of our age; it has become a metaphor for our time. As we process more and more information, we will continue to rely on this "engine" to help us extend the limits of human knowledge and capability.

■ The Charles Babbage Institute is an archive and center for historical research into information processing at the University of Minnesota. Arthur L. Norberg and William Aspray are, respectively, the Institute's director and associate director. Babbage was an early 19th-century English mathematician and pioneer in computer design.



The Remarkable Videodisk

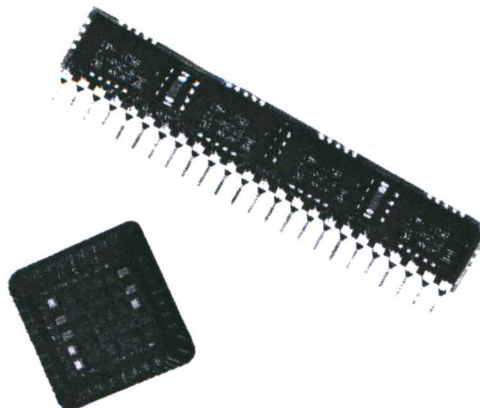
A revolution in information storage is underway with the videodisk, which can store astonishing amounts of visual and audio information on a disk about the size of a phonograph record.

Videodisks, and related audio compact disks, use the same basic technology, called CD-ROM, which stands for "Compact Disk - Read Only Memory." The durable and lightweight videodisk is made of aluminum coated with plastic. Information is etched onto the shimmering surface of the disk in the form of microscopic pits arranged in a long spiral groove. The information—either sound or image—is "read" on a special videodisk player by a laser beam passing over the surface at an extremely high speed. The information is then instantaneously displayed on a screen or emitted through audio speakers.

Videodisks have proved especially useful in the classroom. A student sits in front of a personal computer equipped with a TV screen and a keyboard or control pad. The videodisk containing the course is read by a laser beam and projected onto the TV screen. The computer program, interacting with both the student and the videodisk, can pose questions, point out errors and repeat material for review.

Museums also find videodisk technology useful. The National Gallery of Art in Washington, D.C., for example, recorded images of 1,645 paintings and sculptures—virtually all of its major works—on a single videodisk.

Right, examples of two modern, high-density integrated circuits with computing speeds that are measured in tiny fractions of a second.



■ At Harvard University in Massachusetts, Classics Professor Jeffrey Rusten explores 5th century Greek literature with the help of an Apple computer that can switch from English to Greek characters.

■ At the National Center for Atmospheric Research in Boulder, Colorado, two massive CRAY supercomputers model the complex interaction of the earth's oceans and atmosphere.

■ On eight hectares of ponds in Kansas, Trip Ellison and his father Frank raise and sell catfish—a prized delicacy in the American South—with the help of a portable IBM computer that monitors the entire operation, tracking growth rates, costs and changes in the market.

translate

These examples are remarkable not because they involve computers, but because these computers are adaptable to such an extraordinary range of uses. Such applications are the result of computer programs covered broadly by the term “software.” Simply put, software is what harnesses the computer’s versatility and computing power, and puts it to work. It is the linkage of human beings to machines.

Software translates human questions into the electrical switching understood by the computer. The first computers had to be programmed in machine code, using a set of basic instructions that corresponded closely to the level of electronic switching in the machine, e.g., “load this item,” “store this item in location 185.” To reduce the tedium of listing each of these basic instructions, computer programmers built devices known as compilers. IBM introduced the first compiler, or programming language, called FORTRAN, in 1957. Compilers accept instructions written in a combination of natural language and algebraic formulas, then translate the operator’s instructions automatically into machine code. FORTRAN, and the hundreds of other programming languages like COBOL, PASCAL and BASIC that have been developed since, are used for almost all computer programming today.

With the advent of the microcomputer in the late 1970s, computer hardware became afford-

able to increasing numbers of people. These microcomputers did not proliferate simply because they were cheap, but because of new, easy-to-use software written in non-technical languages for individuals interested only in a particular computer application. The new “user friendly” software has transformed the personal computer into a flexible tool capable of accomplishing an enormous range of tasks.

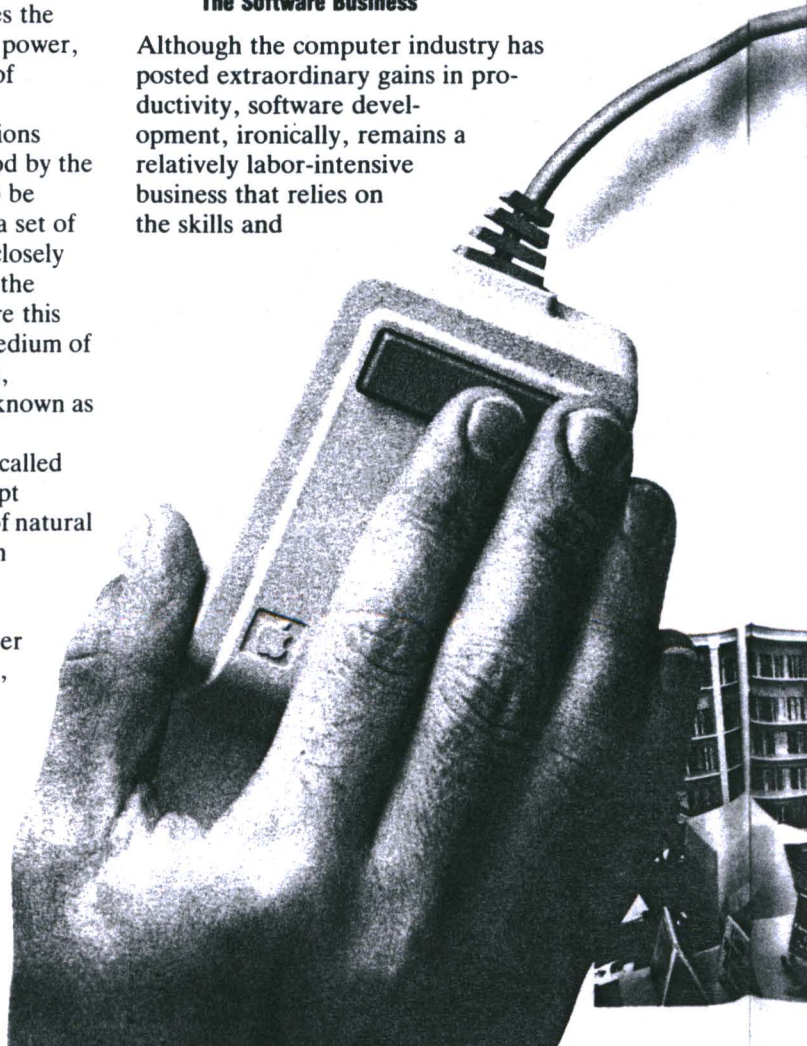
Software can be classified in two categories. The first is systems software, which is used to manage the operation of the computer and, from the user’s viewpoint, may be indistinguishable from the hardware capacity of the computer itself. Hardware manufacturers and software specialists write most systems programs, which are then embedded into the computer’s circuitry, or memory. By contrast, the second category, applications software, is written primarily by the users of computers, not the manufacturers. Applications software is designed to engage the computer in a specific task—whether word processing, accounting, or raising catfish.

The Software Business

Although the computer industry has posted extraordinary gains in productivity, software development, ironically, remains a relatively labor-intensive business that relies on the skills and



In California's Yosemite National Park, ranger Jim Sano (above) collects statistics on park visitors (2.5 million annually), analyzes budget figures and even monitors the movement of bears in the park, using a personal computer and a popular “spreadsheet” software program called Lotus 1-2-3.



creativity of individuals rather than highly automated systems. Nevertheless, software is a large and growing enterprise; software sales jumped from \$5 thousand million in 1982 to almost \$25 thousand million in 1985.

Approximately 10,000 companies, ranging in size from one-person operations to divisions of large corporations, develop computer software for sale; estimates of the total number of programmers in the software industry range from 500,000 to nearly one million. In total, software production is a \$40 thousand million industry in the United States.

That fact has led to widespread reorganization and heightened competition in the computer industry as companies adjust to the demand for better and more varied software. Manufacturers of mainframe and personal computers such as IBM,

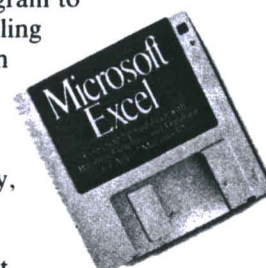
Hewlett-Packard and Unisys have expanded their software divisions or rushed to acquire software companies. At the same time, communication companies outside the computer business (book publishers Simon & Schuster; Dow Jones, publisher of *The Wall Street Journal*, among others) are developing and selling their own software programs.

Managing Complexity

In its early years, computer equipment—the hardware—was the most expensive component of any computer system. Manufacturers usually gave away software free with the sale of their computers; as a result, the cost of acquiring new applications software was much less than the cost of buying and maintaining the computers themselves. That situation is now reversed. For large mainframe computer systems, developing

software is now the principal cost; the creation of suitable software is also critical to wider and more ambitious computer applications. Software costs for a large computer may run as high as 80 percent of the total cost of acquiring and operating the entire system.

Take the case of a large air traffic control system. The software program to ensure the safe and efficient handling of large numbers of airplanes each day can consist of more than half-a-million instructions that must mesh perfectly and be essentially free of errors. Similarly, software programs for manned space flight, nuclear reactors and electronic transfers of money must also be highly reliable and accurate. Supercomputers such as the CRAY, which can perform millions of calculations per second, require novel and highly demanding software programs if they are to take advantage of even as much as 20 percent of their maximum speed.



Above, computer operator at Explorations Systems Corporation uses a sophisticated software program that analyzes geologic data to locate promising oil and natural gas fields in the southwestern U.S. Left, "floppy" disk containing business and graphics software program called Microsoft Excel.



Opposite page, closeup of hand-held mouse that, when moved across a desktop, controls the blinking cursor on the computer screen. The user selects a graphic symbol or instruction on the screen, then activates it by pressing the button on the mouse. Left, writer Stephen King, with his wife Tabby, sits before the computer terminal where he has composed such bestselling novels of horror and the supernatural as *The Shining*, *Firestarter*, *The Dead Zone* and *It*.

PC Software

Paralleling the explosive growth of personal computers (PCs) has been the proliferation of software programs to run them. Perhaps the single most common applications software for personal computers is writing and editing—word processing. Word processing software (with names like WordPerfect and Microsoft Word) enable the writer to work

■ ■ *“The new ‘user friendly’ software has transformed the personal computer into a flexible tool capable of accomplishing an enormous range of tasks.”*

more efficiently, accurately and productively. Instead of typing out multiple drafts, words, sentences and paragraphs can be revised, moved or deleted on the screen with great ease and speed before being printed out in a final, clean copy. Word processing software can check for typing errors and misspellings, search out and replace key words with a substitute, draw up lists, format charts and graphs, and generate multiple mailings from a single computer-generated text.

Another common software application, especially in business, is data base management. Software programs such as dBASE enable the user to create large files of information, and to sort and analyze this information in a variety of ways. Businesses can update orders, payments and inventories; physicians can correlate diseases, treatments and patient histories; lawyers can seek past legal precedents to argue their cases.

“Spreadsheets” are a related software application for businesses, which allow the operator to enter financial or accounting data into the computer. The spreadsheet program then automatically makes the necessary calculations in a number of separate categories—based on preset formulas or percentages. Spreadsheets permit analysts and planners to evaluate the consequences of their business decisions, analyze alternates and monitor current programs.

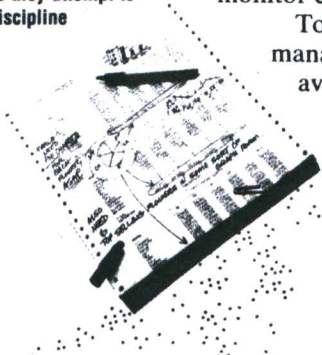
Today, word processing, data base management and spreadsheets are available in single integrated software programs for PCs, together

with the additional features of electronic communications and graphics. Communications software allows businesses and organizations to transmit their data from computer to computer via telephone lines or telecommunication links.

As with any other product, stiff competition among producers has resulted in

Revision and the Computer

One of the virtues of computers is the ease of making multiple revisions and corrections. Below, for example, is the printout of a business spreadsheet program that has been marked with multiple changes. The writer can simply call up the item on the screen, delete the old material and enter the new, then print a clean version. Business and word processing software can also search out misspellings, substitute one key word for another throughout the text, generate graphs and charts, and produce multiple mailings from a single text. English teachers report that computer word processing has facilitated instruction in composition, since students can revise and reorganize their drafts easily and repeatedly as they attempt to master the discipline of writing.



Humorist and composer Chris Cerf (above) poses with Muppet characters that are featured on the children's educational television program, *Sesame Street*. Cerf has collaborated on a number of educational software programs for children featuring the Muppet characters.

better computer software at lower prices. Take the case of a leading software company, Microsoft Corporation. To improve its sophisticated word processing program, called Microsoft Word, the company conducted lengthy in-depth “usability” studies with average citizens, then rewrote its training manuals and produced a new version of Microsoft Word incorporating many of their suggestions.

In the future, software will continue to grow more powerful and diverse—managing ever more complex tasks, yet progressively easier to use.





A WRITER CONFRONTS THE WORD PROCESSOR

By Isaac Asimov

Despite the awesome power and promise of computers, the transition to a new technology is never an easy one, even for an expert in science and technology such as Isaac Asimov. Although best known for his science fiction, Asimov is primarily a writer of nonfiction books that explain to general readers the intricacies of physics, chemistry, astronomy, mathematics and other scientific subjects. Born in Petrovichi near Smolensk, U.S.S.R. Asimov moved to New York City as a child. He taught biochemistry at Boston University (Massachusetts) before becoming a full-time writer. Asimov is one of the nation's most prolific authors. By 1987, Asimov's total number of published books had reached 351...and counting.

I am a creature of habit. Once I have set up a routine in which I feel comfortable I stay there. Others may be adventurous; I am not.

This strikes people as strange. In my imagination, I travel the universe in ships that go faster than the speed of light. My fictional characters think nothing of leaving home and kindred for indefinite periods of time. Why do I insist on living so dull a reality?

People ask me: "How is it that a person who in his mind travels everywhere—in real life refuses to get into an airplane and does not wish to leave home for any reason or by any conveyance?"

I don't know. Partly it is because my imaginary adventures fill my need for such things and I do not require real ones. And partly it is because all I want to do is sit at my typewriter and write. You can believe me when I say that, for I have published more than 350 books, and no one can do that unless writing is all he wants to do.

Notice that I have said, "I sit at my typewriter and type." My father bought me my first typewriter in 1935. By 1981 I had typed on an old typewriter, a new one, and many electric ones—but always on a typewriter. I knew that many writers were going the com-

puter route. But I didn't want one. I was used to my typewriter.

But then the editor of a computer magazine telephoned me. "Dr. Asimov," he said, "We would like you to write an article for us on your experiences with a word processor."

I said cheerfully, "I can't oblige you, for I don't own a word processor."

He seemed stunned. "How is that possible?"

"I don't want one. I am happy with my typewriter."

"But you *must* get a word processor."

"But I won't."

"But you will," he said.

To my astonishment, the computer magazine arranged to have a firm that manufactured word processors deliver one to me, to be paid for upon approval.

I stared at the boxes in the living room with deep concern. What was I going to do with this stuff? Finally, I decided the word processor could scarcely do me any harm if it remained in the boxes. But soon a young man arrived who worked for the firm that had manufactured the word processor. Totally disregarding the look of terror on my face, he pried open the boxes and removed all the parts inside. A "computer corner" was set up. On one table went the word processor; on an adjacent table went the printer.

Everything was plugged in and the young man proceeded to show me how it worked. I was completely lost after the first 15 seconds. I suppose that's another one of my peculiarities. I have written a couple of hundred books on every facet of science, and I can explain the most abstruse concepts in clear and straightforward prose—but that doesn't mean I'm at home with actual technological devices. I can work a

typewriter, I admit, but beyond that, my wife Janet does all the technological chores about the house, like changing light bulbs and using screwdrivers.

I suppose the young man noticed the glaze of confusion in my eyes, for he said, "If you have any difficulties at all, Dr. Asimov, here are two instruction booklets." I looked inside two enormous booklets and saw at a glance that neither was written in a recognizable language.

The young man left. I tried to work the word processor and failed miserably. It insisted on doing what it wanted to do and disregarded all my instructions with a contemptuous sniff.

Weeks passed. I grew no better at learning how to use it. Finally, I called the computer firm.

Two young men arrived and went over everything again, and I tried desperately to understand. The word processor under their strokings, behaved like the tamest housecat one ever saw. Once they were gone, and I tried it myself, it instantly turned into a Siberian tiger.

I had been trying to operate the word processor for a full month and had been defeated at every turn. I therefore thought that I might simply drop it out the window (I'm on the 33rd floor). But I remembered how humorless the police often were, and I decided it might, on the whole, be simpler if I called the computer firm and asked them to take it away. I thought about that for two days, and then decided to give it one more try.

I sat down, and started the machine—and suddenly with no

warning whatever, everything worked. The machine rubbed its head against my leg and purred.

I will never know what happened. A night had passed—an ordinary night—but something in my brain must finally have rearranged itself.

"Nothing to it," I said to my dear wife, Janet. "All it takes is grit, determination, brains and good old American know-how."

I have been using it now for five years, but I have not abandoned my typewriter, and still do the first draft of books on it.

Has it increased my rate of output? In the last 11 years before I started using a word processor, I published about one book a month on the average. In the five years since I started using a word processor, I have published, on average, nearly two books a month.

In addition, my manuscripts are much cleaner. My short pieces (such as the one you are reading now) are done entirely on the word processor. My long pieces, although drafted on the typewriter, are done on the word processor for the final copy.

So on the whole I am glad that the computer magazine asked me to do an article in 1981, and I'm glad I didn't succumb to the momentary impulse to throw the word processor out the window.



Top, writer Isaac Asimov. Right, one of the latest generation of personal computers. The computer's word processing capabilities make it the tool of choice for many of the nation's best and most prolific writers.

Anyone, at any time and virtually anywhere in the United States, can pick up a telephone and be connected almost instantly to any of more than 215 million other telephones in the country, and millions more around the world. Placing a telephone call—something that Americans do more than one thousand million times a day—is a simple task. But the nationwide telecommunications network that makes this possible is the largest and most complex mechanism on earth, capable of interconnecting both people and machines, and of carrying not only telephone calls, but also a wide variety of other signals such as computer data communications, television and other images. It is an “intelligent” network, and it is American society’s key link to the Information Age.

By Albin R. Meier

Until recently, the United States possessed only a basic telephone system for simple voice communication, and complementary telegraph and teletype networks for handling personal messages and business data. Today, America’s communication systems are changing into vast, highly flexible information networks which do not simply transport messages, but provide new and valuable information services.

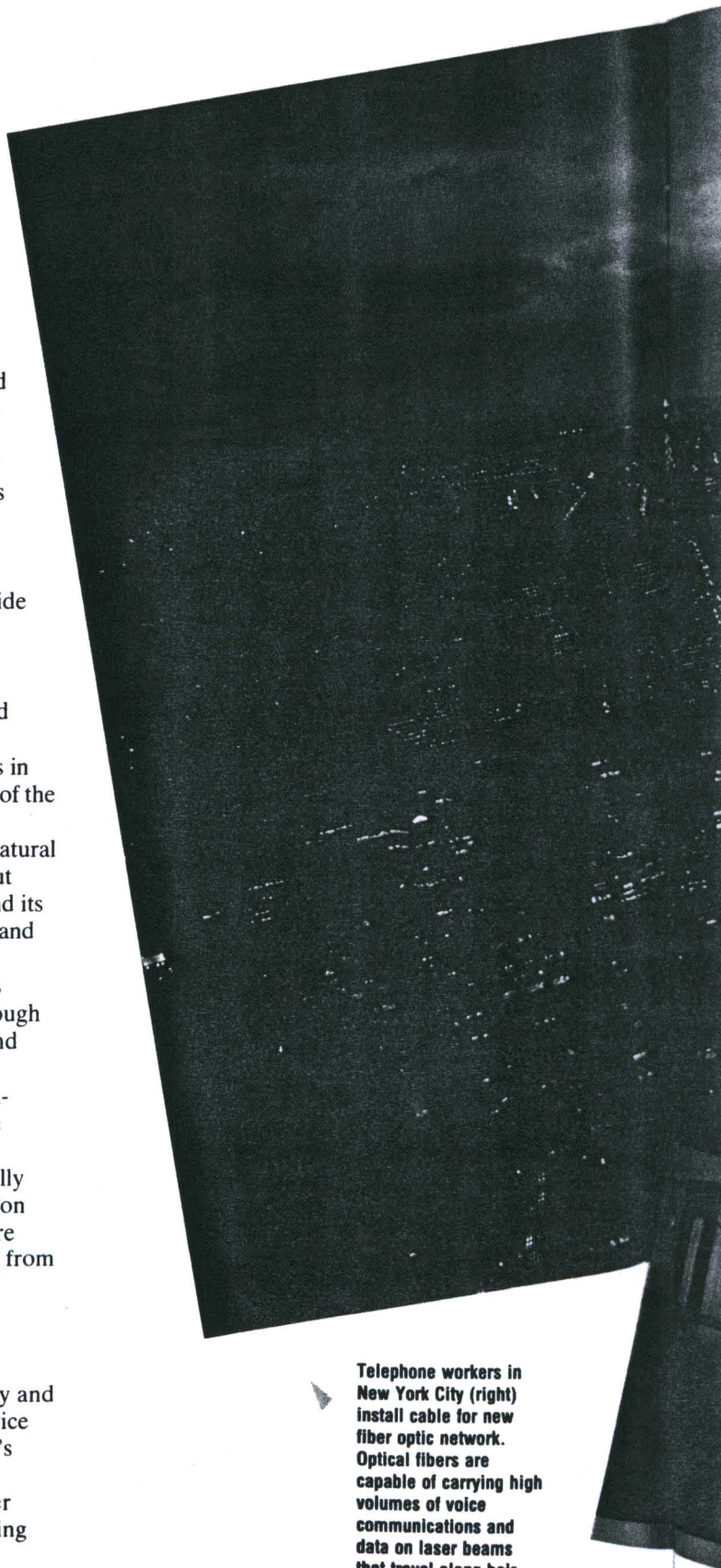
The marriage of digital computers and communications is a natural one, for much of today’s digital technology evolved in telephone industry laboratories. Now, computers are coming home to their roots in telecommunications, and the technologies of the two are converging and rapidly becoming almost indistinguishable. The melding is natural not only because of similar technology, but because both are based on information and its management. One processes information and the other transports it.

Improved information handling aids the entire society and helps it thrive through increased efficiency in virtually every kind of activity, whether business, education, transportation, even recreation. Information processing helps machinery produce other machines—or almost any kind of product—much more swiftly, economically and dependably. For example, information processing devices—microprocessors—are now routinely used to control everything from automobiles to household appliances.

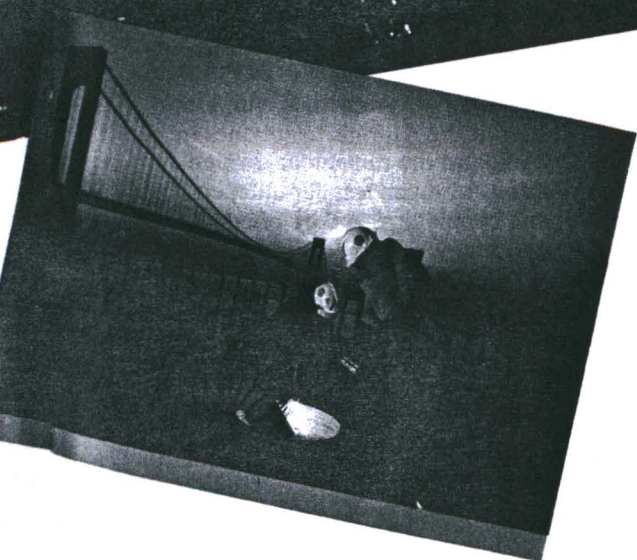
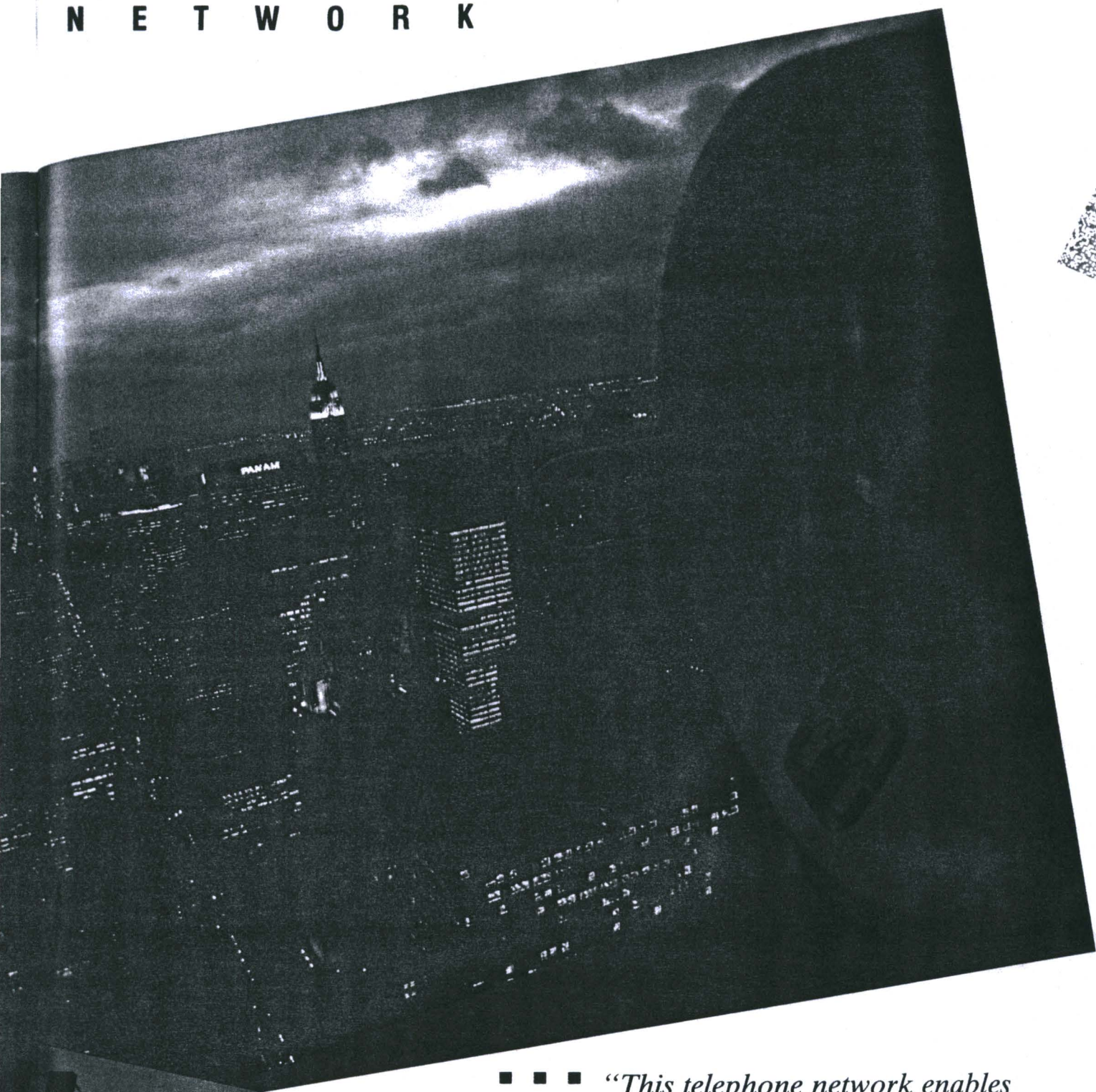
Universal Access

An important element of the U.S. communications system is the universality and ready availability of good telephone service anywhere in the United States. America’s telephone network, consisting of cable, microwave, satellite and new optical fiber links, forms a tightly woven fabric covering

Right, night skyline of New York City from atop the Citicorp Center building in Manhattan. Microwave antenna (at right in photo) is part of a telecommunications system belonging to Citibank, one of the nation’s largest financial institutions. Individuals, cities and nations are increasingly connected by a complex network of microwaves, telephone lines, satellites and optical fiber networks that transmit computer data and television images in addition to voice communications. Modern telecommunications provide computer access to enormous repositories of data; these systems, in turn, are so complex that they themselves are operated by computers. Using digital technology, computer and telecommunication systems are merging, creating a new, global system that can best be understood as a vast, growing intelligent network.



Telephone workers in New York City (right) install cable for new fiber optic network. Optical fibers are capable of carrying high volumes of voice communications and data on laser beams that travel along hair-thin glass filaments.



■ ■ ■ *"This telephone network enables residents and businesses in even the most isolated communities to gain instant access to virtually any other telephone in the U.S.... Americans can also call as many as 230 million telephone "access" lines around the world, often by dialing directly without the help of an operator."*

■ ■ ■ ■ ■

In 1940, the AT&T Bell System set a goal of putting a telephone in every American home. The percentage of households with telephones rose to more than 60 percent in 1950, and is greater than 90 percent today. In addition, with the advent of digital technology, the modern American telephone system is more versatile than ever before, able to combine voice and data communications into a single integrated network.

the entire nation. This network enables residents or businesses in even the most isolated communities to gain instant access to virtually any other telephone in the U.S., a total of approximately 215 million telephone instruments, or 117 million "access" lines, since many homes and offices have two or more telephones hooked to the same line with the same telephone number. Americans can also call as many as 230 million telephone "access" lines around the world, often by dialing directly without the help of an operator.

Not only is the telephone network still growing faster than the population, but it is more versatile now than ever before. Important technical advances permit many new or enhanced services to be offered to all subscribers, whether business or private, and high-quality service is available to all, including the poor and the elderly.

Alexander Graham Bell's original work, which led to the invention of the telephone in 1876, began with the study of sound and hearing. He discovered various ways of modulating an electrical current to produce an electrical analog of the acoustic sound waves which make up distinctive sounds. For almost nine decades, standard telephone technology was based on the same analog methods used in the original telephones.

Shortly after Bell's invention, new businesses relating to telephony sprang up throughout the U.S. Hundreds of telephone companies were formed, often in the same city. Many local groups, including isolated farmers in remote areas, also created their own systems for local communication. Federal laws encouraged universal telephone service by providing inexpensive loans to small, independent telephone companies in rural areas. This enabled many sparsely populated parts of the nation to acquire telephone service comparable to the best available anywhere.

The result was explosive growth. Between 1896 and 1900, for instance, the number of telephones grew more than 32 percent per year. By 1900 the United States had 1.3 million telephones for a population

of less than 76 million. By 1920 the nation had more than 13 million phones provided by thousands of independent telephone companies—some serving separate geographic areas, others in direct competition with each other. The American free enterprise system encouraged vigorous growth but left the dynamic new industry with a lack of coherence, due to varying standards and lack of interconnectivity between many of these telephone enterprises.

To end the confusion and to ensure nationwide availability of telephone service, the U.S. Congress passed a law in 1924 giving American Telephone and Telegraph Company (AT&T) the right to buy and consolidate many of the country's independent telephone companies. The resulting national organization came to be called the AT&T Bell Telephone System. By 1940 AT&T's goal was to put a telephone in every American home; the percentage of American households with telephones rose to 62 percent by 1950, 91 percent by 1970 and currently hovers around 92 percent.

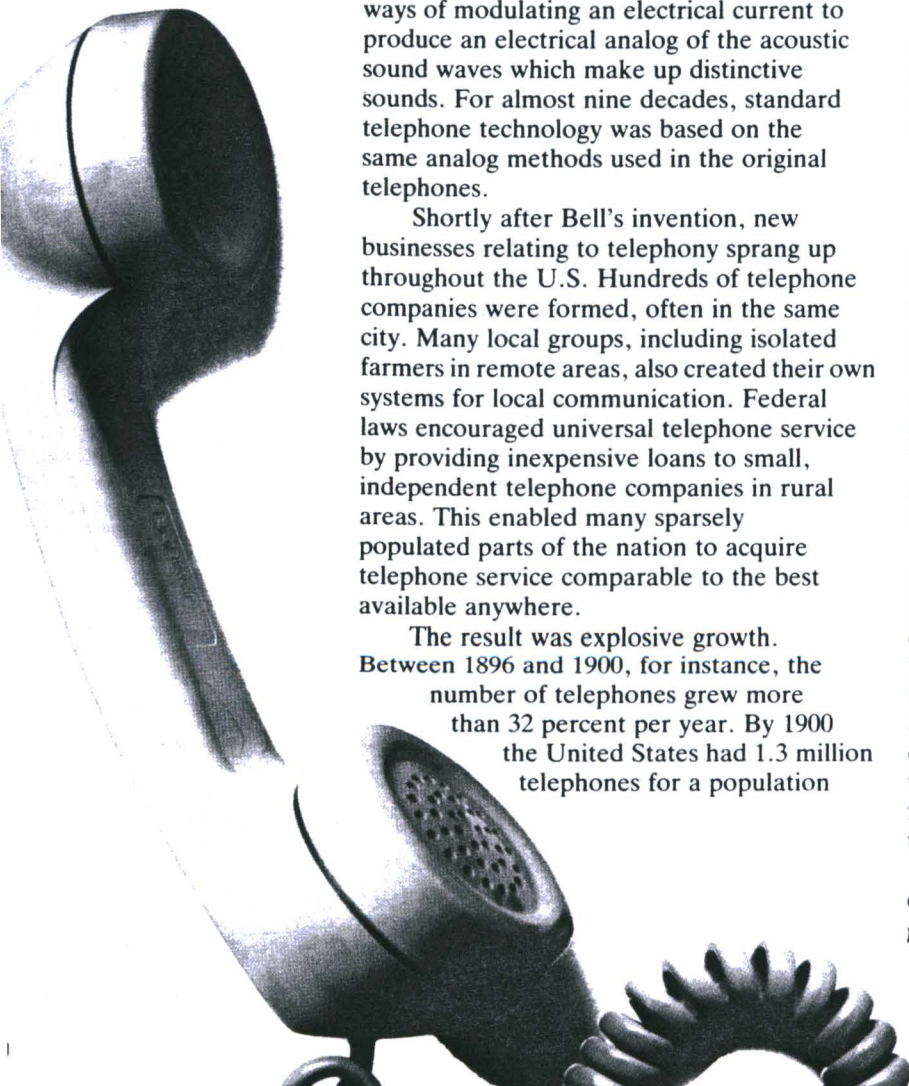
Innovation and Engineering

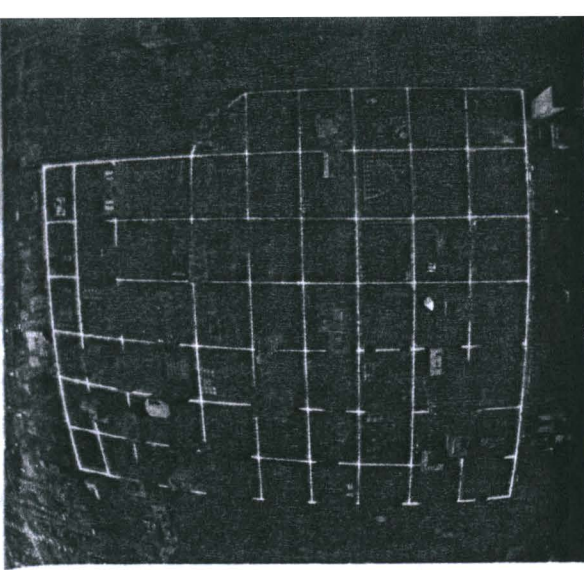
As early as 1885, AT&T's forerunner, the American Bell Telephone Company, had established an engineering department to develop improved technology and hardware for the Bell System. By 1924 the scope and intensity of its research and development efforts had grown so large as to require a separate organization, called the Bell Telephone Laboratories, to conduct basic research and to develop products and practices for the telephone system.

Bell Telephone Laboratories became the world's largest research and engineering facility in its field, even among those operated by national governments. With more than 80 percent of the nation's telephones in the Bell System, and the remainder divided among thousands of much smaller independent telephone companies, AT&T effectively developed the *de facto* technical and functional standards for the entire U.S. telephone industry.

As a result of its intensive research and development efforts, the Bell System generated a steady stream of inventions and

Composite photo at right depicts new lightwave communications system that covers a portion of Chicago, Illinois. Installed under downtown streets, this local fiber optic network, operated by the Illinois Bell Telephone Company, provides high-speed data, voice and video communications for a number of Chicago businesses and financial institutions.





technical innovations that led to today's growing, dynamic intelligent network.

Many of these innovations, and much of Bell's technical expertise, have been shared with other nations through participation in the International Telephone and Telegraph Consultative Committee (CCITT). By helping develop international technical standards, much of the Bell System's work came to be embodied in the telephone practices of many other nations.

In addition to engineering for the telephone industry, Bell Laboratories intensively pursued pure research in many fields not necessarily applicable to telecommunications or telephony. Of course, much of the work eventually proved directly beneficial to the communications business. Basic research in solid state physics in the 1920s, for instance, led to the invention of the transistor in 1948, opening the door to the field of semiconductor technology, and contributing to the invention of the laser in 1960.

Materials research led to more durable and reliable machinery such as telephone handsets, plastic insulated cable and thousands of other kinds of equipment. Bell also conducted extensive research into designing phones that are easy to operate. It is no accident that the telephone, while exploiting some of the modern age's most sophisticated technology, can be used by the average five-year-old child.

The Digital Revolution

The invention of Pulse Code Modulation (PCM) just before World War II produced the foundation for a new age of telecommunications. PCM meant that analog methods could be replaced by digital techniques to eliminate almost completely the old problems of noise and distortion inherent in analog transmission methods.

The problem with Bell's original analog techniques is that, by their very nature,

they are vulnerable to any effect which alters the waveform that represents the original sound. Noise of any sort, and other types of distortions, accumulate in amplifiers or repeaters until the signal can become unintelligible.

Pulse Code Modulation required that a signal waveform be chopped into a series of "samples" frequently enough to faithfully represent the original signal. A brief series of pulses (typically eight) would then be generated to represent each sample. One eight-bit pulse combination, or code, would represent the value of one sample, another combination would represent the next, and so on.

In its most rudimentary form, this wasn't much different from a telegrapher's code in which a sequence of dots and dashes represented a letter of the alphabet. But with PCM, each group of pulses represents the analog waveform which makes up the voice signal. If the voice waveform is sampled frequently enough, the voice signal could then be reproduced faithfully from the stream of pulses. In a typical system, PCM sampling can occur 8,000 times a second.

The elegance of this digital technique lies in the fact that it can resist signal degradation and noise which may affect any transmission. So long as the presence or absence of a pulse can be determined accurately, it is possible to regenerate and replace degraded pulses, thus strengthening weakened signals. This is done in the U.S. telephone system by repeaters placed about every 1.6 kilometers, each of which replaces the incoming degraded pulse stream with a fresh one, identical to the original.

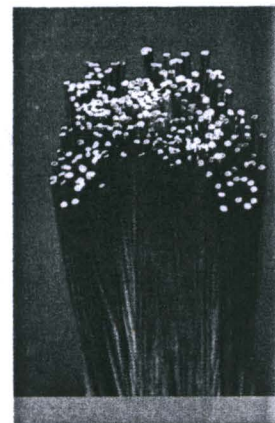
With a flourishing semiconductor industry to supply the components, digital technology has spread rapidly, replacing the older analog methods of transmission and switching throughout the U.S. telecommunications industry.

Deregulation

In the first days of telephony, free enterprise and independent entrepreneurship ensured the rapid growth of the country's telecommunications. Establishment of the Bell System monopoly helped establish uniform standards and facilitated high-quality service. But after 50 years of monopoly, the U.S. decided that the public would benefit from increased competition in telecommunications.

The Future Of Light

Photonics, the science of light, has already demonstrated its value in telecommunications, where optical fibers are replacing conventional telephone wire and coaxial cables. Videodisks, which are read by laser beams, are proving to be enormous repositories of data. But photonics may prove even more revolutionary in the field of computer technology itself, and by the end of the 20th century, a new age of light may replace the still-youthful electronic age. Light has several advantages over electronics: light beams are faster, travel in parallel lines without interference, and can pass through one another undisturbed. Already, AT&T's Bell Laboratories in New Jersey has produced the optical equivalent of a transistor, and intensive research on integrated, optical-electronic computers is underway at a number of U.S. companies as well as in countries around the world. Below, a bundle of glowing, hair-thin optical fibers.



■ Cellular Phones—Cutting the Cord

Today's telephone has cut the cord and gone on the road. Cordless cellular telephones are making it easier for people to make and receive phone calls wherever they are—in cars, on boats, or gardening in their backyards. Estimates are that approximately 740,000 Americans have cellular telephones today, a number that is expected to increase steadily. Callers use cellular phones just like conventional telephones, but the similarity ends there. A cellular telephone call travels through a limited geographic area called a "cell," where a transmission center electronically receives the call and then "hands it off" to the next cell. Using computers, the entire process is virtually instantaneous, with no discernable time lag to the caller. Because each cell automatically selects the best available frequency, the capacity of the cellular system is much greater than conventional radio telephones that rely on a few limited frequencies. In addition, cellular phones interconnect with the standard telephone system, so cellular phone owners can call any telephone number throughout the country. Initially regarded as a luxury, cellular phones are fast becoming indispensable for mobile businesses, such as fleets of delivery trucks, which rely on instant communications to maintain efficiency and productivity. And as more companies enter and compete for the growing cellular phone market, the quality of cellular phones will rise while the price drops. Below, fire fighters in North Carolina display cellular phone that was used to keep emergency center informed when a tornado struck the small community of Jamestown.

In the early 1980s, therefore, the U.S. ended the Bell System's monopoly on telephone service and deregulated much of the telecommunications industry. Today, the choices in long-distance telephone service have expanded considerably following the breakup of the AT&T Bell System. Seven regional telephone companies, spun off from the Bell System, handle local telephone service, while AT&T and competitors such as MCI and US Sprint compete to provide long distance, and business and data communications. In addition, thousands of smaller telecommunications firms offer specialized services and equipment.

Businesses, especially, have been quick to take advantage of the opportunities presented by deregulation, installing their own telecommunication networks to handle growing information needs and link their nationwide or global operations. Examples abound. The Ford Motor Company has built a global telecommunications network to coordinate product design, engineering and marketing of its "world car," the Ford Escort. The First National Bank of Boston (Massachusetts) has a data communications network linking offices in New York, London and Hong Kong with its Boston headquarters; the petroleum corporation, Atlantic Richfield, has established a \$17 million video "teleconferencing" system that allows executives to talk with and see each other in Los Angeles, Philadelphia, Denver, Houston, Dallas and Washington, D.C.

Cables and Microwaves

A telephone network able to provide, on demand, fast, high-quality service to a population of 236 million, spread across a large land mass, must cope with the problem of unifying an extraordinary range of transmission and switching methods, built up during years of rapid growth.

Over the years, the open-wire lines that linked distant switching centers were replaced by paired cables, which were later supplemented by coaxial cables capable of carrying

thousands of voice signals and numerous television channels. In addition, a complex web of microwave transmissions complement these cable facilities. Although private companies such as oil and gas pipeline companies introduced microwave transmission along their routes before World War II, low-frequency microwave did not come into its own until 1950, when the telephone company began using it heavily. Microwave transmission is relatively inexpensive because it can be relayed across mountain ranges and other obstacles without incurring the heavy costs of laying cable.

Microwave has since become one of the major vehicles for meeting long- and medium-distance telephone service. In the 1960s, many businesses began to use microwave to link scattered facilities around cities—a practice that proved so popular in recent decades that the most heavily used microwave bands have become saturated, forcing new users to move up to higher frequencies.

Satellites

In 1945 British writer Arthur C. Clarke, author of *2001: A Space Odyssey*, *Childhood's End*, *Rendezvous With Rama* and other notable works of science fiction, conceived the idea that satellites in geosynchronous orbit (circling the earth 35,880 kilometers directly above the equator) could be used to relay communications signals. A satellite placed in this orbit would travel at a velocity that matched the earth's rotation, making it appear to remain stationary, and enabling the satellite to act as a communications link. In the late 1950s, John R. Pierce of Bell Laboratories demonstrated the feasibility of space communications using early ECHO and TELSTAR satellites; and in 1963 the U.S. orbited the first geosynchronous communications satellite, SYNCOM 2.

In the early 1960s, the U.S. proposed the establishment of an international satellite organization, INTELSAT, to ensure the effective use of this technology. Today, INTELSAT has 112 member nations, and dozens of countries also participate in regional satellite systems. Among those who have established their own domestic systems are Mexico, Brazil, Indonesia and India.

One key to the proliferation of satellite communications has been a dramatic shift in the satellite-ground station equation. Early satellites were relatively simple, but required large and complex earth stations to commu-



■ ■ ■ *"In the U.S., domestic communications satellites provide a wide range of services, including voice-grade telephone service, teleconferencing, high-speed data transmission, and television distribution."*

nicate with them. However, as satellites became more complex and powerful, the size and complexity of ground stations could be reduced commensurately, making access to satellite technology more affordable for countries that want its benefits.

In the U.S., domestic satellites provide a wide range of services, including voice-grade telephone service, teleconferencing, high-speed data transmission, and network and cable television distribution. As of 1985, 10 U.S. companies operated 22 domestic communications satellites, offering about 400 transponder channels. (Transponders relay the microwave signals transmitted from earth stations.) According to a recent estimate, some 1,600 transponders will be used in the U.S. by 1990. About 40 percent of these will be used for data transmission and roughly 17 percent for video transmission.

Although a single communications satellite can carry more than 30,000 speech signals or several television programs, satellites face increasing competition from a new, rapidly emerging technology—fiber optics.

Optical Transmission

One of the most exciting developments in telecommunications is the rapid progress in optical communication. Just as digital techniques greatly improved the telephone system, optical communication promises a quantum leap in capacity and performance.

Optical communication is the result of the marriage of two technologies: the laser, first demonstrated in 1960, and the fabrication by Corning Glass 10 years later of ultra-thin silicon fibers, which can serve as lightwave conductors. With the further development of very efficient lasers, plus continually improved techniques for producing thin silica fibers of incredible transparency, optical networks can transmit pulses of light as far as 135 kilometers without the need for amplification or regeneration.

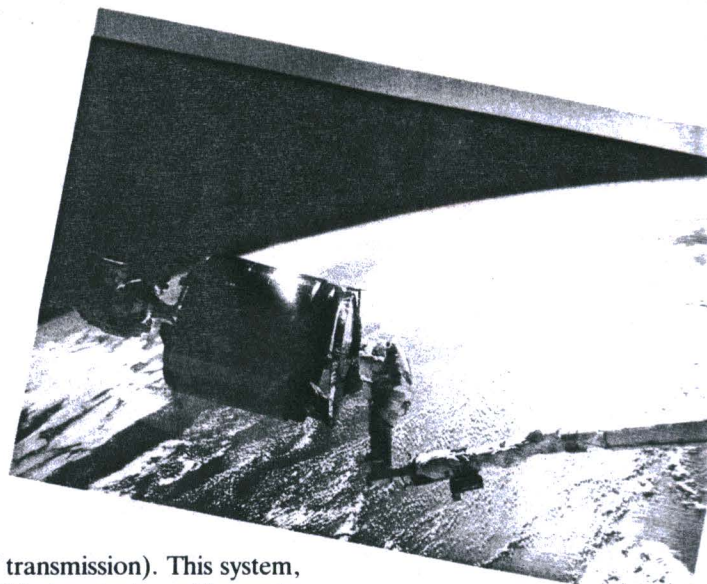
Only now has optical transmission come into its own, and high-capacity optical systems are being installed between many major U.S. cities at a rapid rate. The system most widely used now operates at 417 megabits (thousand bits) per second and accommodates 6,000 circuits over a single pair of glass fibers (one for

each direction of transmission). This system, developed by Bell Laboratories, will soon be enhanced to operate at 1.7 gigabits (thousand million bits) per second and handle 24,000 telephone channels simultaneously.

Optical technology is cost effective, versatile, and finds new applications every day—from connecting communication equipment or computers within the same building or room, to spanning long transcontinental and transoceanic distances.

With its high data capacity and long intervals between repeaters, optical transmission is a natural rival to satellite communications. An undersea transatlantic optical fiber cable now links the United States and Europe, and a similar transpacific system—more than 16,000 kilometers long—will soon connect California, Hawaii, Guam and Japan. Both systems will be able to carry 40,000 voice channels or their equivalent, compared to just 9,000 for a conventional coaxial cable.

The intelligent network of the future will continue to be characterized by the trends toward innovation and convergence, competition and growth. New technologies such as optical fibers will increase the speed and capacity of telecommunications and provide a host of new, specialized information services—whether accessing data bases, shopping via cable TV or setting up business "teleconferences." Voice, computer data, even video images, will be increasingly integrated into a single digital communications network capable of processing and transmitting virtually every kind of information. Competition—among technologies as well as among private companies—will continue to lower the costs of transmitting information and, equally important, ensure that the intelligent network is widely accessible to all who wish to share in its cornucopia of benefits.



■ The Future of Satellites

Above, using the mechanical arm of the Space Shuttle, astronauts repair a malfunctioning satellite in space. The Space Shuttle can carry a communications satellite into low earth orbit, then release it from the cargo bay. A special upper-stage booster rocket attached to the satellite fires and transports the satellite into higher geostationary orbit. Faced with stiff competition from fiber optic communication networks, the International Telecommunications Satellite Organization, INTELSAT, has unveiled the prototype of the world's largest and most powerful communications satellite. When deployed into geostationary orbit in space, INTELSAT VI, built by Hughes Aircraft Corporation in California, will be able to carry 120,000 telephone calls and at least three television channels simultaneously; or alternatively, three thousand million bits of information per second. In an "all-video" mode, the satellite will have the capacity for 200 TV channels. Ultimately, five orbiting INTELSAT VI satellites will be able to transmit more than half a million phone calls at one time—at a cost, officials predict, less than that of optical fiber communications. Says INTELSAT Deputy Director General John Hampton: "The INTELSAT VI spacecraft represents a quantum leap in how the world's communications needs will be met in this century and beyond."

Albin R. Meier is a writer on telecommunications and other advanced technology subjects. He was Technical Editorial Director for Telephony, a U.S. telecommunications journal, for eight years.

the massive, vacuum tube-packed Electronic Numerical Integrator and Calculator (ENIAC).

Data Base Explosion

Computer systems have the capacity to store and retrieve any information that can be represented in digital form. Data bases are simply collections of facts, statistics or other information stored in digital form. The user instructs the computer to search the data base for certain key words or categories. Relevant data are then transferred, via telephone lines or other communications links, to the user's computer terminal.

The memory files of a data base are typically (but not exclusively) stored on magnetic disks. These rotate under arms carrying "heads" with both write and read functions. Digital data are inscribed in the form of magnetized dots along tracks on the disk's surface. The head, which "reads" the dots, hovers a few micrometers above the disk, making high velocities possible. Moreover, in large systems, even greater speed can be achieved by using more than one head. For typical systems, data can be located in an average time of 20 milliseconds and then transferred to the user at high rates of speed. In addition to the new traditional magnetic disks, laser-read optical disks are coming into increasing use.

In recent years, the number of publicly available data bases has also been expanding rapidly. The University of Illinois has established a "data base on data bases" to keep track of their expansion. Their figures show an increase in the number of publicly available data bases from 301 in 1976 to 2,805 in 1985. Over two-thirds of the 1985 total are in the United States; most of the remainder are in Canada, Western Europe, the Nordic countries, Japan and Australia. The 1985 total includes around 300 "umbrella" listings, each of which includes a number of smaller data bases.

Many data bases are primarily bibliographic in character; some, however, are capable of providing

With a computer keyboard, such as the one shown here, a monitor to display information, and a telephone "modem" for communications, researchers can gain access to more than 2,800 publicly available data bases throughout the world.



chemical substances. This data base provides ready access to abstracts of 4,500,000 articles.

MEDLARS and MEDLINE

The National Library of Medicine was among the first U.S. institutions to pioneer the use of computer technology for the production of bibliographic publications and for conducting searches of medical literature. The library's computer-based Medical Analysis and Retrieval System (MEDLARS) now has 20 data bases available for searching from computer terminals at more than 4,000 institutions located throughout the United States. Moreover, anyone—health professional or not—who has a personal computer and has been granted an access code, can search the system directly. In 1985 researchers performed some 3,000,000 searches. MEDLARS centers have been established in a dozen foreign countries.

The best-known of the MEDLARS data bases is MEDLINE, which contains 5,000,000 references going back to 1966. Although MEDLINE is basically a bibliographic data base, it can provide abstracts of about 60 percent of the material

users with abstracts (summaries) of potentially relevant material. A second broad category of data bases includes those which store and retrieve numeric data, such as economic statistics. The third principal category includes data bases which provide users with the full texts of articles, reports and other published material.

Although many data bases are highly specialized, others amount to "information supermarkets" or "electronic libraries." A data base directory published periodically by the American Library Association uses 550 subject headings accessible to data base users.

How has the work of professionals been affected by the availability of such data bases? Martha E. Williams, professor of information science at the University of Illinois, has pointed out that reliable, exhaustive searching for articles in the field of chemistry can now be accomplished electronically in, say, 10 to 15 minutes—less time than would be required simply to remove from library shelves the 20-year index volumes of *Chemical Abstracts*, the authoritative U.S. journal in this field. This computerized data base covers material published since 1965 and includes references to 6,700,000

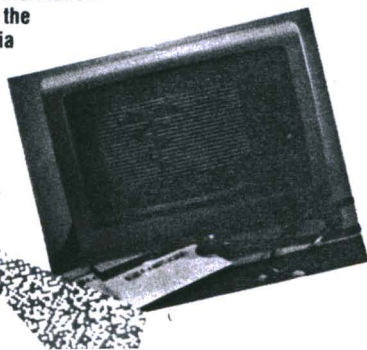
DATA BASES: THE NEW ELECTRONIC LIBRARIES

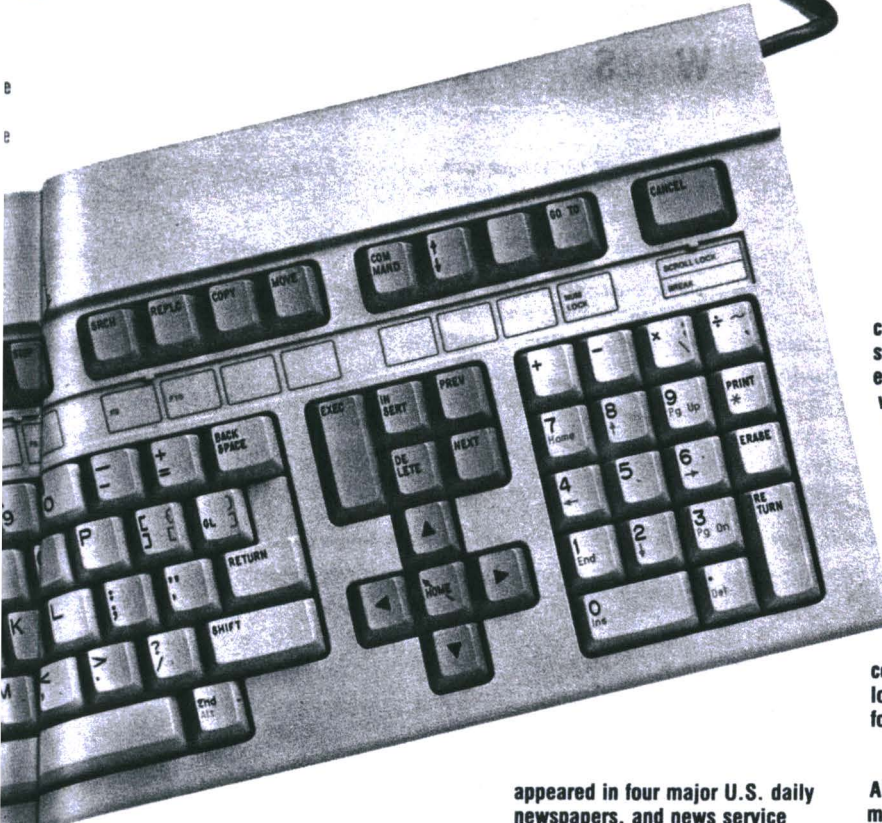
By Wreatham Gathright

In July 1945, as World War II was ending, Vannevar Bush, the leader of America's wartime scientific effort, called attention to the problem of dealing with "the growing mountain of research." He pointed out that the researcher "is staggered by the findings and conclusions of thousands of other workers—conclusions which he cannot find time to grasp, much less remember, as they appear." It was Bush's opinion that: "This is a much larger matter than merely the extraction of data for the purpose of scientific research; it involves the entire process by which man profits by his inheritance of acquired knowledge."

The trend perceived by Bush and others in the 1940s has come to be called the "information explosion." Spurred by continuing advances in the instrumentation available for collecting and interpreting data, by the emergence of new theories and concepts, and by the expansion of global telecommunications, the mountain of information continues to grow at an exponential rate. It has been estimated that by the late 1970s, the American population was being exposed to about 8.7 million million words a day through electronic and print media. This trend shows no signs of abating. Many of these millions upon millions of words have been of only transient interest. But what about those which have, indeed, added to man's "inheritance of acquired knowledge?" How can professionals keep abreast of their fields? How can they find the specific, possibly crucial information in a timely fashion?

As Bush was formulating the dilemma posed by the "information explosion," scientists at the University of Pennsylvania were building the forerunner to the answer—the world's first electronic computer—





originating since 1975. The information in MEDLINE, updated monthly, is drawn from 3,200 journals published in the United States and 70 foreign countries.

MEDLARS and other medically oriented data bases enable health professionals to learn promptly of the latest developments in their fields. Moreover, the data bases can be consulted on a 24-hour basis. For example, a doctor who believes a patient has been exposed to a toxic substance might consult the Hazardous Substances Data Base by describing the effects of the substance. This can cut the time needed to identify the specific substance and speed appropriate treatment.

LEXIS and NEXIS

In addition to government, both nonprofit and commercial organizations produce data bases; among the largest commercial data bases are LEXIS and NEXIS.

LEXIS is designed to provide support to the legal profession and includes the full texts of 3,000,000 documents, including specific cases, decisions and law journal articles.

NEXIS, which serves banks, businesses, journalists and other professions, incorporates 8,000,000 full-text articles from over 125 newspapers, magazines and other sources. The journalistic files of NEXIS, for example, offer access to the texts of articles which have

appeared in four major U.S. daily newspapers, and news service reports from the United States, Britain, Japan and the People's Republic of China. NEXIS adds about 120,000 documents to its data banks each week. These texts are taken primarily from computer tapes supplied by subscriber publications, and from direct satellite transmissions of data. NEXIS computer keyboard operators also enter texts directly into the system.

Searching data bases is carried out through the use of a "profile" of key words which match the user's interests with the material included in the data base. A search can be conducted by NEXIS personnel, research specialists or the users themselves, through computer time-sharing services or the use of their own personal computers.

As an example of NEXIS in action, journalist Daniel Seligman of *Fortune* magazine used his personal

computer to explore NEXIS for statements by a public official. He estimates that about two minutes were required to search through the 3.8 thousand million words stored in the NEXIS journalistic data base. NEXIS offered 17,251 articles of possible relevance.

After redefining the search profile more precisely, he identified 14 relevant articles, a manageable number. As *Washington Post* editor Amy Schwartz wrote in a recent column, "LEXIS-NEXIS has turned a lot of researchers into cult followers."

DATA BASE COMPETITION

Although LEXIS and NEXIS are major data bases, they are by no means unique. Other commercial data base producers, such as DIALOG, offer competing services. The competitive character of the business encourages data base producers to improve the services they offer—by adding to the material offered, by ensuring that the data base is brought up-to-date frequently, and by improving the software and techniques involved in searching the data base.

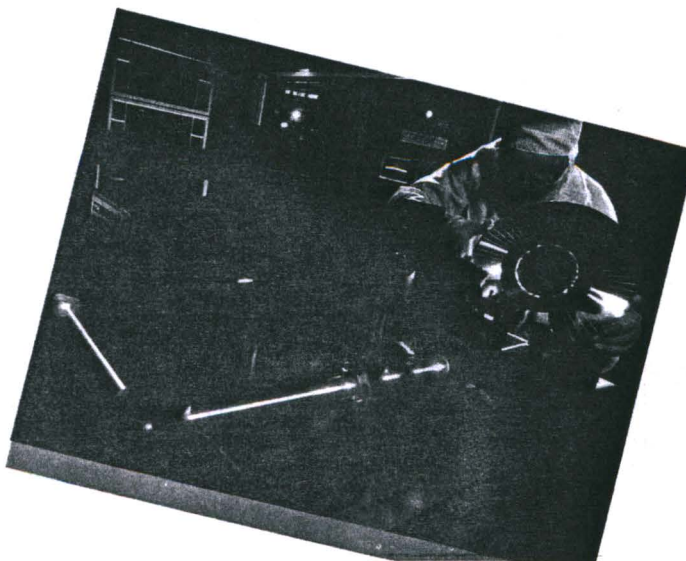
Research efforts are under way to improve all of the technologies involved in data bases. Experts anticipate that some data bases will soon contain several million million units of information. Moreover, researchers are working to enhance the usefulness of large data bases—to make them more efficient and to enable them to meet multiple needs. This effort includes new techniques of searching, new ways of organizing stored data and new designs. The time required for placing information

in a data base and the time needed to retrieve it can also be expected to decrease. The increasing use of new types of telecommunications systems, such as optical fiber, which offers a more effective means of transmitting data, supports these new advances in technology.

The extent to which publicly available data bases are being used in the United States demonstrates that they are capable of meeting the widely varied needs of many organizations and individuals. Some highly specialized data bases have not been used sufficiently to warrant their continuation as separate services. Overall, however, data bases have proved their value in storing and drawing on vast information resources.

As the research efforts now underway lead to further improvements, it appears increasingly likely that the day may come when, in the words of one American scientist, the use of data bases will be "as routine an activity as using telephones."

Wreatham Gathright served for 18 years on the U.S. Department of State's Policy Planning Staff where, among other subjects, he studied telecommunications issues and the worldwide flow of information.



Opposite page, bottom, computer screen display for new medical data-base service called COLLEAGUE. Such medical data banks place enormous amounts of immediately available information at the fingertips of physicians and medical researchers. Left, technician at 3M Company examines a newly developed video-disk that can store up to 250,000 pages of information, yet provide the data within seconds. The information, stored in the form of thousands of millions of pits on the disk's plastic surface, is read by laser beams.

By Stephen Hess

[illegible]

Some of these incipient ventures will not find an appreciative audience or will be badly managed, and they will fail; on the other hand, some new magazines will reward their backers for having properly identified a market and then producing a desirable product.

The media in America, therefore, form two strands that have peacefully coexisted since the 18th century colonial period: the

Left, front page of *The New York Times*, one of the most respected and widely read newspapers in the United States. Center, array of newspapers and magazines available from a street corner newsstand in a major U.S. city. Americans today can choose from nearly 11,000 periodicals on an enormous range of subjects.

more than 8,500 radio stations. Most radio stations are locally owned and controlled, and determine their programming independently. Some stations specialize in popular or classical music; others broadcast news, weather and sports 24 hours a day.

These figures are important not only to show the extent of media saturation, but because polling data suggest that the average American gets most of his news from television. Each weeknight, 38 million Americans watch one of the three commercial networks' news programs. (Others watch news programs broadcast by the noncommercial Public Broadcasting Service, which is supported by a mix of government and private donations, or the Cable News Network, which broadcasts news and features 24 hours a day.)

At the same time, evidence shows that voters—the most politically aware part of the population—are more likely to be newspaper readers. About 1,700 newspapers publish daily

commercial segment, expected to rise or fall on the operator's ability to make a profit, and offering tremendous diversity to the buying public, and a much smaller but significant noncommercial segment in which almost every shade of opinion is represented by its own publication.

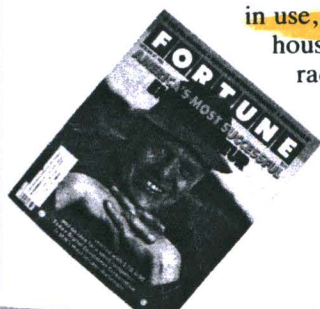
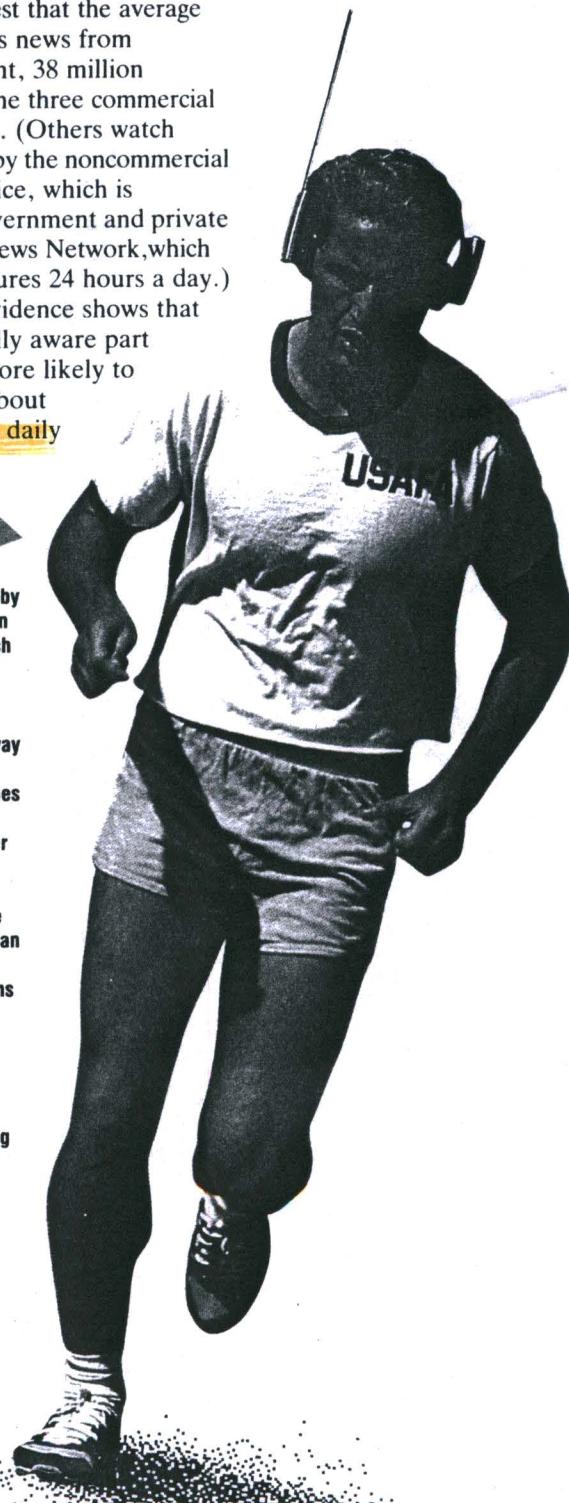
Watching, Listening, Reading

Americans today can choose from nearly 11,000 periodicals published in the United States—although magazines are just one part of the mix that comprises the mass media. In broadcasting, too, the choices have proliferated with the increase in radio and TV stations and channels.

Virtually every home in the United States has at least one television set: Out of a total of 86.8 million households, between 86.1 and 86.4 have TVs. Those television sets receive broadcasts from 919 local commercial TV stations as well as 316 noncommercial stations (often affiliated with a university). Over 46 percent of American homes subscribe to cable TV, with the typical cable system having a capacity of 30 to 53 channels.

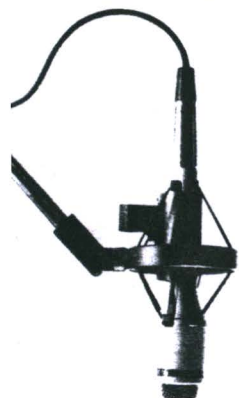
With some 485 million radio sets in use, the average number per household is five (121 million radios are in automobiles). Americans can listen to

Americans are constantly surrounded by information. In addition to the print media, such as newspapers and magazines, television and radio play a large part in the American way of life. Approximately 86 percent of U.S. homes have at least one television set, and over 46 percent of TV viewers subscribe to multiple-channel cable systems. With more than 8,500 radio stations to choose from, Americans can listen to news, music, talk shows or weather reports while driving in their car, at work and at home, or even as they go jogging (right).





Above, members of the international press corps cover the 1985 Geneva summit meeting between President Reagan and General Secretary Gorbachev.



Americans do more than listen to their radios: they can talk back as well. Radio talk shows where listeners can phone in, on the air, with questions and comments have proliferated throughout the country. At station KERA in Dallas, Texas, for example, host Karen Denard selects topics ranging from international affairs, local politics, theater, art, education—often with an expert on either side of the issue as guests—then opens the phone lines to callers. KERA is the local affiliate of National Public Radio, a nationwide network of 320 noncommercial radio stations that, like television's Public Broadcasting Service, is funded by government grants and private donations.

in the United States with a combined circulation of 63 million, as well as 7,700 weekly newspapers whose total circulation is 50 million.

From Printers to the Penny Press

One way of understanding the U.S. news media today is to examine the historic evolution of American journalism in terms of the types of individuals who owned the presses.

The first American newspapers were not produced by "journalists," but by printers, small business owners who used their presses to produce a commercial product in which the "news" consisted largely of reports on ship arrivals and goods for sale in local stores.

According to historian Thomas C. Leonard: "Through most of the 18th century, the four-page weekly paper was not far from the limits of the resources at hand.... There was almost no change in the technology of printing in the 18th century." The state of technology, in other words, would be an important factor in defining the scope of the media throughout this history.

In 1721 Boston (Massachusetts) printer James Franklin (uncle of Benjamin Franklin, one of America's Founding Fathers) added the second strand to American journalism. In addition to commercialism—the wish to profit from his labors—Franklin chose to get into a heated public argument with the authorities. This was in the midst of a smallpox epidemic, and Franklin's *Courant* came out foresquare against inoculation. (Being wrong thus has a long tradition in the American press. As noted American writer E.B. White wrote in a letter more than 250 years later: "The press in our free country is reliable and useful not because of its good character but because of its great diversity. As long as there are many owners, each pursuing his own brand of truth, we the people have the opportunity to arrive at the truth and dwell in the light.... There is safety in numbers.")

The partisan press that appeared in the 18th century is credited to Thomas Jefferson and Alexander Hamilton. Although both were followers of George Washington, they differed sharply on national issues.

Probably to gain attention from the President more than anything, each created his own newspaper to show opposing points of view on government policy. Unfortunately, the partisan press is remembered more for its colorful invective than for serious news-gathering. The press of the early 19th century, however, did in fact help create the political

party system which still defines the politics of the United States today. Nevertheless, the lesson for the modern press is that being beholden to politicians and office-holders is a precarious way to run a business.

From the early 18th century onwards, according to Leonard, printers "idealized a role of scourge to their community." Increasingly, skepticism towards authority became a hallmark of a democratic society, with part of the journalist's job description being that of extralegal investigator of wrongdoing. Indeed, today there is an organization called Investigative Reporters and Editors (membership 3,000), whose prime targets are usually government officials.

A new type of newspaper was founded in 1833. *The New York Sun* sold for a penny, one-sixth the price of other newspapers. The "penny press" was a revolutionary concept in journalism. Within three years, *The Sun* was selling 15,000 copies a day, whereas in 1833 the combined circulation of the city's 11 dailies had been only 26,500. The idea behind the penny press was to seek a large readership which in turn would attract advertisers; the newspapers would be politically independent and would produce timely news aimed at the growing middle-class. No longer was the mainstream media to be merely an adjunct of the printer or a vehicle of the politician; it now would be a self-contained branch of commerce under the direction of the publisher.

"The modern mass-circulation newspaper would be unimaginable without the technical developments of the early 19th century," according to sociologist Michael Schudson. The steam press replaced the hand press; the cylinder press replaced the flatbed press, and by replacing rag-fiber paper with ground wood pulp, the cost of newsprint dropped dramatically. Newspapers could be printed fast and cheaply.

The second half of the 19th century also saw the rise of the great press lords, such as Joseph Pulitzer and William Randolph Hearst, whose circulation battles, especially between Hearst's *Journal* and Pulitzer's *World* in New York, featured glaring headlines, color comics, numerous illustrations and sensational articles.

Modern News Reporting

A group of New York newspapers organized the first wire service or news agency, the Associated Press, in 1848. The purpose of



■ ■ ■ *"The press in our free country is reliable and useful...because of its great diversity. As long as there are many owners, each pursuing his own brand of truth, we the people have the opportunity to arrive at the truth.... There is safety in numbers."* ■ ■ ■

■ Above, one of the three major U.S. television networks, NBC (National Broadcasting Company), covers the 1984 presidential elections from its news headquarters in New York City. State elections were covered from locations throughout the country and transmitted to the NBC network by satellite. As soon as the polls had closed on Election Day, all three commercial networks (NBC, CBS and ABC) broadcast election results continuously through the evening and nighttime hours.



■ Newspapers By Satellite

The Wall Street Journal, a sober, black-and-white newspaper covering business and economics, and *USA Today*, with short, entertaining features and flashy, color graphics, have one thing in common. Both use satellite technology to reach millions of readers in the United States and around the world.

The Wall Street Journal, for example, with a daily readership of more than 2 million, transmits its editions to 18 printing plants scattered in the U.S.—as well as to plants in Hong Kong and The Netherlands—via a geostationary communication satellite orbiting at 38,800 kilometers above the equator. As a result, readers in New York, Chicago, San Francisco, Tokyo and London get the same business news the same day. *USA Today*, with approximately 1.4 million daily readers, uses a similar communication satellite, WESTAR 3, to beam complete pages—including color pictures—to 30 U.S. printing sites, plus facilities in Singapore and Switzerland.

the cooperative was to use the same reporters to gather news for all the member publications. Writes journalism educator Fred S. Siebert: "The news agencies instructed reporters and writers to remember that their writings were being distributed to both Democratic and Republican newspapers and other clients, and had to be acceptable to both. Writers became adept at constructing nonpartisan accounts, and from this practice grew the concept of objective reporting which has permeated American journalism to the present."

If objective reporting was rooted in technology (the development of telegraphy) and economics (the profit in expanding services), it was also caused by the desire to turn journalism into a profession. (The first training school for journalists was created at the University of Missouri in 1908.) As a reaction to the sensationalism of the press lords' era, objective reporting is simply the effort to separate fact from opinion in covering hard news, to try to keep the reporter's personal views out of his writing, and, at the same time, to tell more than one side of a story. If the reporter's opinion is given, the article is expected to be labeled as such, or to be placed in the editorial section of the newspaper.

Within this framework of objective reporting, a recent survey of 1,001 American journalists identified three common press functions—adversarial, interpretive and disseminator. Their findings are that journalists often put themselves in more than one of the following categories: adversary of the establishment (i.e., government, business and other major institutions), 17 percent; investigator/interpreter of the establishment's actions and claims, 62 percent; and prompt disseminator of information about the establishment, 51 percent.

The news business in the 20th century has followed some of the same tendencies toward greater concentration and consolidation that can be seen in other major industries, such as automobiles and oil. In 1900 the eight largest newspaper companies controlled perhaps 10 percent of the national daily circulation; today over 70 percent of U.S. daily newspapers are group-owned and the 20 largest companies in this business own a total of 494 newspapers.

Some observers, such as media critic Ben H. Bagdikian, find fault with this trend because they claim it puts too much power in too few hands. Writes Bagdikian, "No small group, certainly no group with as much uniformity of outlook as large corporations, can be sufficiently open and flexible to reflect the fullness of society's values and wishes." Others contend that large media companies no longer need be influenced by the politics of their advertisers whereas small operators might not have been able to afford this luxury.

The same centralization can be seen in the television business. While government regulations do not permit a company to own more than 12 TV stations, most stations are joined contractually to one of three competing national networks (ABC, CBS, NBC), which provide them with most of their programming. This means that Americans, regardless of where they live, see the same news broadcasts at breakfast and dinner. However, independent stations, noncommercial public broadcasting, and the proliferation of cable TV are diversifying the outlets for televised news and information.

What is the future in an industry experiencing such rapid technological change? Harvard University professor Gary Orren predicts that despite the centralization of the media in the corporate era, advanced technology, paradoxically, is likely to produce greater media decentralization. One key to decentralization is the satellite. Take the Washington press corps: The greatest growth since 1979 has been in TV reporters representing stations from every part of the United States. The reason is that satellite transmission allows them to beam individualized material from Washington that is of special local interest without relying on the big three commercial networks. The stories arrive back in their home stations almost instantly and at an affordable price.

According to Professor Orren, whatever the mix of media, there will be more of it. Printed matter did not disappear when radio appeared, and radio did not disappear when television came on the scene. Following the same pattern, we can expect to have newspapers, magazines, radio and television coexisting with newer forms of communicating, such as computer-to-computer electronic mail, or teletext, which delivers textual and graphic information to TV screens. In short, the new media will supplement, not replace, the diversity of news media that now exists.

Stephen Hess is a Senior Fellow at the Brookings Institution. He is the author of 10 books, including *The Government/Press Connection: Press Officers and Their Offices* (1984), and *The Ultimate Insiders: U.S. Presidents and the Media* (1986).



By Derek Bok

In theory, at least, information technology has the power to transform the nature of the university. Much routine student advising could shift to a network of personal computers linked to a common data base. Students could instantly have the answers to a host of factual questions about course requirements, employment interviews, campus events and homework assignments. In time, lectures could move from classrooms to television screens so that students could listen to a professor and immediately test their comprehension of the material by working through a series of questions and problems presented by an appropriate computer program. For example, art history majors could use a videodisk linked with a computer to explore the great museums of the world, examine the details of any painting they chose for as long as they wished, and summon up text to explain the picture and the circumstance under which it was painted.

Student at Dartmouth College in New Hampshire works at a personal computer in her dormitory room. Using the college's computer network, students collaborate on joint projects, and tap into the school library catalogue.

Experience, however, should also make us wary of dramatic claims for the impact of new technology. Thomas Edison was clearly wrong in declaring that the phonograph would revolutionize education. Radio could not make a lasting impact on the public schools even though foundations gave generous subsidies to bring programs into the classroom. Television met a similar fate in spite of glowing predictions heralding its powers to improve learning.

In each instance, technology failed to live up to its early promise for three reasons: resistance by teachers, high cost and the absence of demonstrable gains in student achievement.

Will the new technology lead to improvements in learning that go beyond mere convenience? It all depends on how students use the time technology saves them. In many cases, educational benefits will unquestionably occur. For example, the personal computer has not only enabled Business School students at Harvard University (Massachusetts) to avoid drudgery; it has allowed them to grapple with more complicated, realistic problems, using linear programming and other sophisticated analytic techniques not previously feasible for ordinary homework assignments. In Harvard's Design School, computer-generated maps and models reduce the time and skill required to complete a drawing so that students can experiment with many more ways of solving landscape planning problems. Word processing in experimental sections of Harvard's undergraduate expository writing course has not merely spared students the drudgery of typing over papers; teachers can now ask students to revise and rewrite until they submit a more polished piece of work than would have been possible without the new machines. In all these cases, time previously spent doing dull, repetitive tasks can now be devoted to thinking about much more challenging, important questions.

"The new technology not only frees students from drudgery and routine; it often comes with software expressly designed to improve learning."

Computer-Assisted Instruction

The new technology not only frees students from drudgery and routine; it often comes with software expressly designed to improve learning. One of the most common methods is called computer-assisted instruction (CAI). According to psychologist B.F. Skinner, the aim of designing programmed learning was to construct a series of questions that almost every student could answer correctly. The act of giving the correct answer and the reinforcement that followed served to plant the knowledge more firmly in the student's mind.

The earliest computer-assisted instruction exemplified this method. The architects of CAI, however, soon broke with Skinner and sought to build programs that would be more challenging for the student. They stopped asking only questions that would elicit correct answers and began supplying text and helpful hints that would lead erring students to recognize their mistakes and figure out the correct answers. A simple example of such a program is the following:

Computer: Who was the first president of the United States?

- (1) Thomas Jefferson
- (2) George Washington
- (3) Abraham Lincoln

Student:

Abraham Lincoln

Computer: Sorry. Abraham Lincoln was president of the United States during the Civil War from 1861 to 1865. The first president served from 1789 to 1797 and had previously been commander-in-chief of the Continental Army during the American Revolution. Would you like to try again?

Student: George Washington

Computer: Good work....

Such exercises can help in several ways to supplement regular classwork. Students have to think and cannot merely read passively to take in information. They can practice when they wish and for as long as they wish. They can proceed as rapidly or as slowly as they please, moving on to new material only when they have mastered what has gone before. Well-crafted programs give students all the help and added explanation they need and automatically move to levels of difficulty appropriate to the learner. By instantly recording whether each response is correct or not, the computer allows students to recognize areas in which they need to do further work while alerting the



instructor to problems that the entire class has encountered in mastering the material.

Despite these advantages, CAI has obvious limitations. The programs are highly controlled in that the student must answer the precise question posed by the machine and choose among the limited number of responses appearing on the screen. There is no room in this format for challenging students to define the problem for themselves, explore a new hypothesis of their own, or speculate about the material under study. Because of these limitations, CAI is chiefly used in universities to master foreign language vocabularies and grammar, or learn the rule of accounting, the elements of anatomy, and other bodies of basic information.

Developing Higher Levels of Thinking

In recent times, more and more psychologists and educators have become interested in high levels of thinking and thus have grown impatient with the limits of conventional CAI. In fact, the problem of training the computer to be a tutor has proved much more elusive than early enthusiasts assumed. One difficulty with most complicated subjects is that questions can often elicit so many answers that it is difficult to anticipate them all and provide for suitable responses in a program. Even if one could foresee all the answers, each would require a proper question in response that would in turn

provoke a further profusion of answers, each requiring an appropriate question, and so on. The result is what experts call a "combinatorial explosion" that could exceed the capabilities of the programmer and even the computer itself. Worse yet, no one knows how to formulate a set of rules by which a computer can compare statements and recognize them as equivalents. A human being with adequate knowledge and experience perceives the similarities instantly. We simply do not understand how the process works.

Another way of teaching higher-level reasoning comes from so-called expert systems. One of the best-known examples is MYCIN, a computer program that can rival specialists in diagnosing bacterial infections in the blood and prescribing appropriate treatments. The heart of the program consists of a few hundred rules that take the form: "If X is true, then ask the following question or take the following action." These rules in turn were created after long interviews with acknowledged experts to discover how they would go about making diagnoses and prescribing treatments. Physicians can use such systems as a check on their own clinical judgments.

Other programs can simulate environments that are either too dangerous, too expensive, or too remote and inaccessible for humans to encounter directly. For example, with the help of computer graphics, undergraduates can observe the path of the moon circling the earth and conjure up changes in the mass or velocity of the moon in order to observe the effects of gravity on the shape of its orbit. Chemistry students can conduct simulated experiments on their TV screens combining substances too dangerous for laboratory use. Biology majors can watch simulated fruit flies breed at an accelerated pace and try to deduce genetic rules from the results. Medical students can observe the workings of the circulatory system and see how the removal of blood or the cutting of the nerve regulating blood pressure affects the functioning of the entire system. In all these cases, students have opportunities to visualize phenomena that they encounter ordinarily only in abstract form.

Objections to the New Technology

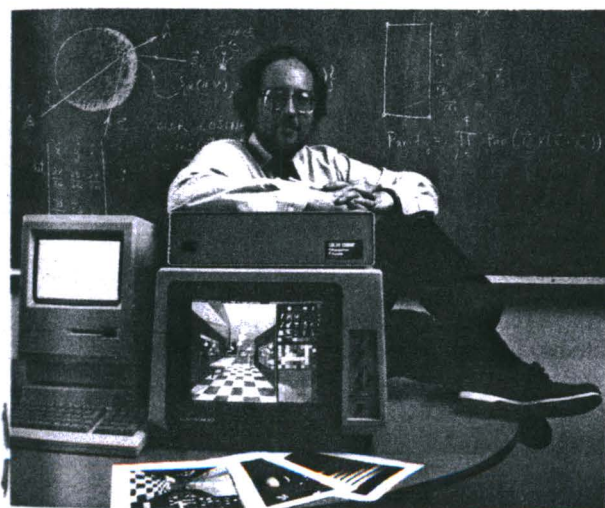
Now that we have looked at a sample of ingenious and arresting applications, let's examine them with a cold and skeptical eye. Apart from the excitement of the new machines, what is it, exactly, that they can do to improve the process of learning?

Computers in College

Computers are proliferating on college campuses throughout the country, and in many cases, universities are either requiring that entering freshmen bring a computer, or providing access to computers once they begin classes.

At Drexel University in Philadelphia, Pennsylvania, science students are using computers to solve algebra problems and simulate complex crystal structures and molecules. Drexel faculty members have been encouraged to write their own instructional software, resulting in a library of nearly 100 original software programs in subjects from physics to foreign languages.

Dartmouth College students in New Hampshire can use the campus computer network, called DartNet, to exchange information and written drafts with each other and to search through the entire catalogue of the Dartmouth library. Among the computer software programs that have been developed: "Venn"—an introductory philosophy course with practice in logic and syllogisms; "Orbital Mixing"—graphic displays of the shapes of molecules; "Atlas"—exercises in constructing and interpreting maps; and "Appletones"—instruction in musical theory and composition using Apple computers. Other programs provide statistical analyses for the social sciences, and foreign language drills.



Richard Crandall (above) is part of a faculty team at Reed College in Oregon that developed a software program, called "ColorPaint," for sophisticated color graphics. Students run the program on their personal computers, which are connected to high-resolution color TV monitors that display the dramatic results.

Athena and
Andrew

"Project Athena" is an experimental program in advanced computer technology at the Massachusetts Institute of Technology (MIT). A number of U.S. companies are providing equipment, software programs and technical assistance for the program. Eventually, about 3,000 computer terminals, or small workstations, will link up to larger mainframe computers via a MIT network. Students can also tap into off-campus data bases in the course of their research.

Athena is designed to use sophisticated graphics and instructional materials to supplement textbooks and classroom lectures. These programs take the student step-by-step through a difficult program, evaluate his or her solutions, and, when the student gets stuck, provide more data or related information.

At Carnegie-Mellon University in Pittsburgh, Pennsylvania, a computer system called "Andrew" provides word processing, statistical analysis, scientific programming and electronic communications for an eventual network of between 5,000 to 10,000 users. Using Andrew, students have access to a range of information normally found in a large research library. For example, introductory psychology students use the computer to duplicate classical experiments in memory and perception. Using such software, students go beyond ordinary textbook presentations, and form their own opinions and hypotheses based on realistic evidence.

The first point to remember is that many important tasks remain beyond the reach of the new technology. With all its powers, the computer cannot contribute much to the learning of open-ended subjects like moral philosophy, religion, historical interpretation, literary criticism or social theory—fields of knowledge that cannot be reduced to formal rules and procedures. Since such subjects are among the most important in the curriculum, this limitation is hardly trivial. Computers are also incapable of inspiring students or serving as role models. They cannot conduct a genuine dialogue because they cannot comprehend analogies or metaphors or even understand conversation beyond the five-year-old level. Finally, machines can rarely tell why a student is experiencing difficulty in learning and understanding.

Whereas these limitations are important, they still leave ample room for applying technology to learning, especially in the major professional schools, in science departments, in engineering programs, and in many areas of social science. Other criticisms of technology, however, are more sweeping. They warn that computers may harm the entire educational process by gradually eroding some of the intangible, more humane values of university life.

A familiar concern of this kind is that computers may erect barriers that will isolate students and divide teachers from learners. If students have to spend more time with their new machines, they may become more solitary and avoid the human contact that does so much to enrich the university experience. There is also a risk of overlooking subtler benefits that come from older, less "efficient" methods of education. Lectures may be passive, but as the early devotees of self-paced instruction soon discovered, they can have an inspirational value, not replicable by machines, in showing what it means to be truly in command of an important subject. Answering student questions via computer may be more efficient, but posing a routine question to an adviser is often the way by which a shy student reaches out for help in dealing with homesickness, insecurity, and other problems to which no electronic device can possibly respond.

To many people, the greatest threat from the new technology is not the fear of isolation or addiction, but the



risk of undermining forms of knowledge and understanding that are not quantifiable or reducible to formal processes and rules. As one author puts it, "The issue is not whether the computer can be made to think like a human, but whether humans can and will take on the quality of digital computers."

But technology need not force people to reason only in analytic or quantitative ways. Even with more conventional applications, machines are unlikely to do much lasting damage to intellectual discourse in fields like literature and philosophy. The greater risk arises in subjects, such as business management and public administration, where students learn to think about problems that involve a mix of different considerations including some quantifiable elements along with other values, possibilities and risks that are intangible and not susceptible to precise measurement.

Effects on Learning

A radically different set of criticisms comes from investigators who question whether technology truly enhances learning. For example, the questions and answers contained in most computer-assisted instruction could also be provided, albeit in more awkward form, by a cleverly arranged workbook. The computer simulations that help develop diagnostic skills might be given by a live tutor who acted as a patient and responded to questions until students could make an accurate diagnosis. Expert systems could be duplicated by simply allowing a student to observe a real expert go about solving difficult problems. In principle, therefore, the new technology seems unique only in allowing students to address certain kinds of problems with greater depth and sophistication through its remarkable power to manipulate data.

Although in principle most advantages of technology can be duplicated by conventional methods, the truth is that few

Learning About Learning

of these advantages will be achieved without the new machines. Instructors could spend 200 hours preparing for a traditional class just as they must often do to develop an hour of computer-assisted instruction. But rarely will they actually do so. Medical schools will not provide individual tutors patient enough to allow each student to practice endlessly developing diagnostic skills. Nor will distinguished specialists be available to explain to each medical student how they reason step by step to arrive at a diagnosis. With American student-faculty ratios of 20 or 30 to 1, a law school professor cannot work with individual students to check their progress in understanding the dialogues in which they participate vicariously in class. Even the humble word processor has advantages. Without it, students in expository writing courses will continue to revise by merely adding a word here and changing one there; they can seldom be made to do the so-called global revisions that involve major shifts in the argument, the elimination of some material, and the introduction of new evidence and sometimes a new point of view.

The opportunities that technology brings to life have great educational value. At present, most instruction in American universities is far too passive. Professors rely excessively on the lecture. Seminars are often consumed by dull recitations of student work. Discussion groups are typically led by graduate students who lack experience in teaching.

As knowledge increases and methods of analysis grow more complex, it is less and less desirable to base education so heavily on the passive experience of listening to lectures and reading texts. Habits of critical thinking, of perceiving and solving problems, of deriving useful generalizations from bodies of data, all seem increasingly important and all require more active effort by the student. Even if technology could not enhance the learning process, we can be reasonably sure that the graduates of most professional schools will need to work with computers—or at least understand their uses and limitations—in order to practice their calling in later life.

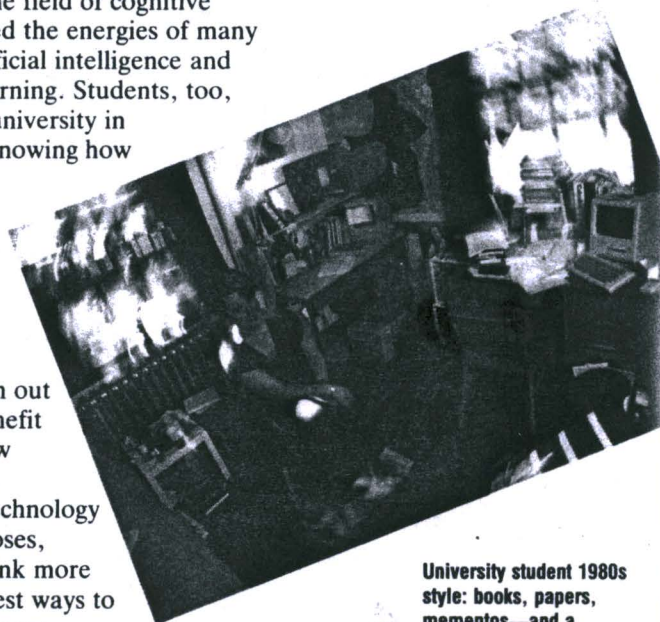
Thus far, the balance of benefits and risks seems to favor the new technology. Over the past 20 years, computers have proved a major stimulus for eliciting work and thought about teaching methods and the processes by which human beings learn. By their power and versatility, the new machines have given a stimulus to the field of cognitive psychology and turned the energies of many scientists toward artificial intelligence and its applications to learning. Students, too, are coming into the university in increasing numbers knowing how to use the computer; four million

American young people possessing such experience will enroll by 1987.

This growing interest may well turn out to be the greatest benefit to result from the new technology. As more people begin to use technology for educational purposes, they are bound to think more carefully about the best ways to help students absorb new knowledge and master new intellectual skills. One simply cannot produce good software for teaching without paying close attention to the details of how best to present the material to enhance learning and sustain student interest. Every step of the process must proceed with a careful eye to its effect on the student or the program will not work. This is the critical difference that probably accounts for most of the gains in speed and effectiveness of learning often attributed to computer-assisted learning.

With all the exaggerated claims and the media hype, we can still look upon the new technology with cautious enthusiasm. At the very least, universities should manage to use technology to engage students in a more active process of thinking and problem solving that will help them learn more effectively. At best, the new machines may also be a catalyst to hasten the development of new insights into human cognition and new ways of helping students learn.

Derek Bok is the 25th president of Harvard University, located in Cambridge, Massachusetts. Reprinted by permission from Harvard. Copyright (c) 1985 Harvard Magazine.



University student 1980s style: books, papers, mementos—and a personal computer for conducting research and writing papers.

CONNECTING COMPUTERS AND KIDS

By Deborah Showalter

Picture the classroom of the future. A satellite dish will be perched on the school roof, computers on each desktop. The computers will be connected to a large closed-circuit television screen on which the teacher can change video images with the push of a button. But it is not the future, it's the Brookhaven Elementary School in Placentia, California.

The computer revolution is arriving in American schools. From elementary schools to middle and high schools, computers are becoming an innovative and integral part of educating American children. A 1986 survey revealed that more than one million computers were already in American classrooms; 85 percent of all public schools have at least one computer. Studies indicate that by 1990 there will be an estimated 4.8 million computers in U.S. public schools. According to the market research firm, Link Resources, the average child-to-computer ratio in 1981 in the U.S. was 750 to one. Today it is 30 to one.

A number of computer companies have "adopted" certain schools by donating personal computers for classroom use: first, to introduce children to computer technology, and second, to open up the education market to future sales of their computers. In a 1979 program, for example, Apple Computers, which emphasizes the educational applications of its products, distributed 9,000 of its popular microcomputers to California schools under a program called, "The Kids Can't Wait." Since then, Apple has distributed over 2,000 computer systems and software programs to schools throughout the U.S.

The proliferation of educational software has also made the computer a valuable tool for teachers. A few years ago schools that had computers mainly taught programming and used the machines for drill and practice exercises. Children became bored because the computer tended to emphasize rote memorization, much as any unimaginative teacher might. Now, with the educational software field widening, teachers are able to pick software that challenges students with problem-solving exercises, attractive graphics and simulations that makes them want to come back for more.

Muppet Learning Keys, based on TV puppet characters, helps young children to identify letters, colors and numbers. "Sticky Bears Opposites" assists the mentally handicapped to differentiate between such words as "inside," "outside," "up" and "down," by using an on-screen bear accompanied by musical sound effects. In a new innovative computer program called, "Where in the World is Carmen Sandiego?" players "fly" from one exotic location to another in search of international thieves. Students receive a concentrated course in geography and deductive reasoning as they research obscure facts in reference volumes to solve the game's clues.

High school students can use computers to tap into data bases for research projects, or investigate colleges they might want to attend. Videodisks, which can store enormous quantities of data on subjects ranging

from history to science and languages, are also beginning to appear in classrooms.

When the computer revolution first began, many educators and parents were afraid that students would be wasting valuable class time playing games, or even become isolated and obsessed with the computer screen. Studies have concluded, however, that children who regularly use computers are average or better-than-average students, and are regular participants in afterschool activities.

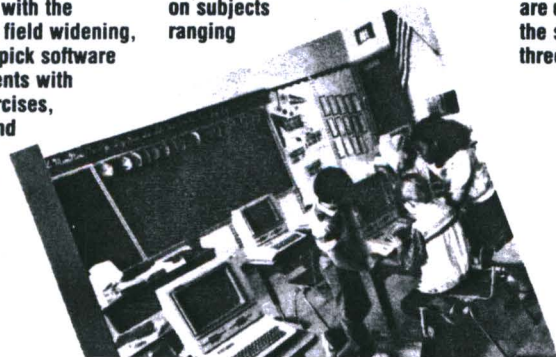
Education is decentralized in the United States, and schools are run by local school boards that usually have wide discretion in meeting the curriculum requirements set by the states, not the federal government. Not surprising, the ways in which individual schools are using computers are as varied as the schools themselves. Here are three examples.

New Jersey - Data Bases for Research

In suburban South Brunswick, one of four New Jersey school districts experimenting with computers, Dow Jones & Company, a major New York investment and brokerage firm, and publisher of *The Wall Street Journal*, has developed 35 sources of electronic information, or data bases. These data bases include full texts from several newspapers, an encyclopedia, a medical and drug reference library, financial analyses and weather information.

When Dow Jones offered the use of its data bases to the Brunswick schools free-of-charge, administrators jumped at the chance. Since South Brunswick already owned the necessary computers, they had access to the Dow Jones system. Regular customers, by contrast, normally pay Dow Jones about \$300 a month for the same information services.

The school set several goals for the new system. First, educators wanted to use computers to develop skills in problem-solving. The answer was a simple computer language called LOGO, specially designed for schoolchildren by Seymour Papert of the Massachusetts Institute of Technology,





Left, students in the South Brunswick, New Jersey, school district proudly hold signs saying, "I Compute!" Younger children use computers for individualized instruction; older high-school students use them for searching out information in electronic data bases and writing reports. Below left, opposite page, elementary school students cluster around an Apple IIE, most widely used personal computer in American classrooms today. Below, youngster uses the introductory computer language called LOGO to duplicate a hand-drawn house on the computer screen.



and widely used in schools throughout the country. Another was to teach children to use computers as a research tool. Students learned how to locate information in data bases, then write reports using the computer's word processing programs. Older students constantly use the Dow Jones Information Retrieval Service to research class projects and keep up-to-date on current events. A final goal was to teach keyboard skills to all students, a necessity for future computer usage.

California - Helping the Handicapped

More than three million children in U.S. public schools are handicapped with speech problems. At the Infant Program of the Exceptional Children's Foundation in Los Angeles, California, mentally and physically handicapped children learn to speak by using computers with talking keyboards. The child can

choose what to say by typing in any letter, word or sentence. The computer "talks back" by repeating whatever is typed, giving the child new-found confidence in his or her ability to communicate. Dr. Laura Meyers, one of the pioneers behind talking keyboards, says, "All of a sudden they think, 'I can.' And the words just start to come out."

Computers with talking keyboards have not only taught children to learn, but in some cases have changed their whole personality. Shy, withdrawn children who had to be coaxed to participate in any activity, have become outwardly mobile and energetic. Other children with reading and writing problems and coordination and speech deficiencies have also been helped by using talking computers.

New Mexico - Computers for Native American Students

In northern New Mexico, the Native American Tiwa Indian village of Taos

Pueblo has changed little in over a 1,000 years. In keeping with traditional Indian values, the village's small adobe (clay) houses have no running water, electricity, central heating or plumbing. The adobe school, however, has electricity and central heating, and computers.

Purchased with government funds, the 13 computers at the Tiwa school are available for about an hour a week to each of the 120 students, ranging from kindergarten to eighth grade. The computers run more than 100 separate software packages chosen to meet individual needs. The word processing program called "Bank Street Writer" (developed by inner city students themselves at Bank Street School in Philadelphia) enables students to improve their writing skills.

"Rocky's Boots" introduces children to the principles of logic via an imaginary world. "Talking Typewriter," a program that draws the letters of the alphabet on-screen and then pronounces them, has reduced the time required to teach English to kindergartners, who often speak only the Tiwa language when they start school.

Since the Tiwa Indian school acquired its computers, the reading ability of the students, traditionally low compared to the state average, has soared. School officials attribute this result largely to the use of computers. Says school superintendent Roy French, "The connection is clear—and it validates our original thinking that computers were necessary to make our kids competitive in today's world."

Deborah Showalter is a writer with the U.S. Information Agency.

T H E T R A N S F O R M A T I O N O F

THE NEW OFFICE

By Howard Cincotta

The business of America is business," said President Calvin Coolidge more than 60 years ago. Today, the business of America is information. In Coolidge's day, roughly one-quarter of the U.S. work force consisted of white collar workers whose primary function was to process information; today, that number is more than 60 percent of the working population and growing.

As the number of information workers has expanded, the location where most of them work—the office—is being transformed by the revolution in microelectronics and communication technology. The reason: the business office is essentially a communications hub whose function is to gather, record, retrieve, analyze and distribute information.

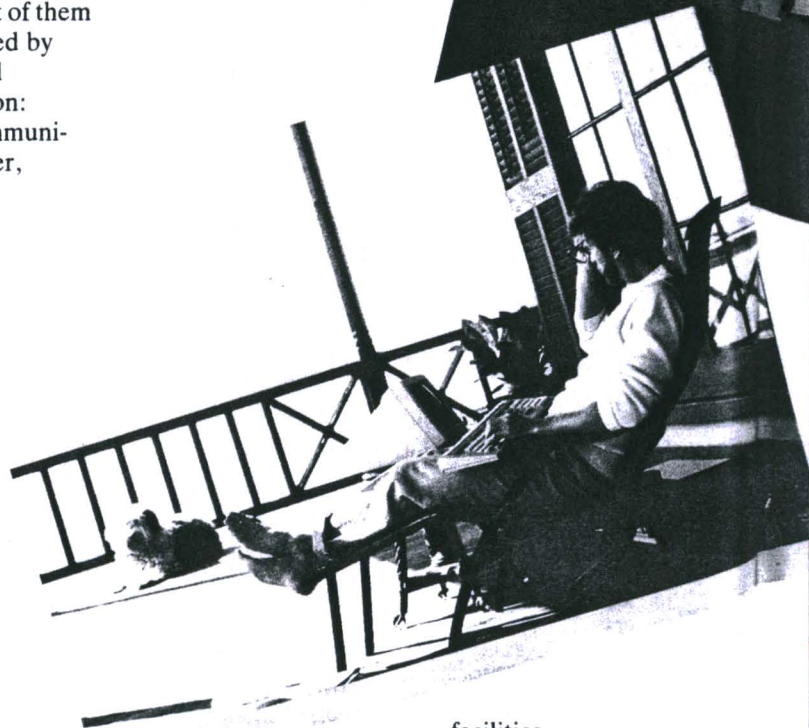
According to the Office of Technology Assessment (OTA), a research arm of the U.S. Congress, American business handles some 400 thousand million documents annually, a number that increases at the rate of 72 thousand million a year. Fortunately, computer and telecommunications technology provide the means for storing thousands of millions of characters (letters or numbers) in a single computer storage unit, and for moving data at the rate of millions of characters per second.

The mechanization, or automation, of the office is hardly a new phenomenon, however. The steel-tipped fountain pen had replaced the quill pen by 1880; by the end of the century, the telegraph, cash register, adding machine—and most importantly—the typewriter and telephone constituted the "industrialization" of the office. Office automation continued unabated in the 20th century with the electric typewriter, calculator and photocopying machine.

The computerization of the office has proceeded in three, overlapping stages. The first computers were large, centralized

The ubiquitous office computer: right, this sales office, like 85 percent of all U.S. businesses with more than 1,000 employees, relies on computers for record keeping, office communications, word processing and a host of other functions essential to operating a successful enterprise in America's competitive economy. Below, with personal computers as easily portable as this DIGITAL model, a business executive doesn't need an office to conduct work.

Computers are now virtually indispensable for any kind of advanced scientific and technological work. Below, engineers at the General Electric Company use computer graphics to design the fuel elements and other components of GE's commercial nuclear reactors that are sold around the world.



facilities, operated by specialists, that processed massive amounts of "batch" information such as payrolls, inventory, mailing lists, bill payments and the like. The second phase began in the late '70s with the introduction of stand-alone word processors and personal computers.

OTA reports that in only two years, between 1983 and 1985, the percentage of firms using personal computers increased from 32 to 46 percent; more than 85 percent of businesses with 1,000 employees or more now have computers, as well as almost 25 percent of small businesses with less than 20 workers. By the mid-1990s, OTA predicts that nearly every office in the U.S. will have a computer, just as all have telephones today.



Networking, the third phase of office automation, is just beginning—linking microcomputers to each other and to larger mainframe computers. Using computer networks, information can be transmitted electronically to a terminal around the corner or around the world, and at a fraction of the cost of producing and mailing a piece of paper. Networking can also mean linking computers to printers and copiers, establishing high-speed microwave or fiber optic transmission lines for computer-to-computer data communications, using telephone modems to tie in desktop computers to distant data bases, and providing teleconferences as substitutes for face-to-face meetings.

What is the net impact of this technological innovation? At first glance, the new office doesn't appear that different from the old. Contrary to the predictions of some futurists, today's office workers still generate plenty of old-fashioned paper. But upon closer examination, significant changes are also apparent, as researcher and consultant Vincent Giuliano describes in this overview, first published in *Scientific American*:

Some of the keyboard workers are indeed

secretaries preparing or correcting conventional correspondence on word processors. Other workers are at similar keyboards that serve as computer terminals. In one office they are managers checking the latest information on production performance, which is stored in a corporate data base in the company's mainframe computer. Economists are doing econometric modeling, perhaps calling on programs in a commercial service bureau across the continent. Librarians are working at terminals connected to a national network that merges the catalogues of thousands of participating libraries. Attorneys and law clerks are at terminals linked to a company whose files can be searched to retrieve the full text of court decisions made anywhere in the country. Airline personnel and travel agents make reservations at terminals that are part of a nationwide network. Some of the devices are self-contained personal computers that engineers and scientists, business executives and many other people depend on for computation, data analysis, scheduling and other tasks.

Office automation, while eliminating some jobs, has boosted productivity, heightened the demand for information services—and thereby created large numbers of new jobs. From 1972 to 1982, for example, employment of professional, technical and managerial workers jumped more than 40 percent; clerical workers increased almost 30 percent. These office jobs, according to U.S. Labor Department projections, will grow another 28 percent by 1995.

One result of combining computers and telecommunications is that office work no longer needs to be done in the office. Already, some 240,000 Americans work at home and "telecommute," using computers linked by telephone modems to their office's mainframe computers.

Two spinoffs from research into artificial intelligence will also find their way into

Below, the stock brokerage firm of E.F. Hutton is automating its nearly 400 nationwide offices with a computer system that will allow some 6,000 executives immediate access to fast-breaking financial information. Bottom, California stockbroker Terrance Howard doesn't drive into work each day, but "telecommutes" from his home via his computer, which is linked to the office by a computer modem and the telephone.



the office of the future: expert systems, which distill the knowledge of experts in fields such as medical diagnosis, petroleum exploration, banking and accounting; and computers that talk. The California-based Voltan Corporation, which produces speech recognition equipment, estimates that the market for computers with the ability to handle spoken language will grow from \$150 million in 1986 to \$1 thousand million by 1990.

As much as the office has changed in the past, the future appears to offer an era of even greater growth and transformation of office work.

*Howard Cincotta is
an editor with the
U.S. Information Agency.*

SUPERCOMPUTERS AND ADVANCED SCIENTIFIC TECHNOLOGY

By Larry Smarr

The exponential growth in computing power is ushering in a new approach to knowledge that is termed computational science. It differs from theoretical and experimental/observational science in both its tools and methodologies. This new approach is based on the technology of the supercomputer, whose distinguishing characteristics are speed and size. Modern supercomputers can perform millions of calculations per second and possess a sufficiently large memory to display the results almost instantly.

To use "pencil and paper" methods to solve mathematical equations, scientists often restrict the problem by freezing it in time or simplifying its geometry. Unfortunately, these equations are not powerful enough to enable researchers to answer very complicated problems. Although scientists have gained important insights to many areas of science and engineering this way, they are unable to calculate solutions with the rich complexity that we see in nature, e.g., a developing thunderstorm or a complicated biological molecule.

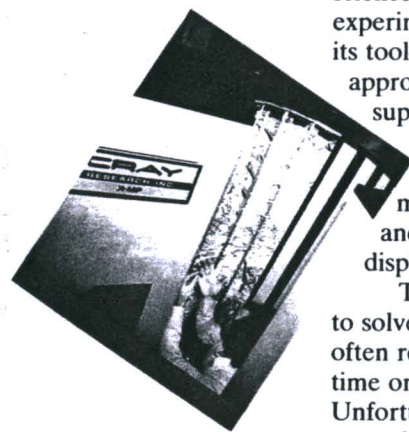
Scientists need to calculate these solutions because the only other way to learn about them, through experiments or observations, is often very difficult, and in many cases impossible. For example, we cannot see the center of the sun or the inside of a steel beam which is fracturing, but we need to know how such processes work.

The computer, however, allows scientists to create "artificial realities" by solving the laws of nature governing the phenomena through the procedure known as computer simulation. The computer is able to perform this "magic" by using an approximation to reality, gathering a finite set of numbers which approximate complicated solutions of the laws of nature. For instance, a large biological molecule may be approximated by numbers which give the distance and angle between all the atoms in the molecule; the smooth distribution of air flowing around a car may be replaced by numbers which give the air velocity at points along every centimeter of a grid which covers the space around the car.

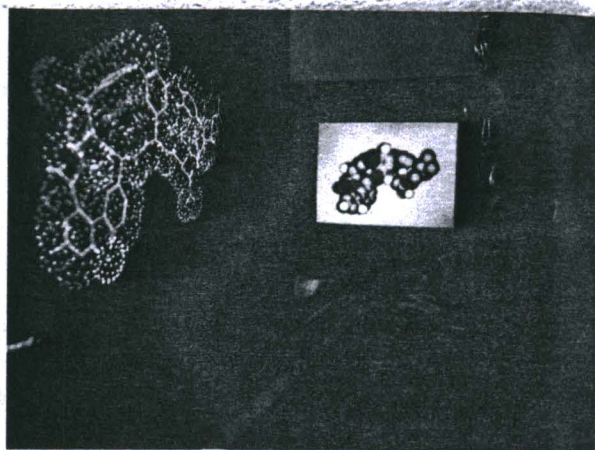
In short, scientists with computers can replace continuous space and time with discrete points in space and time. Obviously, the finer they make the "mesh" of grid points, the better the approximation. These data are then programmed into the computer. The program moves through the points solving for the unknown functions point by point. The faster the computer, the more points it can update in an hour. This is why scientists are always demanding computers with greater capacity. Each time the computer speeds up, the face of reality looms closer.

As the computer becomes faster, the necessity for more storage grows. Modern supercomputers can perform over one thousand million multiplications per second and have storage requirements in the million millions of bits. As a result, the technology of visualization is replacing the numerical printout. The sets of numbers representing, for instance, air flowing past a car are transformed into color images of the air flow itself. The scientist watches movies of his results on powerful computers linked to the supercomputer and mass storage units through high-speed networks.

These new technologies are allowing researchers to solve heretofore intractable problems, and in many cases create new fields of science. Perhaps because numerical solutions are much more realistic than



Cray supercomputer (above) is among the world's fastest, with a capacity for more than 20 million operations per second, using a data base of more than one million million words. In the U.S., supercomputers such as the Cray are used primarily for advanced scientific research, weather modeling and forecasting, mineral and petroleum exploration, and aircraft design. At top right, scientist at the pharmaceutical company, Eli Lilly, uses computer to model complex organic molecules that may provide the basis for new and more effective drugs in the continuing fight against disease.



"pencil and paper" methods, computational science is having a major impact in a variety of scientific fields.

One field is biochemistry. Here the structure of many of the important biological molecules are explored with the supercomputer. Last year at Purdue University in Indiana, a researcher was able to reconstruct the atom by atom structure of the rhinovirus, which causes the common cold. The supercomputer is now computing the chemical interaction of different drugs with that virus. In another approach, using the laws of quantum mechanics, scientists are computing the paths along which electrons transfer from one site to another on these enormous biological molecules. This process, for instance, underlies photosynthesis. The practical impact of this new knowledge in medicine and agriculture will be enormous.

Structural engineering relies on supercomputers for many types of problems. Increasingly complex designs for chemical refineries, airplanes, automobiles, electrical power grids and space stations all require computer simulation. Scientists can anticipate accidents by testing their designs, model the formation of stars and "see" inside of steel beams as they fracture and understand how to strengthen them.

In meteorology, supercomputers are now simulating vast shifts in climate such as a gradual warming of the planet or a decrease in the ozone layer. On a much smaller scale, researchers are simulating the birth to death cycle of severe storms, learning how deadly tornados or downbursts are generated.

By taking mathematical models of nature and solving them with supercomputers, we can understand the world around us in much more depth than previously. This process should continue for many decades as the advances in hardware are translated into advances in human knowledge.

Larry Smarr is director of the National Center for Supercomputing Applications at the University of Illinois.

THE NEW FACTORY

By Gene Bylinsky

The second part of the CAD/CAM equation, CAM, stands for Computer-Aided Manufacturing. Combined with CAD (Computer-Aided Design), it is the key to the long-awaited factory of the future where computer-driven robots will do the heavy and dangerous work, and workers will become supervisors of the machines.

One key ingredient of CAM, automated control of machines—known as numerical control (NC)—was first developed in the U.S. in the 1950s. From guiding metal-milling machines with punched paper tapes, numerical control has expanded to include a wide variety of machine tools. Although still a small percentage of total U.S. machine tools, more than 100,000 NC metalworking machines are in operation in the United States today.

Some years ago, manufacturing engineers, such as aircraft builders, began to link the emerging CAD terminals with numerically controlled machines. One American passenger airliner, the DC-10, for instance, has 4.8 kilometers of hydraulic tubing that twists, bends and turns throughout the fuselage. Formerly, it was necessary to construct a mock-up of the airplane's tubing. Then craftsmen bent and fitted the tubes by hand, a job that often took weeks, even months. Now American manufacturers such as McDonnell Douglas, the maker of the DC-10, produce such tubing in minutes with CAD terminals linked to computer-controlled, tube-bending machines.

Designers of the factory of the future, however, have their sights on even more advanced factory automation. In this system, a designer could determine the cost of materials by tapping into a common information pool; a foreman could check on the wear of the drills and presses by calling up computerized data obtained by sensors attached to those tools; and the factory manager, by pressing a few buttons on his computer console, would have an overview of the whole operation as though he were everywhere at once.

Such flexibility would be attained by employing robots and other programmable production machines whose directions could be changed

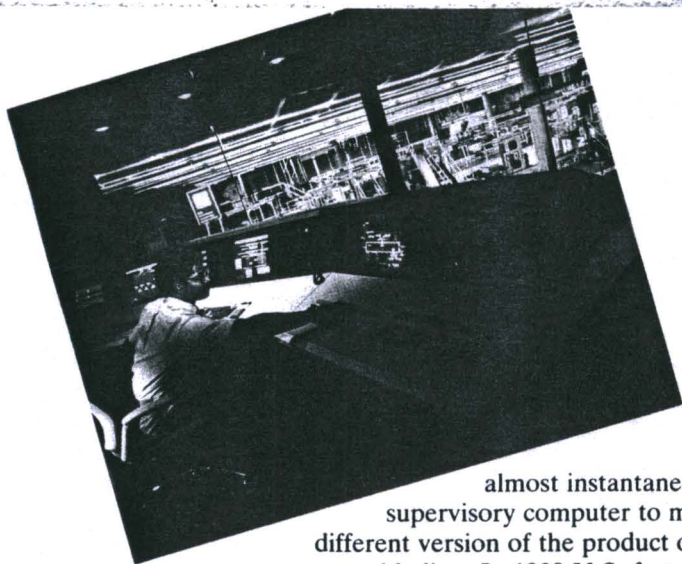
Desktop Publishing

- In Massachusetts, Susan Owens quit her job as a reporter and began publishing her own newspaper, the *Hull* (Mass.) *Newsweekly*.
- In Alaska, guitar instructor Robert Jacobson decided to use a computer/printer system to publish the *Fairbanks Music and Entertainment* magazine; six months later, he was selling 19,000 copies of his 50-cent tabloid.

From one-page job resumés to full-length books, new computerized technology has spawned a group of small, independent publishers whose entire equipment literally fits on a desktop. Previously, publishing required a large, costly typesetter and the services of a skilled designer to paste up strips of galley type and artwork on page layouts that could then be sent for printing. Desktop publishing, by contrast, requires only two relatively small pieces of equipment. The first is a new generation of printers that uses laser beams instead of contact print heads to imprint the images and letters on the page. Laser printers, which once sold for \$20,000, now cost as little as \$2,000; and they can produce an enormous range of high-quality graphics and illustrations, plus text in a variety of type faces. The second ingredient is a personal computer capable of running sophisticated software that delivers word processing, layout and graphic options, and printing instructions in a single program. Already, a new magazine, *Publish!*, is devoted entirely to desktop publishing.

California desktop publishers display attractively designed publications produced with microcomputers and laser printers.





Above, computer control center monitors operations at this highly automated plant in Louisville, Kentucky, which manufactures dishwashers. Color graphic displays on the computer screens provide updated information on the status of operations every 15 seconds to ensure quality and productivity. Below, computer-controlled robots weld auto bodies at this Chrysler automobile manufacturing plant.



almost instantaneously by a supervisory computer to make a different version of the product on the same assembly line. In 1980 U.S. factories employed about 3,100 robots of varying levels of sophistication and ability; that number had grown to 19,500 by 1986 and is projected to reach almost 70,000 by 1990.

One concern about factory automation in general, and robots in particular, has been the threat of unemployment. Certainly, robots and CAM systems are "labor saving" devices that require fewer workers. On the other hand, factory automation increases productivity and maintains competitiveness which creates new, albeit different, jobs. For example, studies of jobs directly affected by factory automation show an overall shift from "blue collar" manufacturing jobs, to "white collar" jobs supervising automated machines. Looking to 1990, experts project decreases for job categories such as metalworkers, assemblers and welders, but offsetting increases for engineers, laboratory technicians, computer analysts and maintenance mechanics.

Changing jobs is an accepted fact of American life, which can ease the difficult transition for workers who do face the loss of their jobs. Government agencies, and many companies, offer placement services that help locate new jobs for workers. Job training programs are available for many as well, and monthly unemployment compensation payments provide income during these periods of transition and retraining. Americans also move readily to find new job opportunities; when employment in the industrial Northeast declined during the past decade, thousands of workers moved to the "Sunbelt" states of the South and Southwest where the job market was expanding.

One impressive example of computerized manufacturing is at Allen-Bradley Inc., a Milwaukee, Wisconsin, manufacturer of industrial controls, where a section of an old plant has been transformed into a computerized assembly line that makes

contactors and relays for electromechanical starters, and controllers for industrial electric motors.

The assembly line at Allen-Bradley starts with a large IBM computer relaying the previous day's orders to a master scheduling computer on the factory floor. The scheduling computer then sets in motion an assemblage of machines that can make controllers and relays in two sizes with 999 possible combinations of parts. Such versatility is made possible through the use of bar code labels, which are computer-printed on the spot in response to customer's orders. Optical readers tell each processing station which parts to install in what combination in each casing. The 600 units produced each hour at the plant theoretically could represent 600 different orders. In practice, the number of different orders is smaller, but the ability to turn out specified contactors and relays on demand has given Allen-Bradley a competitive advantage. And as is usually the result of computerized automation, the quality of contactors and relays produced on this line has soared compared to the quality of hand-made parts—in part because there are 3,500 automatic inspection steps.

In a factory that makes larger products, flexible manufacturing systems include computer-controlled machining centers that work on complicated metal parts at high speed, robots that move the parts and perform additional operations on them, and remotely guided carts that deliver materials. Computer controls prescribe the steps to be taken by machines at each stage.

The giant new tractor assembly plant at Deere & Co. in Waterloo, Iowa, typifies this type of flexible automation. Almost all handling of materials at the plant is under the control of computers that automatically deliver parts to the assembly line just when they are needed. On the line, each part is automatically assigned to a specific customized tractor ordered by a dealer. Thanks to flexible automation, Deere now builds tractors twice as fast as in the past.

In the words of Allen-Bradley manager John Rothwell, advanced computer systems will help bring about the day "when goods will flow like water through the line"—making true a long-time dream of manufacturing engineers everywhere.

DESIGN BY COMPUTER

By Gene Bylinsky



Seated before today's computers, skilled operators are able to manipulate numbers to design and test new products, machines and equipment inside computers, saving time and the trouble of building models out of metal or wood. This epochal advance goes under the modest name of computer-aided design, or CAD for short. It is the first step in the computerized chain that leads to computer-aided manufacturing (CAM), the second part of the equation, which, in turn, paves the way toward the factory of the future.

CAD systems allow the designer to create a model, then rotate it, break it up into segments, enlarge or shrink details, cut a cross-section through it, or see how it fits with other parts. On that same computer screen, designers can subject their models of an airplane, tractor or a bolt to stresses and strains the object would encounter in real life.

Designers and engineers can test drive cars inside computers, as is now routinely being done by automakers in Detroit, or drive a tractor pulling a full load over rocks or soft soil, as do several American tractor manufacturers. They can design a bridge and see on the computer screen if it can withstand high winds and the demands of traffic, or design a crane and see if it can safely lift heavy objects. Furthermore, if a part of the structure under design fails, designers can then strengthen it on the computer screen to see if the new design works better.

Such time and cost-savings in design analysis and testing become possible thanks to the continuing evolution of CAD. When the

systems were first introduced, they were little more than computerized aids to the draftsman. Gradually, though, complex software programs have created a revolution in mechanical, structural and architectural design.

At the center of the new CAD capabilities lies solid modeling, the ability to create a solid-appearing representation of the parts and assemblies being designed. Solid modeling is an advance over an earlier CAD "wire frame" technique where only the edges of the objects being designed, not their surfaces and interiors, were defined by the computer program.

In contrast, solid models are constructed out of equations that comprise so-called "primitives"—cubes, spheres, cones and other pieces of electronic "clay." Although built out of computer numbers, these building blocks appear on the computer screen as real as if made of more tangible substance. In fact, they so faithfully represent whatever material the designer chooses to use that by cutting a model in half, the designer can see its simulated metallic sheen, or the grain of wood, and measure its mass, center of gravity and volume. By then rotating the whole mechanism, such as steering structures of cars and trucks, the designer can make certain no parts interfere with one another. Another CAD technique, finite element analysis, consists of breaking up a model into tiny brick-like elements. Each is assigned appropriate equations to measure the effect of stress, heat, pressure, motion and

other parameters. When the entire structure is subjected to the desired test, the effects of the test on the parts of the model show up as color-coded contour plots. For example, the highest stress levels may be shaded red, intermediate levels yellow and green, and low stress levels blue. Deflection due to mechanical stress also becomes visible. In a literal sense, in CAD the computer becomes an electronic wind tunnel, a test chamber where electrons and equations do the job of the wind, heat and pressure.

The benefits to the consumer are substantial. CAD systems can ensure that products are safer, more efficient and more reliable than before. In addition, lower production costs translate into lower prices for the consumer.

CAD is turning out to be a big money and time-saver for many American companies. Using CAD, for example, General Electric Company, which produces more than 59 million kilos of plastic parts a year, found that savings just from eliminating mistakes in the making of metal molds for plastic parts amounted to \$100 million a year. Another U.S. company, Pratt & Whitney, now makes turbine blades

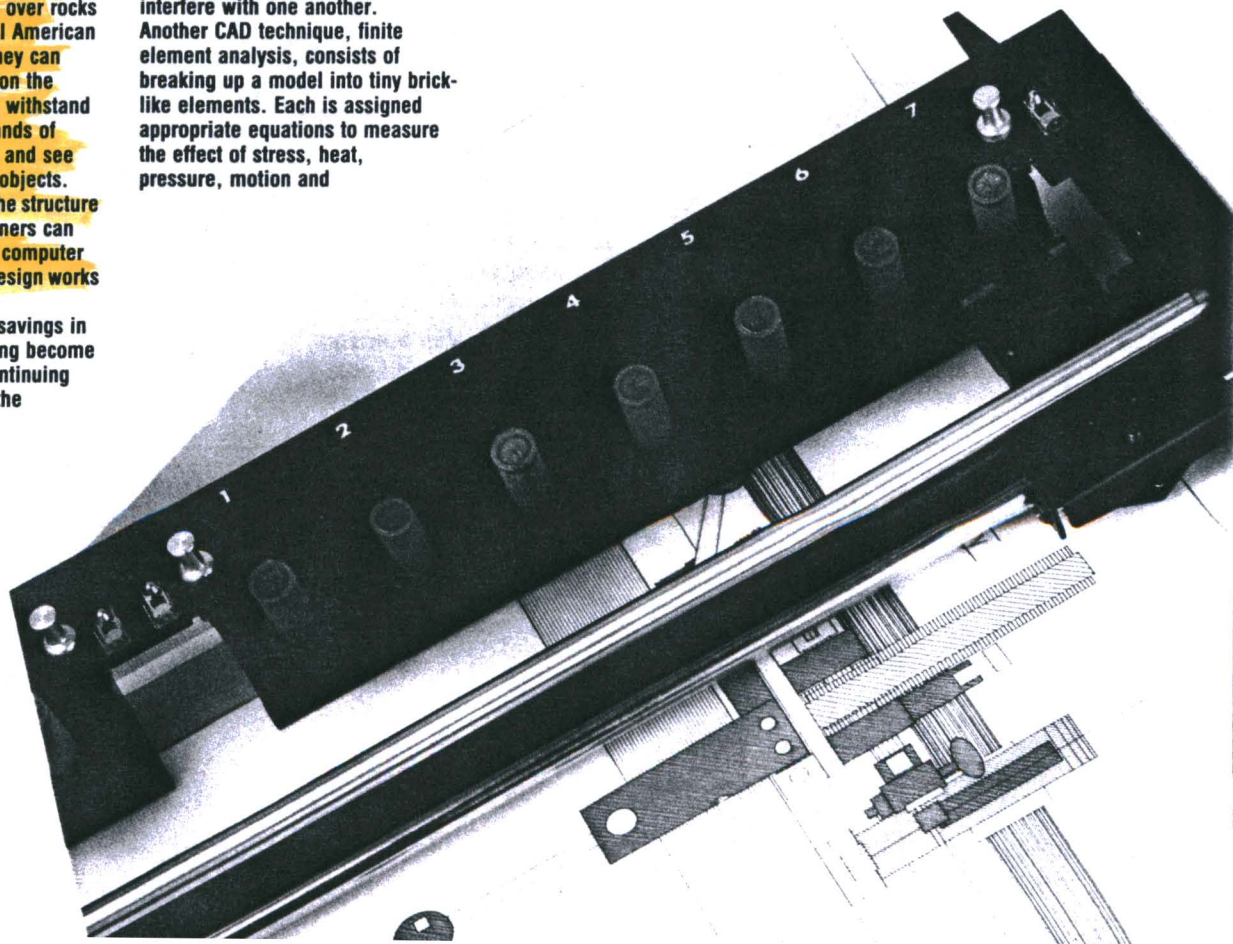
directly from CAD images. Officials report the CAD has cut the process time in half, and the job can now be done with one-fifth the personnel previously required.

Typically, relatively few workers actually lose jobs when CAD systems or other new technologies reduce the number of workers needed. In many cases, these jobs are eliminated by "attrition": the job is cut only as workers retire or transfer. Other workers can take advantage of job placement programs, sponsored by the company or local government agencies, or enter company training programs, where they learn computer or other technical skills, enabling them to move into higher-paying jobs.

This linkage of CAD with Computer-Aided Manufacture (CAM) into a single process is the ultimate aim of CAD users. Little wonder that managers and engineers—in the U.S. and other countries—believe that the arrival of CAD signals a giant step in the evolution of manufacturing.

Gene Bylinsky is a senior editor with Fortune magazine.

Top. Computer-Aided Design (CAD) system displays machinery part that engineers can rotate and subject to simulated stress on the computer screen. Engineers can use a specialized digital plotter (right) to print out high-resolution, color images generated on the screen by a CAD system.



■ NETWORKS

William Capobianco's one-man financial consulting firm in suburban New York would not exist without the electronic data networks that allow him to advertise his company across the U.S., chat with clients, make travel plans and keep up with current affairs.

The networks changing his life—and the lives of millions of Americans—are the ones connecting the nation's 30 million computers in a vast maze of interlocking grids. America's infatuation with the electronic computer is blossoming into a network love affair. Says Louise Herndon Wells, an analyst with the California research firm Dataquest: "We have more desktop computers wired together with information devices than any other country in the world."

Customers who want to send gifts of flowers across the country quickly can take advantage of one computer system linking florists in New York (on the east coast) with similar shops in Oregon (on the west coast). Another yokes travel agents to airlines and hotels around the world. Others bind together bank tellers, brokers, car rental chains, defense contractors, factory robots, police departments and university laboratories. Says Robert Metcalfe, inventor of the networking system called Ethernet: "It's like one big nervous system."

Brian Daly, public relations manager for Rockwell International, a major aerospace firm, experiences that synergy (network benefits) nearly every working day. When a reporter calls with a question that he cannot immediately answer, Daly plugs into a network that reaches from the company's Pittsburgh, Pennsylvania, headquarters to its El Segundo, California,

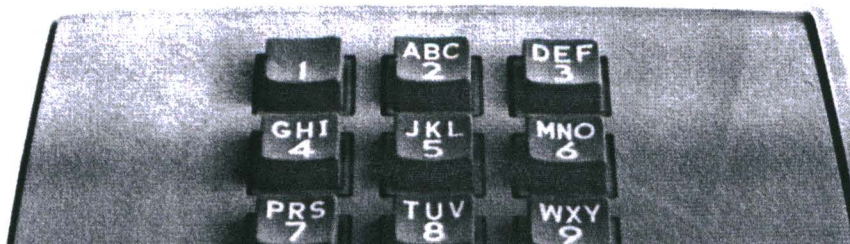
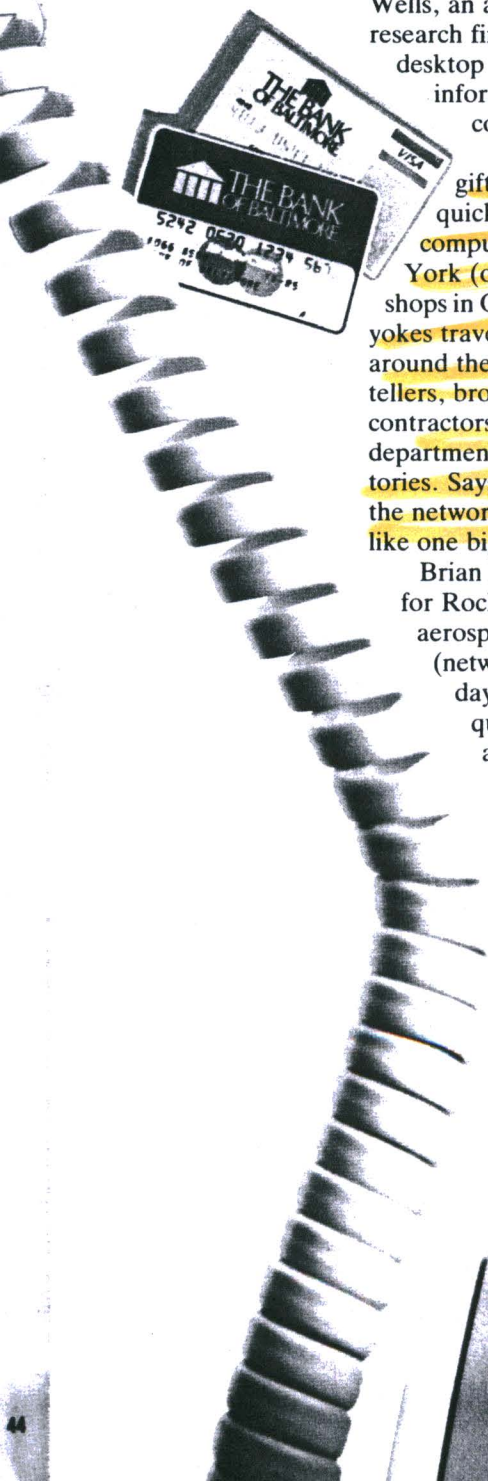
aerospace facility, linking 10,000 terminals, 7,000 personal computers, 60 high-performance minicomputers and one Cray X-MP supercomputer. "The value of networking is that you can share data and information," says James Sutter, Rockwell's general manager of information systems. But the biggest advantage, Sutter adds, is increased productivity.

Take the example of the Travelers Insurance Company, one of the nation's largest. Like hundreds of U.S. corporations, Travelers has gone on an office automation binge, spending \$300 million in each of the past two years to bring its 30,000 employees and 10,000 independent agents under the umbrella of an IBM systems network. Today the company has 35,000 terminals and PCs connected to 18 mainframe computers. Every day 3.7 million messages pass through Travelers' two million feet of coaxial and fiber optic cable. Net yearly savings: 32 railroad boxcars of paper.

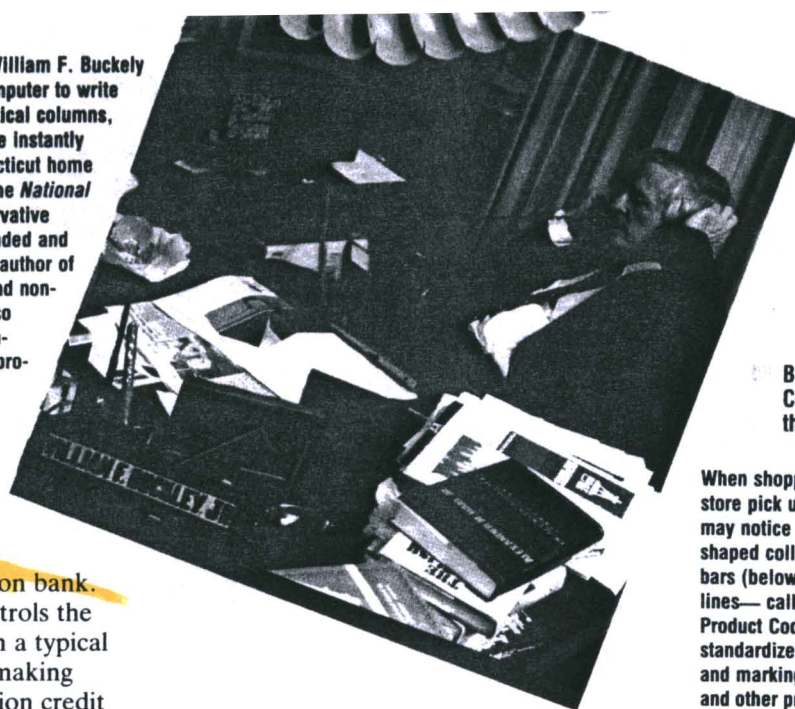
Thanks to the networks, some 240,000 Americans are now computing, rather than commuting, to work. Hewlett-Packard and Continental Illinois allow selected employees to do their work at home. Hedi Hesse, a computer programmer for Pacific Bell, visits her office just once a week. "A desk is a desk," says Hesse. "As long as I have a phone and a modem, I can do this anywhere."

Money networks now hand out cash to anyone with a thin plastic bank card and access to one of the country's 45,000 cash machines. In larger cities, banks are pooling their ATM (automated teller machine) networks to create regional systems or national networks. Today, a traveler can draw ready

With a telephone and plastic credit card (two samples are shown above), Americans can purchase everything from theater tickets to household appliances. The buyer provides a credit card number over the phone; within seconds the seller, using high-speed computer networks, confirms that the bank issuing the credit card authorizes payment.



Writer and editor William F. Buckley (right) uses the computer to write his syndicated political columns, and to communicate instantly between his Connecticut home and the offices of the *National Review*, the conservative journal that he founded and edits. Buckley, the author of numerous fiction and non-fiction books, is also host of the long-running public-affairs program, *Firing Line*.



cash from a Miami ATM while automatically reducing the balance of his checking account in his Boston bank.

A parallel set of networks controls the nation's 800 million credit cards. In a typical month, Visa cardholders who are making store purchases will initiate 50 million credit checks to 18,014 member banks through a high-speed authorization system that allows the bank to approve payment in as little as 1.0 second (down from 1.3 seconds last year).

The biggest network is the oldest: a national telephone grid, run almost entirely by computers, that connects 100 million homes and businesses through 1.6 thousand million circuit kilometers of wire, cable, microwaves and satellites. With 215 million phones for a population of 236 million people, virtually every U.S. household has at least one telephone. The U.S. telephone system remains one of the technological marvels of the modern world, handling more than 1.1 thousand million telephone calls a day with unmatched clarity and precision, and also carrying the bulk of the country's data traffic.

The payoff of networking is the same everywhere: more efficiency, productivity and control. The New York Stock Exchange, for example, credits the computerized stock trading network, which sends orders directly from member firms to the floor of the exchange, with an extraordinary 400 percent increase in productivity over the past 18 months.

There are clouds hanging over the networks, however. Since a thousand computer messages can be as easily sent as one, electronic junk mail tends to proliferate, forcing users to scroll through useless verbiage to find the information they need. Some systems are slow, or impossibly hard to use. Employees can become so engrossed with on-line browsing that they neglect their legitimate work, squandering whatever productivity gains the technology might have brought.

Moreover, the competitive fervor of the U.S. computer industry has now become an impediment to the networking of the

nation. Despite efforts to standardize the sharing of data, many U.S. firms are promoting their own proprietary communications systems, creating what has become a veritable skyscraper of Babel—a confusion of computer languages.

Nevertheless, the wiring of America proceeds apace. Some local phone companies are testing systems that will divide standard voice telephone lines into three digital channels, allowing telephone customers to plug terminals directly into their wall sockets, without benefit of modems (the devices that currently link computers and telephones), and to program their phones like computers. Networking firms, such as 3Com, Sytek, Ungermann-Bass and Network Systems Corporation, are stringing up kilometer after kilometer of high-speed coaxial and optical fiber cables and offering communications rates in excess of 275 million bits of information a second.

What will tomorrow bring? Futurists are now envisioning a brave new world of one-stop networking. Commuters will set burglar alarms, start air conditioners and program their VCRs—all through the digital keypads of their mobile phones. When appliances break down, homeowners will plug them into diagnosis outlets, dial the manufacturers and be told in a flash precisely what has gone wrong. This vision may be a little farfetched. Still, says communications expert Patrick Gordon, "The integrated computer-communication network is not a fantasy. It's already on its way."

Bar Codes: Controlling the Goods

When shoppers at a major food store pick up a box of cereal, they may notice a small rectangular-shaped collection of light and dark bars (below). This collection of lines—called the Universal Product Code (UPC)—is a standardized system for numbering and marking grocery packages and other products so that they can be identified by an optical scanner at the time of purchase. More commonly known as bar codes, the symbols appear on millions of cartons, cans, bags, bottles and other items.

At the checkout stand, the store clerk simply slides the merchandise over the scanner in the counter. A laser beam "reads" the bar code and transmits the data to a computer. The computer, in turn, records the bar code, instantaneously flashes the information back on a small display screen in front of the clerk, and prints the purchase out for the customer. The whole process of scanning, data transmission, screen display and printout takes but a fraction of a second. The printout is given to the customer after the amount is paid.

Shoppers move quickly through the checkout line, and can see exactly what they bought and how much it cost. Bar codes also enable store managers to know exactly which items are selling quickly, and which are not, on a continuous basis. As a result, the store can be restocked from the warehouse automatically when the inventory gets low, ensuring that customers rarely have to confront bare shelves. This kind of efficiency also means cost savings to the store, which translates into price savings for the consumer.



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COMPUTERS AND AGRICULTURE

By Donald A. Holt

Computers are beginning to play important roles in agriculture in the United States. Through a combination of communication, monitoring, analysis, simulation, expert systems and automatic control, computers are making the U.S. farm even more productive and efficient. By 1985, about eight percent of U.S. farmers owned personal computers, and most large-scale dairy farmers used computerized data bases.

For farmers of every size and speciality, information is becoming increasingly important. World commodity prices fluctuate widely because of the vagaries of weather and politics. Technological and political developments in the U.S. and abroad are dramatically increasing the number of management options.

For example, expert systems, which are computer programs incorporating the knowledge of teams of specialists, have become an important tool for farmers. One of the first agricultural expert systems, designed at the University of Illinois Plant Pathology Department, is called PLANT/ds. It is used in diagnosing soybean diseases, and combines diagnostic rules provided by human experts and machine-

induced rules derived by a computer from a data base of soybean disease observations. PLANT/ds permits almost any farmer who knows the difference between soybean leaves, stems and roots, to diagnose soybean diseases as accurately as an expert. In an initial test, the system outperformed human experts, registering 100 percent accuracy to their 96 percent.

Kansas State University is currently working on an expert system called CORNpro, which provides analyses for corn producers of costs, productivity, fertility, seedbed preparation, hybrid selection, soil-insect control, weed control, irrigation and marketing. Other U.S. universities are working on similar programs for cotton, alfalfa and wheat.

In farm fields, miniature computer-generated weather stations monitor for potential frost damage, moisture levels, and heat and solar radiation accumulations. Using computers and simulators, a farmer can use weather and soil moisture data, along with short- and long-range weather information, to predict the status of crops and pests. For livestock and dairy farmers, computers scan electronic ear tags attached to animals such as milk cows to identify each cow as it enters the milking stall. At feeding time, a computer uses the information from the tag to cause a measured amount of grain and feed additives to be

released for each animal. The computer also monitors the quantity of milk flowing from each quarter of the cow's udder. Recently, in laboratory research, computers have measured conductivity in the udder to detect infections. The computer is then capable of diverting the milk to another udder.

Farmers can also tap into about 400 different agricultural data bases throughout the United States. These data bases provide timely information on weather and markets; current fertilizer, seed, fuel, pesticide supplies and prices; and insect and disease predictions.

Future farmers will need computer systems that are at least as advanced as those used in any other business. The farmer of the future who survives in the competitive environment of American agriculture will be one able to acquire the most accurate and best organized information, and use it efficiently.

In such a future, the American farmer will use a custom-designed "master farm management" program—an enormously complex combination of simulations, data bases, and expert systems—to make decisions on such matters as livestock marketing, pricing of grain and the impact of government programs.

Computer simulations will help the farmer anticipate problems, tap useful sources of information and project a course of action. Take, for example, a threatened infestation of corn borers. First, the farmer will walk into the field with a portable "laptop" computer and enter information concerning plant and soil conditions.

Still in the field, the farmer will type in IPM (an acronym for Integrated Pest Management) on the keyboard. This command will establish microwave communication with the local agricultural extension office, which provides research, technical and marketing information for local farmers. The extension office, in turn, will provide a computer program, available nationwide, that leads the farmer through identification and diagnosis of the insect infestation—using voice, text and color pictures displayed on the portable computer screen. When the degree of infestation has been verified by actual sampling, the computer will prescribe control procedures that are most effective at the least cost, and that are environmentally safe.

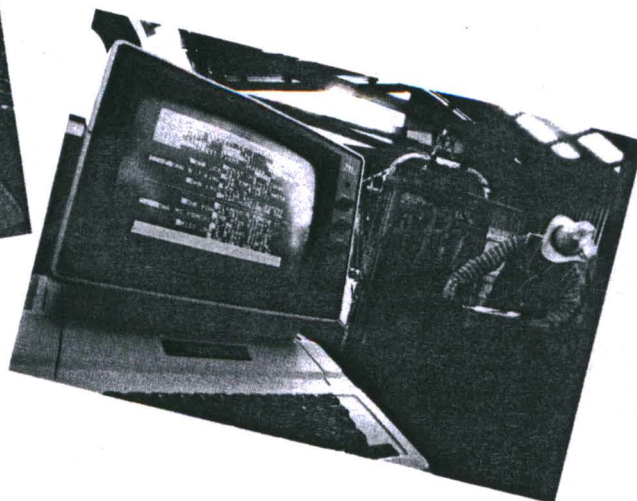
As this example demonstrates, computers, linked through advanced communications systems, will provide a widening range of applications to agriculture. The farmers and agricultural scientists of the future will be able to evaluate the genetic characteristics of livestock and plant species; check the condition of farm animals through implanted sensors; simulate physical and chemical changes in soil caused by machines and the application of pesticides and fertilizers; analyze pollutants and other chemicals in soil; monitor ground water, sub-ground aquifers, rivers and streams; and obtain more accurate, detailed weather and crop forecasts.

In short, the computer and communications network will play a vital role in increasing the efficiency and productivity of farms of the future, in the United States and throughout the world.

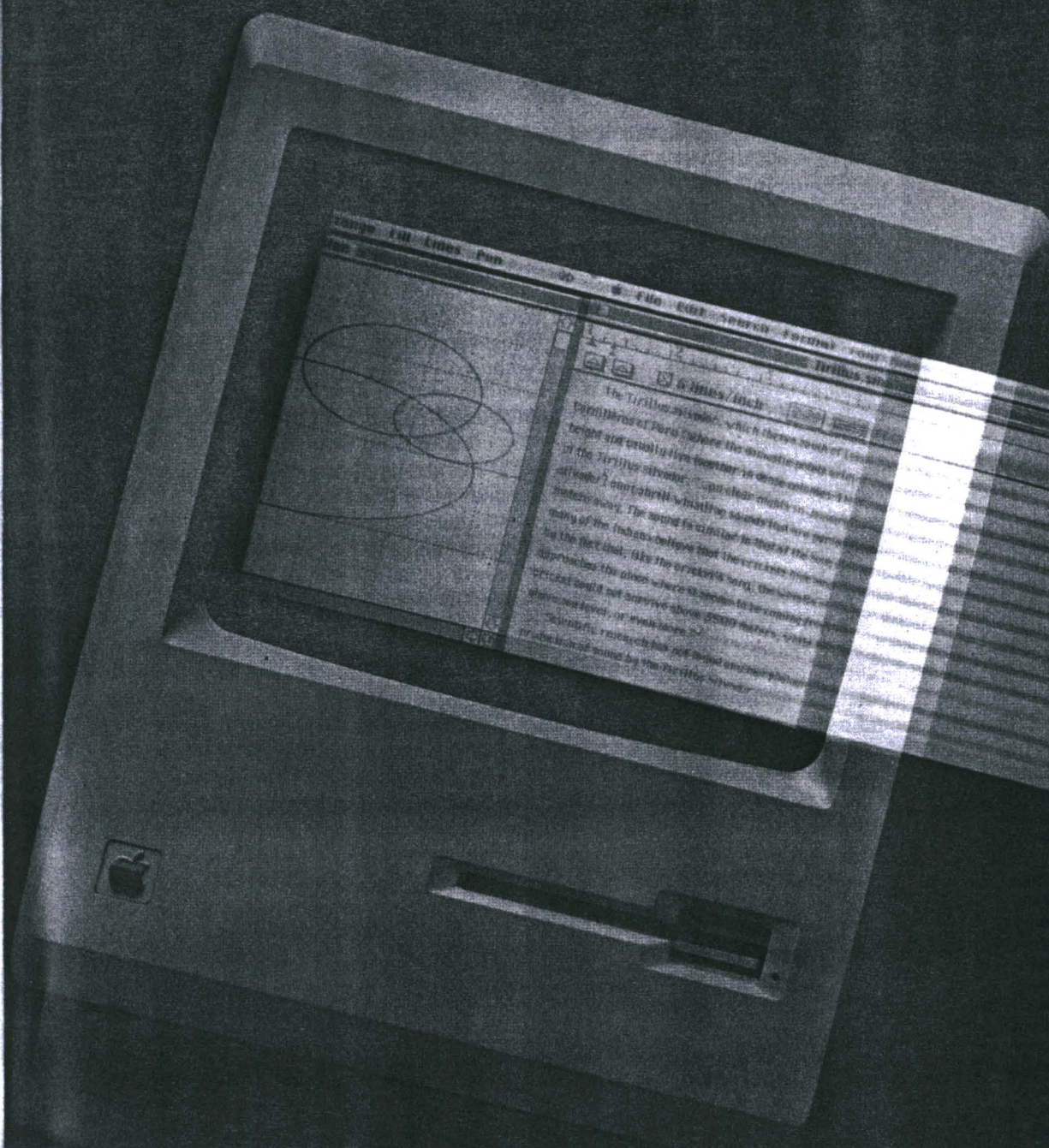
Donald Holt is associate dean of the University of Illinois College of Agriculture and director of the Illinois Agriculture Experiment Station at Urbana.



Above, modern cowboy keeps track of cattle on a ranch in Wyoming with help from a portable computer. Right, U.S. dairy farmers make heavy use of computers to monitor the quantity and quality of milk output from each cow in their herds.



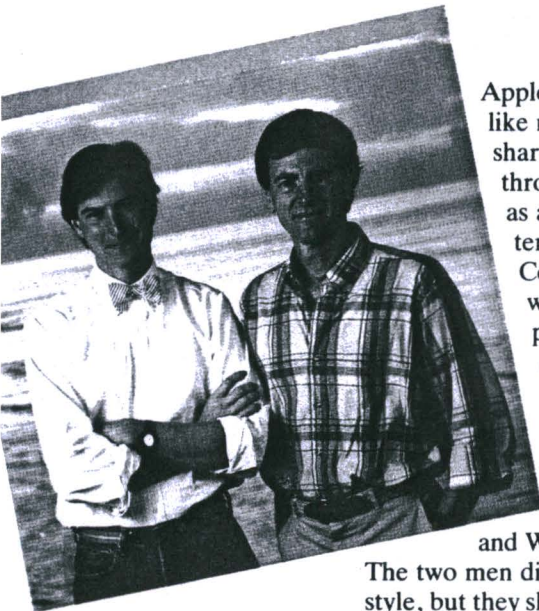
The Rise and Fall and Rise of A P P L E C O M P U T E R S



By Deborah C. Wise

Visitors to Paul Jobs' garage in suburban Los Altos, California, in the summer of 1976 would have been hard pressed to predict that the scene of technological junk and electronic mayhem was the embryo of a company that would be worth thousands of millions of dollars. Here, amid silicon chips, printed circuit boards and the family washing machine, Jobs' 21-year-old son Steven and his 25-year-old friend Stephen Wozniak pieced together the first Apple computers. Barely five years later, Apple Computer, Incorporated, was already a legend. From its modest garage beginnings, sales of its computers topped \$335 million in 1981. By 1986, some 2.5 million Apple IIs alone had been sold. And in 1987, Apple's sales are approaching \$2 thousand million.

■ Above, the Apple Macintosh, whose ease of operation and superior graphics have made it one of the world's most popular personal computers.



Above, the visionary and the executive: Steve Jobs (left) and John Sculley. Jobs, a founder and guiding force behind the phenomenal early success of Apple Computers, hired Sculley, an experienced business executive, to serve as president of the firm. Jobs' easy-to-use, graphically superior Macintosh computer was a technological marvel, but it failed to win widespread acceptance in business offices. Jobs later left Apple, but the Macintosh flourished as an outstanding computer for "desktop publishing" (see page 41). Top center, the young, dedicated team of Apple experts who designed and built the Macintosh computer.

Apple is continuing to grow, but like most adolescents it has had its share of growing pains. Yet, through it all, Apple has emerged as a phenomenal success. International Business Machines Corporation (IBM), the world's largest computer company, may have taken over as the market leader in personal computers, but it is Apple that continues to produce remarkable technological innovations.

Apple creators Jobs and Wozniak were unlikely partners.

The two men differed in temperament and style, but they shared an interest in computers. Jobs, a college dropout, went to work for one of the leading new technology companies, Atari, the home of the first video game. Wozniak, or Woz as he is known, was working at Hewlett-Packard, a computer company that, coincidentally, was also started in a garage. When others they knew started building computers, it seemed only natural that they should try as well. The primitive-looking Apple I was their first effort.

The Apple II

In 1976 personal computers were bought primarily by technical hobbyists who reveled in tinkering with bare circuitry, similar to the original Apple I. If Apple were to grow, however, Jobs realized that he would have to reach beyond this small cadre of customers. Jobs allocated a good proportion of Apple's limited capital on the packaging for Woz's second design, the Apple II. He contracted for an attractive plastic molding with a built-in keyboard—a landmark move that propelled the computer into the orbit of a more general, and consequently, much larger audience.

Sales of Wozniak's superbly built Apple II took off. People new to computing started buying Apple IIs because they looked "friendly." Beneath the plastic molding, however, Wozniak had crafted a singularly impressive machine. It not only incorporated the state-of-the-art microprocessor technology, but also had some special Woz touches. The computer invited its user to delve into the guts of the machine. Unlike competing models, the Apple II had what is called an "open system." Apple published the technical specifications of the product so that people could develop their own software and add-on

devices to make it more useful. This approach spurred sales, and within a year hundreds of companies started forming to write software programs and build devices, such as additional storage units and printers, that could be attached to the computer to make it more powerful. The Apple II had spawned an industry all its own.

The Perils of Success

Within two years everyone was waiting for a follow-up product. The first attempt at a new computer, the Apple III, was announced before it was technically sound, and it failed. To add to Apple's distress, a new competitor entered the market: IBM, the world's largest computer company, an astounding 130 times the size of Apple.

Within a year, IBM's Personal Computer had whittled away Apple's lead in the marketplace and had come close to shutting the door on the California company's bid to sell personal computers to businesses—the fastest growing segment of the market.

The personal computer industry started to follow IBM's lead. Hundreds of companies formed to build products that worked like and with the IBM Personal Computer. Jobs refused to capitulate. Apple, which built machines that did not use the same technology as the IBM design, was determined to make a bold stand on its own. Its answer to IBM was Lisa, Apple's costliest project yet.

The idea for the machine essentially came from another company altogether, Xerox Corporation, the copier giant. In the early 1980s, Jobs went on a tour of Xerox's computer research center and was impressed by what he saw. Xerox had pioneered the use of a hand-held pointing device, called the mouse, which lets you move an arrow on the screen by rolling an object the size of a cigarette pack on the table next to the computer. The screen shows a selection of functions the computer can do, usually in the form of a graphic icon, and when the arrow is pointing to an icon and the button on the mouse clicked, the computer executes that particular function.

Jobs saw the Xerox approach, using the mouse, as a way to bring computing to the masses. Problems arose, however, when the cost of developing the Lisa computer started getting out of hand. Lisa would end up selling for \$10,000 versus the \$2,500 for an Apple II. Jobs opposed the price. He





saw Apple losing its roots as a company that was working towards a goal of one person, one computer.

Enter Macintosh

Instead of working to make Lisa a success for the greater good of Apple, Jobs mounted an independent operation that proved to be a key element in Lisa's ultimate failure. More importantly for Apple, however, he laid the groundwork for the company's current success: Macintosh.

Jobs formed an elite group to work on Macintosh—a smaller, lower-cost version of Lisa. (It is named for an American-grown variety of apples.) It set up shop away from Apple's headquarters and started a three year round-the-clock crusade.

Essentially, Macintosh looked like Lisa's younger sibling, with high-quality graphic displays, or icons, and the hand-held mouse. The hard task was making all this work in a personal computer that cost \$2,500. The Mac team—young, inspired and working impossible hours—succeeded in doing just that. Their pride in their work was immense, but the obvious competition between the Lisa and Mac projects hurt morale—and the sales of Lisa computers.

Transition and Recovery

Apple's top management then underwent a major reorganization. After an exhaustive search, Jobs settled on a new president, John Sculley, the 44-year-old president of PepsiCo., maker of Pepsi Cola soft drinks.

In January 1984, Apple launched the Macintosh. The compact, even "cute" computer, caught the imagination of the press and the public. Macintosh jumped off to an impressive start.

The euphoria, however, didn't last long. After the initial burst of activity, Mac sales slowed precipitously. Although everyone admitted Mac was the world's easiest computer to use, it was slow to perform many of the tasks the IBM PC did at the touch of a button. Business, a key target market, eschewed the Mac in preference for the more established IBM name. Apple invested \$20

million in an automated factory able to produce 80,000 Macintosh computers a month, yet sales hardly reached 30,000. In addition, Jobs failed to deliver key follow-on products needed to keep the Macintosh competitive with the IBM PC.

Sculley responded by reorganizing management and manufacturing, laying off 1,200 people, and shutting down three factories. Jobs had glorified the super-smart technology whizzes. Sculley would do the same, he said, but he would also reward the line managers who performed the mundane tasks, such as accounting and inventory control, so necessary to running a large company. Jobs subsequently resigned from Apple and formed a new, independent firm, called Next, to explore advanced computer technologies and applications.

Since Sculley's corporate overhaul, Apple's fortunes have improved considerably. When more powerful versions of the unique Macintosh became available, such as the Macintosh II, sales picked up. The "Mac II" operates four times as fast as the older version, has a larger, 13-inch color screen and its memory can be expanded up to four megabytes, by allowing users to insert specialized circuit boards.

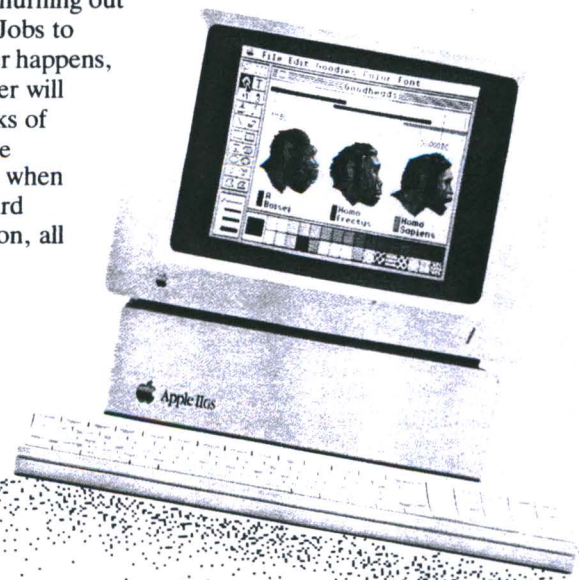
Another boost has been the recent, astonishing upsurge in small independent publishing based on the graphics capabilities of the latest personal computers. Linked to a new generation of laser printers, the Macintosh, with its superior, easy-to-use graphics programs, has proved to be the ideal system for individual, or "desktop" publishing.

Though only a decade old, Apple has reached a critical mass in both market share and manufacturing capability. It is now mentioned in the same breath with IBM as a solid, major corporation. Its products are sold in 85 countries worldwide. Apple's continued success will depend on its ability to keep churning out innovative designs without Jobs to provide the vision. Whatever happens, the story of Apple Computer will go down in the history books of American business as a pure example of what is possible when opportunity, innovation, hard work, luck and determination, all converge.

Deborah Wise a San Francisco-based free-lance writer, was formerly a Business Week magazine correspondent covering the computer industry in California.

Apple's Newest Crop The IIGS

In September 1986, Apple introduced the Apple IIGS (below), the latest version in its venerable Apple II series of personal computers. The IIGS runs all existing Apple programs, plus it has a host of new software all its own. Operators interested in graphic design can select from 4,000 different colors and shades, using up to 64 different colors on the screen at the same time. The Apple IIGS also has a 15-channel sound system that can repeat words entered on the screen or generate musical tones. Another bonus is speed: Software in the Apple IIGS runs nearly three times as fast as that of its siblings, Apple II, IIe and IIc. With a powerful microprocessor, sophisticated color graphics and sound for games and music, company officials hope the IIGS will attract a whole new generation of PC buyers—much as the first Apple II did a decade ago.



IBM - THE BIG BLUE MACHINE

By John W. Verity

IBM is known throughout the world as one of the largest and most profitable U.S. corporations. Because of its size, technological expertise and marketing power, IBM in many ways defines the computer market. Its numerous, but smaller competitors often measure their success against IBM's technical standards, or seek "niches" in which to provide specialized peripheral devices for IBM equipment.

The story of IBM begins with its founder, Thomas J. Watson, who, beginning in 1914, transformed a small company making tabulating and other equipment into a modern computer giant. Watson and IBM were hailed as a new breed of modern managers and companies, whose trademarks included hard work, a strong company identity, white shirt and blue suit (hence the nickname "Big Blue"), and the blunt slogan "THINK." IBM's personnel practices—with its emphasis on participation, constant training and education, promotion strictly for merit, and encouragement of creativity—continue to be emulated widely throughout corporate America today.

In 1951 an IBM competitor, Remington Rand, marketed the first commercial electronic computer, the famous UNIVAC, delivered to the U.S. Census Bureau. Two years later, IBM countered with its own digital computer. Computers were large and costly to run in the 1950s, and most of the early machines were used for scientific research, not traditional business data processing. With increased competition and improved technology, however,

prices had fallen sufficiently by the early '60s to make computers attractive to several thousand private enterprises.

In 1964 IBM unveiled the System/360 to this accelerating market, a now-famous line of computers that helped entrench the company as the undisputed leader in its field. Some 20,000 System/360s were installed in the U.S. alone, giving IBM as much as two-thirds of the total computer market.

The System/360s, known as mainframes, were relatively large machines, particularly compared to those that became available during the 1970s, which were known as mini-computers. As the minicomputer market emerged, however, IBM began to face a new kind of competition. Small but nimble companies, using advanced technology that IBM for various reasons had declined to pursue, began to build replacement components for the many installed System/360s and their successors, the System/370s.

The same pattern occurred when the microcomputer, or personal computer, arrived on the scene in volume in 1977, pioneered by Apple Computer.

IBM watched and waited as the market for personal computers exploded with the advent of the superbly engineered Apple II in the late '70s. When Apple faltered with its follow-on computers, the Apple III and Lisa, IBM leapt into the market with its own PC, and swiftly overtook Apple as the world's leading manufacturer of personal computers, primarily by focusing on the fastest growing computer market, the business office.

IBM's powerful personal computer, with an "open" design easy for others to copy, has proved so popular that

many competitors, both U.S. and foreign, sell functionally equivalent machines (IBM-compatible computers referred to as "clones"), often for lower prices than what IBM charges. IBM has responded to this agile competition by cutting prices on its own machines, and increasing the IBM PC's speed and capability. Still, because of the intense competition, IBM's share of the U.S. personal computer market dropped from 31 percent in 1984 to 26 percent in 1986, although it remains by far the largest single PC manufacturer. (Apple's market share is nine percent.)

IBM hopes to recapture a portion of the market with introduction of a new "family" of computers—called the Personal System/2. The least expensive of Personal System/2, the model 30, runs twice as fast as its predecessor, the IBM PC-XT, but is the most compatible with older IBM computers. The medium-priced machines, the Model 50 and 60, run faster than the fastest previous IBM, the PC-AT, and possess color graphics designed to rival those of Apple's Macintosh and other competitors. Top of the line, the model 80, retails for \$11,000, but will match the power and memory of the huge System/370 mainframes that IBM sold in the mid-1970s for several million dollars.

IBM's entry transformed the personal-computer market in three fundamental ways. Before IBM, companies sold a swarm of different personal computers that talked different computer languages and were largely incompatible with one another. IBM, with its sheer size, has enforced a standard on the entire industry, so that today most PCs basically come in only three categories: IBM, IBM-compatible "clones," and Apple. IBM has not eliminated the competition; rather, it set industry-wide standards for

computer hardware by which computer firms large and small, foreign and domestic, can compete.

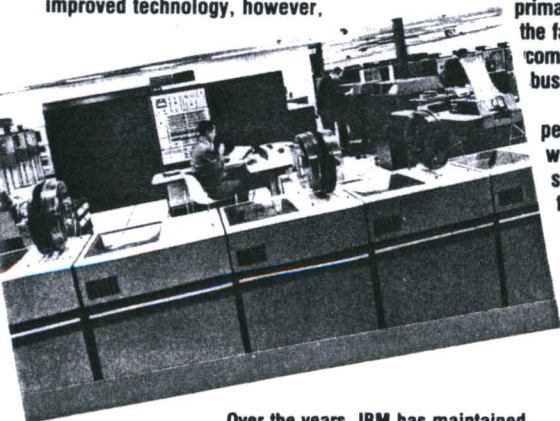
Second, IBM machines and "clones" have served as catalysts for the growth of the software industry, which is now pumping thousands of programs—from word processing to graphics and games—that can exploit the capacity of IBM computers. Third, IBM, unlike Apple, has always emphasized the telecommunications capabilities of its PCs, so that they can be used to automate offices and link up with other, larger computers.

As the world's largest maker of data processing equipment, IBM has always had a large budget for research and development. In 1985, for example, it spent some \$4 thousand million exploring technologies and engineering new products, which was more than the total annual revenues of most of its competitors.

IBM seems destined to remain the industry leader for the foreseeable future. Most observers agree that the immediate future of computing lies in tying computers together into globe-spanning data networks. With two-thirds or so of the very largest computers, IBM is in a strong position to stay ahead of the pack.

Sustained technological innovation and marketing skill will continue to be essential if IBM is to maintain its position of dominance in the rapidly transforming world of computers and information technology.

John W. Verity covers the computer industry for Electronic News and Datamation Magazine.



Over the years, IBM has maintained its dominant position in the computer field with a steady stream of innovations. Above, the System/360, the IBM mainframe computer system introduced in 1964. Top right, one of IBM's latest products is the PC Convertible, a portable computer that weighs only 5 1/2 kilograms, yet contains as much computing power as many conventional personal computers.



By Nancy Knight

The application of modern information technology in health and medicine is having profound effects on the quality of life in the United States. Advanced diagnostic techniques, communications networks linking large banks of medical data, emergency medical services, organ donor networks, and an explosion of health information available to the general public are changing the nation's medical practices.

Over 10,000 different computerized systems are now at work in the health field. Some monitor patients; others analyze laboratory samples. Still others provide the data needed to make informed medical decisions, or produce detailed images of the body's internal organs.

The information generated by this new technology joins an already vast store of medical knowledge. At the same time, the new information technology helps keep health professionals from becoming paralyzed by the sheer volume of new data.

Physicians now have instant computer access to virtually every printed page of writing in their fields through information networks such as MEDLARS and MEDLINE (see pages 24-25). As a result, medical professionals throughout the world are able to tap this growing pool of information and share in the benefits of medical research almost immediately.



Magnetic resonance imaging (MRI), shown here, is one of several computerized techniques for seeing inside the body in great detail without surgery.



Marissa Emple, youngest successful recipient of a liver transplant in the U.S.

For newborns, the critically injured and the elderly, modern communication and computer systems are saving lives. On previous page, MRI computer-enhanced image of four-year-old child detected a paralyzing tumor (shaded red) next to the spinal cord. After immediate surgery, the child regained the use of her legs. Above, 100-day-old Marissa Emple received a successful liver transplant, thanks to a nationwide organ donor network that can identify, match and deliver vitally needed organs, even for infants, within hours of becoming available. Opposite page, top, helicopter ambulance transports critically injured patient to a hospital in Allentown, Pennsylvania. Hospital is able to monitor the patient's vital signs throughout the flight. Right, opposite page, Rose Iacona, 70, a victim of severe arthritis, describes herself as "semi-synthetic." She is holding X-rays of all her artificial joints: both shoulders, elbows, hips and knees. Six years ago, she couldn't brush her teeth; today, she shovels snow in the winter.

One of the early applications of international medical communications was the treatment and elimination of contagious diseases. A dramatic example is smallpox. After years of sharing and analyzing data from around the world, an international team of physicians was able to locate and treat the last known case of smallpox in Somalia in 1977.

Individual Americans, with greater access to this growing store of medical knowledge, have become better informed and resourceful on health matters: As research has revealed the ties between personal habits and major diseases, many people have begun to exercise regularly, learn about nutrition, and give up smoking and alcohol. New home health tests and monitoring devices, as well as a thriving popular health publishing industry, provide the basic know-how for practicing preventive medicine.

The following is a sampling of some of the varied applications of information and communications technology in medicine and health today.

Deeper Diagnoses

New technologies supply images of the interior of the body with a clarity and interpretive detail undreamed of only a few years ago. Computer tomography, for example, generates diagnostic images by using computers to reconstruct two-dimensional X-ray data in digital form. The results are computer-enhanced, three-dimensional color images that are far superior to conventional X-rays.

An even more advanced method of "seeing" inside the human body is magnetic resonance imaging, a technique that uses magnetic waves, which are then enhanced by computers, to create dramatically detailed color images. Another procedure is high-frequency sound, or ultrasound, which can provide images of moving organs such as the heart, a fetus or soft tissues such as blood vessels and muscles.

This evolving family of imaging technology is an increasingly valuable means of diagnosing disease and injury without the trauma of surgery or other "invasive" techniques. Imaging technology also enables the physician to tailor specific treatments to the individual needs of the patient.

Paramedic treats severely injured patient on helicopter flight to hospital.

The Cardiac Connection

In general, information is one resource that expands and becomes more valuable as it is used—and shared. For example, on December 16, 1985, U.S. and Soviet physicians were linked in a two-hour televised medical conference. Heart specialists in the U.S. talked with their counterparts from the National Cardiology Research Center in Moscow through an international satellite broadcast system. The conference, which ranged from standard treatment methods to the goals for future research, is the first of a series planned between Soviet and American medical specialists.

Cardiology is also the subject of intensive research that crosses the traditional boundaries between biology and computer science. At New York University, for example, a team of mathematicians and physicians are using supercomputers to simulate the dynamics of heart motion and blood flow with techniques normally associated with airplane design.

Medical ID's

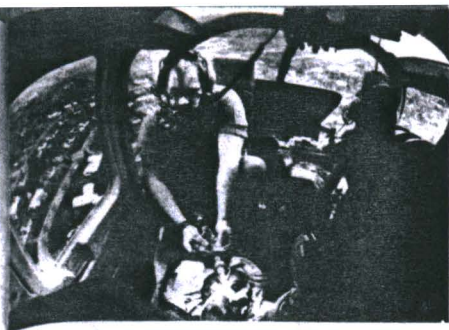
One of the most persistent problems in critical care of the injured or acutely ill is the lack of even simple information. Often the patient cannot communicate at all. Especially for those with chronic problems, such as heart disease or epilepsy, an emergency may mean an inability to convey the few phrases which could bring immediate relief. For millions of Americans, the answer is wearing a medical identifier.

A variety of groups—corporations, insurance companies and public health programs—offer medical identification cards, tags or jewelry. Most cards alert the health provider to basic information: the bearer's blood type, allergies to foods or drugs, specific medical problems, and the name of an emergency contact.

New and more efficient means of emergency identification are being developed. One company is testing a laser-encoded card which can provide immediate access to as many as 800 pages of information—including X-rays and photographs.

Gifts of Life

Although Alice Richardson is two years old, she weighs only seven kilos. Her skin is yellowed and puffy, and her parents have been told that she will die within weeks. They have known since she was three months old that she has a rare condition called biliary



atresia: her liver does not function, and it produces poisons which will cause her death. Alice and her parents have one hope: a liver transplant. It is a hope which rests on the strength and depth of the nation's health communication network.

In 1985, for example, 7,695 kidney transplants, 602 liver transplants, 719 heart and 30 heart-lung transplants took place in the United States. Pancreases and bone marrow are being transplanted as well.

The transplant network uses computerized procedures to match donors and recipients and to speed delivery of the transplant organ. Children like Alice are first put on a donor waiting list. Operators record more than 80 physiological criteria, each necessary for matching to potential donors, which are then entered into a nationwide computer network. When an organ becomes available through the accidental death of a child, an immediate computer search yields a match. Within hours, special teams of physicians travel to the donor's hospital, pack the tiny liver in ice, and board a waiting airplane to carry them to the recipient. Without this highly refined interactive computer system and coordinated transportation, time required to match donor and recipient would render the organ useless.

Early morning. Alice's parents watch as their daughter is prepared for surgery and taken to the operating room. Although her new liver is in an airplane hundreds of kilometers away, she will be ready for the transplant as soon as the medical team arrives. The donor organ is less than six hours old, and the Richardsons know that Alice has excellent chances for a full recovery and normal life.

Recently, the United States organized a single nationwide network to match organ donors and recipients. With government funding, the United Network for Organ Sharing, a nonprofit organization based in the state of Virginia, maintains a national computer list of individuals who need organs such as hearts, kidneys and livers, and operates a 24-hour telephone service for those seeking information on tissue types and the availability of organs.

Networks of Response

A driver is injured in an automobile crash; a child accidentally swallows household cleaner; a flood devastates a small midwestern town. In each of these cases, communications networks are critical to saving lives and alleviating suffering.

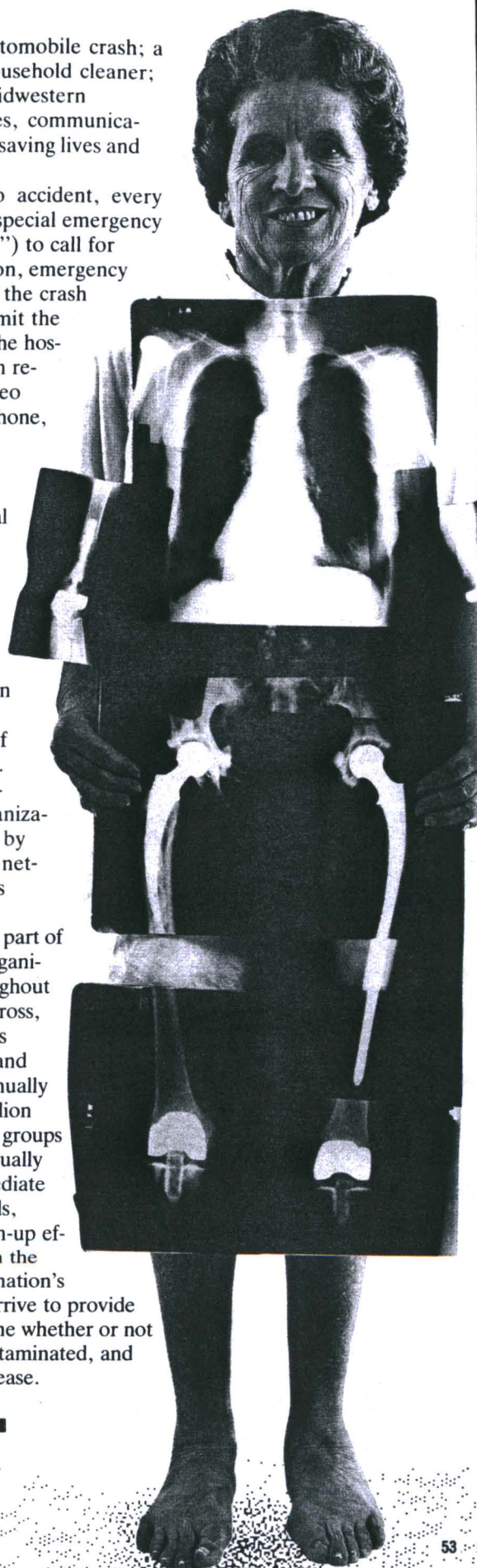
In the case of an auto accident, every American community has a special emergency phone number (usually "911") to call for ambulance service. In addition, emergency personnel often can monitor the crash victim's vital signs and transmit the data from the ambulance to the hospital. There, the physician can review the information on a video screen, give advice over the phone, and prepare for treatment as soon as the victim arrives.

For victims of accidental poisoning, one call to a special "hotline" will place a frantic parent in contact with a professional who can provide advice on immediate first aid treatment before taking the child to a hospital. Such health hotlines abound in the United States, for emergency help and other kinds of medical counseling or advice.

In the example of a midwestern town, volunteer organizations are alerted to the flood by the nation's communications network. One organization that is invariably on the scene is the American Red Cross, which is part of the international charitable organization and has branches throughout the United States. The Red Cross, mostly staffed by volunteers, is responsible for the collection and distribution of the nation's annually donated blood supply (5.7 million liters). It also is among the first groups to respond to any disaster—usually within hours—providing immediate medical aid, shelters, hot meals, clothing and assistance in clean-up efforts. Later, investigators from the Public Health Service and the nation's Centers for Disease Control arrive to provide additional support, to determine whether or not the water supply has been contaminated, and to prevent the outbreak of disease.

Nancy Knight is a medical writer and historian in Washington, D.C., with a special interest in the social consequences of new medical technology.

Seventy-year-old Rose Iacona of New Jersey shows X-rays of her artificial shoulders, elbows, hips and knees—all made of compounds of metal and plastic.



If you took a survey, chances are the most common question asked in the typical American household is...

W H A T' S O N T V ?

By Richard Zacks

The road snakes down along a mountain ridge into Craig, Colorado, population 8,000. Until 1979, citizens there—looking for spectacular entertainment besides watching the coal-mining trucks roll by—could choose from only a few fuzzy channels on their television sets. But now, thanks to a cable video revolution sweeping the United States and reaching even tiny towns like Craig, TV viewers can choose from 21 different channels delivering thousands of different programs each week by means of a cable directly into their homes.

Cable TV's Many Faces

Roughly 86 percent of all American homes have television sets and about half of all households have access to cable TV, which offers an average of more than 30 channels per television. For the viewer, the result is convenience and choice. America's 6,500 cable systems—which relay programs into homes through a network of high-capacity cables rather than over-the-air broadcasts—provide a veritable smorgasbord of special interest programming. Entire channels are devoted exclusively, around-the-clock, to single topics: news, sports, music, movies, health, foreign language programming, religion, even a 24-hour weather service.

Cable television first sprang up in 1949 as a means of delivering TV signals to rural areas far from big-city transmitter towers, and to mountain areas with reception problems. Communities set up huge antennas to receive network signals, then charged viewers a small fee for feeding those signals into homes via cables. Cable grew slowly, however, until the 1970s, when local cable systems began to “import” signals from distant stations.

Cable television's next big step forward was to find a satellite connection. In

1975 Home Box Office (HBO), a small cable movie service, started bouncing its signal off a satellite 35,880 kms above the earth. The signals—largely full-length movies uninterrupted by commercials—were then picked up by cable systems nationwide.

Satellites provide a cheap, efficient means of distribution, and by the mid-1980s more than 50 cable services bounced their signals off a flock of overhead satellites.

Let's go into a living room in Boston, Massachusetts, and pick up the cable channel-selector box that's sitting beside the TV set. Boston-area viewers pay only \$2 a month for a package of 29 basic services (including local channels that also broadcast over-the-air), or \$12.50 for 46 channels. In addition, they then can purchase so-called pay channels (such as HBO) for about \$12.50 each. Most cable channels telecast shows around the clock. (To compare the relative costs of these cable channels, the average American worker in private industry earned roughly \$8.50 an hour in the mid-1980s; average monthly income was slightly more than \$1,200.)

Here are thumbnail sketches of several of the 50 services available to our Boston family, which are typical of the selection nationwide:

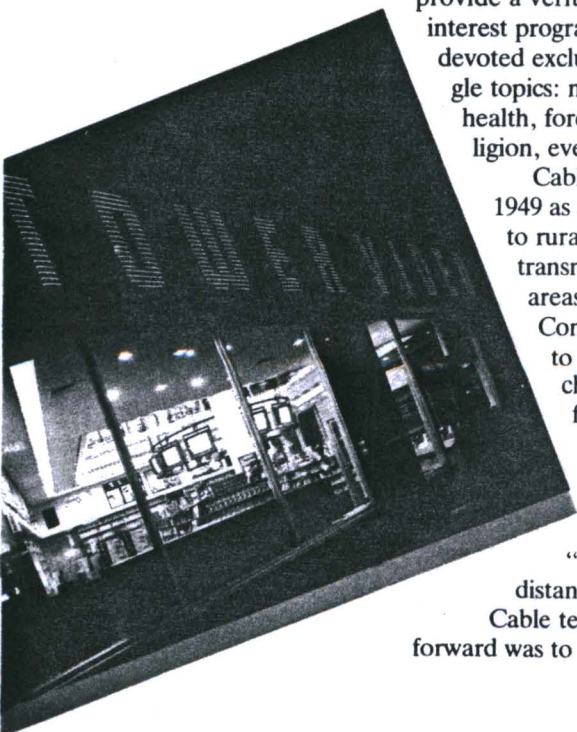
—Music buffs can tune into MTV, a high-voltage, teen-oriented series of mostly three- to six-minute pop music videos: The Rolling Stones, Michael Jackson, A-Ha. Famous performers interpret their songs in filmed performances replete with special effects, or in a stream of disparate, surrealistic images, often using computer graphics and other high-tech video techniques. MTV participated in the “Live-Aid,” international relief effort to help Ethiopian famine victims.

—News watchers can tap into the “Cable News Network” (CNN). CNN, also shown in 15 other countries, feeds up-to-the-minute national and international news 24 hours a day from its 20 bureaus around the world.

—Afficionados of cultural programming can tune into “Arts & Entertainment Network,” which puts a spotlight on the international performing arts: music, dance, opera, theater.

—Click the channel selector one more time and you hit a round-the-clock sports service, ESPN. In 1986 ESPN broadcast 3,000 live hours of sports—including hockey, soccer, basketball, tennis and boxing.

Below, “Tower Video” outlet in New York City is one of more than 20,000 video stores across the country where viewers can rent videocassettes for as little as \$2.50 per night. The average store offers a selection of approximately 2,000 titles, with between 200 and 400 new cassette titles available for rent or sale each month.



—Several more clicks can deliver the U.S. national legislative bodies, the House of Representatives and the Senate. These two channels, called "C-SPAN" (Cable Satellite Public Affairs Network) provide live coverage of elected congressional representatives in debate. C-SPAN also offers, three times daily, national two-way telephone interview programs where citizens can call in and ask questions of prominent politicians.

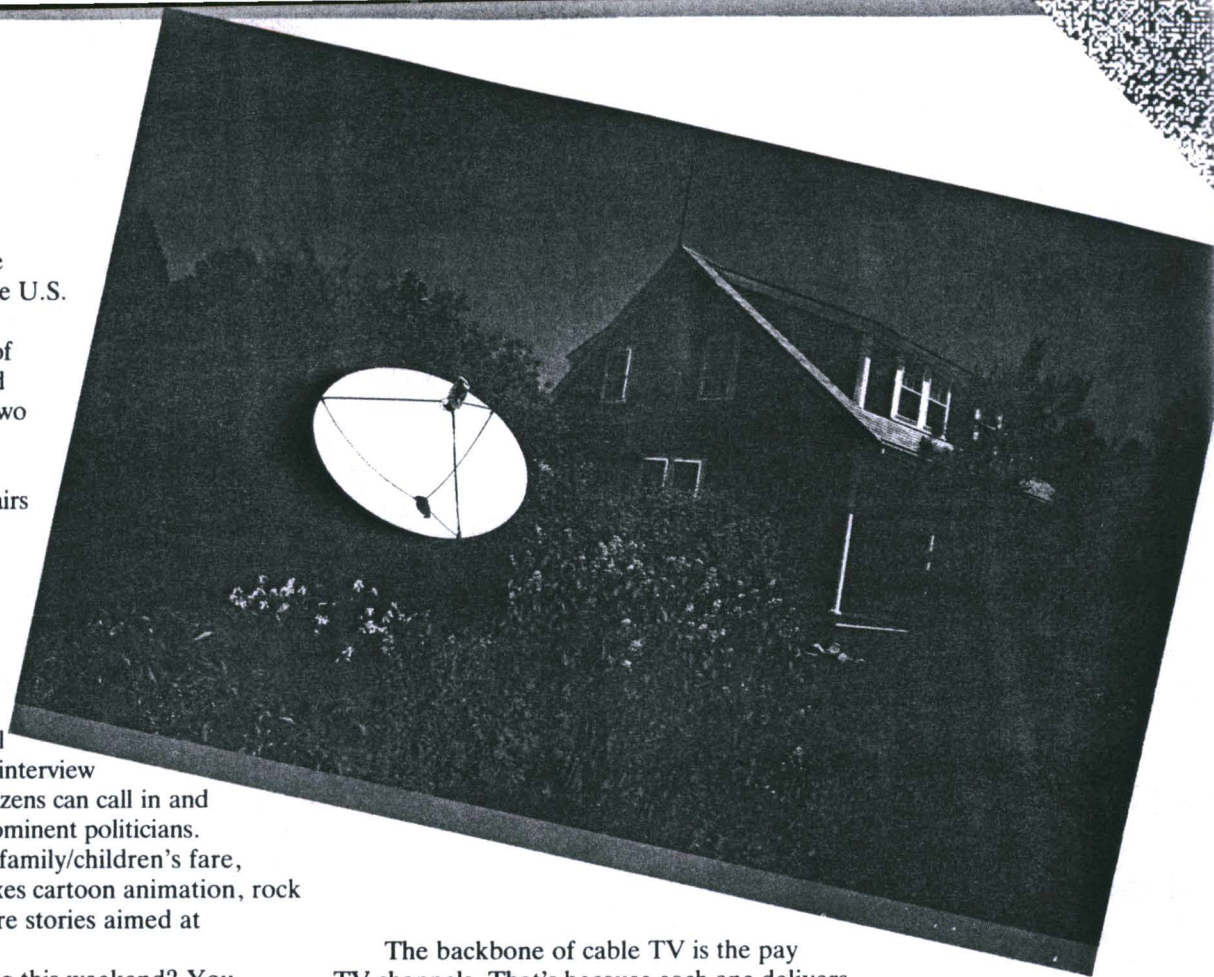
—If you want family/children's fare, "Nickelodeon" mixes cartoon animation, rock music and adventure stories aimed at youngsters.

—Going fishing this weekend? You had better find out about the weather. "The Weather Channel" provides round-the-clock, up-to-the-minute national and local weather.

—Cable television also devotes several channels to religious telecasting, including the nationwide Christian Broadcasting Network. According to a private association, the National Religious Broadcasters, 414 different organizations across the country, representing a wide variety of religious denominations, produce religious films and programs that appear on more than 220 television stations. Some religious programs are broadcast nationally, often on Sunday morning; many others are produced and broadcast locally.

—America's minorities receive specialized programming on cable as well. The Black Entertainment Television network, for example, broadcasts movies and public affairs programming oriented toward black Americans, while Univision—formerly the Spanish International Network—blends news, sports, music and entertainment for millions of America's Hispanic citizens.

—Most cable systems also "import" one or two local TV stations from other parts of the country. These big-city independent stations, called "superstations," usually feature a mix of popular movies and live sports.



The backbone of cable TV is the pay TV channels. That's because each one delivers full-length movies, more than 50 different titles a month for a national average of \$10.50—about the price of two tickets at a movie theater. Pay TV also delivers these movies years before they appear on over-the-air, free television.

As of 1986, for example, about 15 million American homes subscribed to Home Box Office, which competes with three other similar pay TV services: "Showtime," "Cinemax" and "The Movie Channel." Each month, HBO beams in 80 movies—as well as an occasional big event, such as a heavyweight boxing match, or a performance by a big-name singer or comedian.

For families eager to provide the ideal mix of instructional and entertaining programming for their children, there is the "Disney Channel." Long noted as one of the best family programmers, the Disney studios provide animated and live action fare, drawing from its peerless library of TV and film gems, such as *Pinocchio* and *Snow White*.

More new developments loom on the horizon. One is "Home Shopping Network" which operates through cable systems as a kind of TV catalogue of consumer goods. Viewers just phone in their orders. Two-way cable communications provide the technology for instantaneous viewer polling,

Above, television satellite dish blooms in a Cape Cod, Massachusetts, garden along with lilac and iris. This home is one of more than 1.6 million American residences with home satellite dishes that can pull down a host of TV signals from several orbiting communications satellites. Many satellite dish owners live in rural areas where the choice in local TV programming is limited. Satellite television permits them to select from literally hundreds of movies and sporting events broadcast each month, in addition to regular network and cable programming.

for home security services, even for banking and paying bills from home.

VCR Explosion

But this vast cable TV bonanza is just half the story of change in the American TV landscape. The rest is provided by the most revolutionary device to hit home entertainment since the television set first became popular in the 1950s. That's the briefcase-size videocassette recorder or VCR, which enables people to watch TV programs broadcast when they are not home, or are otherwise occupied.

Americans are now freed from the TV schedule. A family, for example, can visit friends or run errands in the evening, and tape that 8 p.m. movie, say the popular comedy, *Ghostbusters*, while they are gone. Going away for the weekend? Our family can program its VCR to record as many as four to six scheduled broadcasts a week.

VCRs first hit the U.S. in bulk in the late-1970s when the Japanese company, Sony, started selling Betamax videocassette recorders for about \$1,000 each. By the late 1980s, about half of all American households had a VCR, with VCR prices as low as \$189. VCRs are expected to be in 85 percent of American homes by 1990.

But viewers don't need to record movies to watch them with VCRs; they can rent movies through local stores or video clubs. By the mid-1980s, companies were releasing 400 different titles a month to more than 20,000 video stores across the country. With this vast selection, the VCR provides the ultimate in ease and variety. Video stores offer an average of 2,000 different titles each for rental at \$2.50 a night per tape or for sale for as little as \$9.95. Opera, ballet and instructional tapes covering everything from tennis to cooking can be found on video store shelves; exercise workout tapes featuring actress Jane Fonda have become a VCR bestseller.

Nevertheless, movies are the most popular video rentals, accounting for 70 percent of all transactions. A blockbuster title, such as *Tootsie* starring Dustin Hoffman, will reach the video store about six months



Above, rock star Bruce Springsteen in concert. Springsteen, like many popular musicians today, has reached new audiences with video presentations of his songs that appear on the 24-hour cable channel, MTV (short for Music Television). Many rock videos are simply performances filmed in a recording studio or before a live audience. Others are innovative narrative interpretations of the songs that employ a variety of animation and other special effects, giving the videos a dreamlike, surrealistic quality.



after its run in the theaters. Home video is competing directly with pay cable systems such as HBO, since the title won't hit cable for another six months.

Home video and cable TV are facing competition from another quarter as well. Small backyard dish antennas, connected to a home TV set, can pull down a vast number of satellite TV signals, including those of the cable networks. Satellite dish systems, which some observers think will be installed in 1.6 million American homes by 1990, can bring in as many as 50 to 100 channels, depending on location and now cost as little as \$2,000 to build.

Television American Style

Despite the vast cornucopia of TV options provided by cable and home video, the most frequently watched programs in America are still delivered by the three major commercial networks: ABC, CBS and NBC. To understand what these networks are, you must understand how the U.S. television system works.

The commercial television networks, which are privately owned corporations, receive their income from businesses and other organizations that pay to have their advertisements broadcast. Unlike cable TV, viewers pay no fee directly to the networks: Over-the-air (broadcast) TV is free to the viewer, except for the cost of the television set itself.

Producing and broadcasting TV programs are expensive, and the commercial networks compete fiercely to attract the most viewers to their networks. The bigger the audience—as measured by private research organizations—the more the network can charge for running commercials. The range can be enormous. In Boston, for example, the local NBC affiliate, WBZ-TV, which broadcasts 24 hours a day, will charge advertisers approximately \$150 for a 30-second advertising spot between 2 a.m. and 5

■ ■ ■ *"This vast cable TV bonanza is just half the story.... The most revolutionary device to hit home entertainment since the television set first became popular in the 1950s...is the briefcase-size videocassette recorder, or VCR."*

Left, Bill Cosby (center) and members of his television family prepare for a scene in the popular situation comedy, *The Bill Cosby Show*, currently the most popular TV series on the air. From *I Love Lucy* in the '50s through *All in the Family* in the '70s, family comedies like *Cosby* have had widespread appeal for American TV audiences.

a.m., when only a few late-night viewers are watching. On Thursday nights, however, the station charges as much as \$18,000 for 30 seconds of advertising. Why? Because hundreds of thousands of Boston-area households are watching the nation's current top-rated program, *The Bill Cosby Show*.

Television's popularity means that it is an effective way to reach large numbers of viewers, so American business annually spends more than \$8.5 thousand million advertising on the three networks. Most U.S. TV shows have about 10 minutes per hour of these little sales pitches; the average American household receives about one hour per day of commercials, according to the Television Bureau of Advertising.

There is an alternative, however. The Public Broadcasting System (PBS) is a non-commercial network supported by governmental grants and private donations. PBS delivers educational, public affairs and cultural programming, such as the daily *McNeill/Lehrer News Hour*, the innovative children's program, *Sesame Street*, and the weekly drama series, *Masterpiece Theater*, to a skein of 300 stations across the nation, many of which are run by universities. About 40 percent of PBS's total budget comes from state and federal governments, supplemented by corporate contributions and by individual donations that are solicited during periodic on-the-air fund drives.

Although the government supports PBS financially, it plays no role whatsoever in PBS's news coverage and programming decisions. The chief distinction between PBS and the commercial networks is that PBS does not need to attract advertising by delivering mass audiences for its broadcasts. For more than 135,000 viewers a year, PBS programs can be part of their college curriculum. In 1986, for example, PBS series on physics (*The Mechanical Universe*) and language (*The Story of English*) were two of a number of broadcasts for which busy, part-time students could receive academic credits at one of more than 1,000 colleges.

So what are the most popular shows in the U.S. today? What do Americans watch? First on the list—in Boston and throughout the country—is a comedy about a black physician and his family—*The Bill Cosby Show*. Each week, one out of every three American homes tunes in to watch this half-

hour situation comedy starring Cosby, a veteran comedian and actor.

Over the years, situation comedy (i.e. where the jokes are anchored in a humorous, real-life situation) has proven to be the most popular and durable TV format in the U.S. Two of the top four most popular shows of all time have been situation comedies. In the mid-1950s, *I Love Lucy*—a situation comedy about a zany redhead (Lucille Ball)—dominated the ratings. In the 1970s, *All in the Family*, an often controversial comedy about prejudice and conflict between the generations, was number one for an unprecedented five straight television seasons.

The other two most popular shows in past decades have been *Gunsmoke*—a western airing in the late 1950s and early 1960s, and a TV "news magazine" called *60 Minutes*, specializing in controversial issues and hard-hitting investigative reports, which debuted in 1968 and is still on the air.

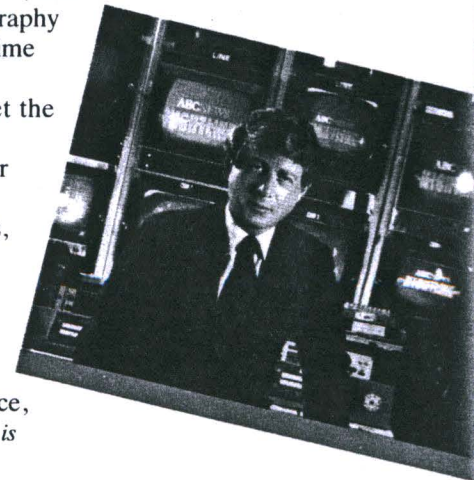
In addition to *Cosby*, so-called adult soap operas continue to be popular in primetime: *Dallas*, *Dynasty* and *Falcon Crest*, which revolve around wealthy families who battle each other for money, power and love. Even their most ardent fans, however, would agree that such shows are quintessential escapist entertainment.

Police dramas are another enduring favorite of American television; two of the most popular in recent years have been *Hill Street Blues*, which traced the intertwined lives, on-duty and off, of police officers in an inner-city precinct; and *Miami Vice*, featuring two detectives in Miami, Florida. The stylized film sequences of *Miami Vice*, sometimes done in slow motion to rock music, reveal the unmistakable influence of MTV; and in turn, *Miami Vice*'s polished cinematography has influenced the look of other prime-time television shows.

Since cable TV and home video get the theatrical movies first, the networks produce their own movies especially for television—132 of them in 1985. These movies range from dramas to comedies, but one of the most popular types is dramatization of current controversial topics. The networks, for example, have shown movies, such as *A Time to Live* on coping with muscular dystrophy, *Picking Up the Pieces* on divorce, *This Child is Mine* on adoption and *Love is*

■ Seeing the News

News programs are a staple of the American television diet. Each evening, viewers can watch half-hour news programs broadcast nationally by the three major networks, CBS, NBC and ABC, usually complemented by an additional hour or more of local news coverage. Americans can also wake up to morning news and interview shows, or monitor the news 24 hours a day on the Cable News Network (CNN). In addition, the Public Broadcasting System (PBS) presents a one-hour daily newscast, plus a host of public affairs programs that provide in-depth examinations of current issues. Below, Ted Koppel, the anchor for ABC's *Nightline*, uses satellite television to broadcast live interviews and debates among newsmakers in cities scattered throughout the country and around the world. Five nights a week, from 11:30 p.m. to midnight, Koppel, based in Washington, D.C., introduces a topic, then, using the instantaneous reach of satellite communications, switches to officials or experts in locations stretching from Manila to Mexico.





Televised sports enjoy enormous popularity in the U.S. College basketball (shown above) draws as many as 50 million viewers during the tournament that determines the number one college basketball team in the nation. And the single program that annually attracts the largest number of TV watchers is another sporting event—the American football “Super Bowl,” played each January between the country’s two top-rated professional football teams. With ESPN, enthusiasts even have a 24-hour cable channel devoted exclusively to sports ranging from tennis to ice hockey and auto racing.

Never Silent on deafness. Miniseries—dramas whose episodes extend from three to five days or more—are another TV staple; the most popular miniseries of all time is *Roots*, which traces the history of a black American family all the way back to Africa.

TV News

Television’s timeliness and impact make it an extremely vital means of transmitting the news. Every evening at 6:30 or 7 p.m., the three commercial networks each deliver a 24-minute fast-paced series of highly compressed national and international news stories. (PBS presents a slower-paced evening news hour, with reports supplemented by in-depth interviews.) A well-known journalist—backed by sophisticated computer graphics illustrating the event—introduces correspondents who deliver quick news segments—generally ranging from one to three minutes in length. Americans can also wake up to television news and features, with a choice of NBC’s *Today Show*, ABC’s *Good Morning, America* and *The CBS Morning News*. For cable viewers, however, national news is available around the clock with CNN.

In addition, local TV stations deliver one to three hours a day of local news tailored to the individual community. These focus on local city government, weather, sports and features on local newsworthy citizens.

Americans may sometimes criticize TV news for its superficiality, but they also rely upon it as an objective source of information that is uncensored by the government in any fashion; news accounts that report criticisms of government actions are so common as to be unremarkable. Virtually the only government regulation of television is through the Federal Communications Commission, which licenses TV stations to use certain broadcast frequencies. The FCC has consistently issued rulings to foster competition and to prevent any one communications company from becoming too powerful. No company, for example, can own TV stations reaching more than 25 percent of American households; and a newspaper publisher cannot own a TV station in the same market. If companies misuse their license, the FCC can decide not to renew it—a power that it rarely has to exercise.

As for program content regulation, the government’s input is again relatively minimal. It forbids obscene material and has traditionally tried to promote fairness in handling public issues, with rules generally requiring that opposing viewpoints be aired on controversial subjects. The “equal time” provision requires that candidates for public office of opposing political parties be given equal opportunities to air their opinions.

One of the most innovative news programs is Ted Koppel’s *Nightline*—a high-tech example of global telecasting. Every night at 11:30 p.m., *Nightline*—often by means of satellites—connects opposing speakers in a brilliantly modulated debate on the day’s hottest topics. In February 1986, for example, *Nightline* put Corazon Aquino and Ferdinand Marcos—the current and former leaders of the Philippines—on the same show; in March 1985, it put South Africa’s foreign minister, R.F. Botha, on the same show with black South African leader and Nobel Peace Prize winner, Bishop Desmond Tutu.

Television and the Public

Television in the U.S. serves as a laboratory for democracy—providing an uncensored forum for differing opinions. In one sense, the whole television system is one vast example of democracy in action. Viewers—voting with their channel selectors—decide what airs on American TV. For the big three commercial networks—ABC, NBC, CBS—the size of the audience determines whether a show survives or not, since the audience determines the rate that they can charge for advertising. Cable television is also concerned with attracting viewers, but with dozens of channels available, they can seek out smaller audiences with more specialized interests, whether news, sports, or cooking and gardening shows. PBS, without such commercial constraints, can provide high-quality cultural programs and serious investigative reports, even though some lack wide popular appeal.

Added together, the American viewer today can choose from a vast and varied selection of television programs for news, entertainment and information.



Richard Zacks writes a weekly column on home video for the New York Daily News that is syndicated in newspapers across the country.

RESERVING THE GREAT AMERICAN VACATION

By Don Picard

■ Bill and Ellen, who live in the midwestern city of Minneapolis, Minnesota, had a problem. With their two children, Mark, eight, and Denise, six, they had just begun a vacation in San Francisco, California, on the West Coast, nearly 3,000 kms from Minneapolis. But Bill's father, who lives in Raleigh, North Carolina, on the East Coast, suddenly had to leave on a lengthy trip out of the country. Was there any way that the family could change its vacation plans immediately and visit him?

Ellen was upset because she had planned this vacation for months, poring over maps and guidebooks for the state of California. "What about Mark and Denise?" she asked. "They'll be terribly disappointed. They were looking forward to seeing Disneyland in Los Angeles."

"They won't be," Bill promised. "Instead of seeing Disneyland, we'll drive down to Disney World in Orlando, Florida. It's only a two-day drive from Raleigh."

Promising was one thing; accomplishing another, Bill knew. It was December, a month when many Americans travel to other parts of the country on vacation or to see relatives for the Christmas holidays. The airlines would be busy and many hotels would be completely filled.

Bill's and Ellen's vacation had been booked by AAA (American Automobile Association), the largest travel agency in the United States. And that's where he turned for help to reschedule his family's trip.

AAA maintains a 24-hour-a-day travel service center in Falls Church, Virginia, so Bill dialed them immediately and discussed his needs with an AAA travel counselor, Marcy Jacobs. Bill could hear the clicking of computer terminal keys over the phone as Marcy queried the computer system to see what was available.

"Okay," said her friendly voice over the phone five minutes later. "I have you and your family scheduled on a United Airlines flight out of San Francisco at 11 a.m. this morning. You'll change flights in Atlanta (Georgia) to a Delta Airlines flight and be in Raleigh at 8 p.m. tonight.

You're booked into the Raleigh Airport Holiday Inn for two nights.

"There will be a rental car waiting for you at the Raleigh airport, reserved for two weeks.

Marcy went on. "I've booked you for one night into a Marriot Hotel halfway to Orlando, but all the hotels in Disney World itself are full. However, the computer found a nice room available for 10 days at a Ramada Inn about 24 kms away. And I've reserved four seats for you on a direct flight to Minneapolis on Northwest Airlines leaving from Orlando."

"That's great," said Bill. "You've saved our vacation."

"Glad to help," Marcy said. "By the way, when you're driving to Orlando, will you need maps of the area?"

"Sure will," Bill said. "I've never been there before."

"Okay, I'll notify the AAA office in Raleigh to have a Triptik (a book of strip maps that shows a specific route), a packet of maps and TourGuide books ready for you when you arrive. Drop by their office anytime and pick them up. How are you planning to pay for the trip?"

"With a credit card," Bill said, and read her his plastic card number over the phone. Within seconds, Marcy was able to obtain a computer check of Bill's credit card number, ensuring payment. Bill, in turn, knew that he would receive an itemized statement from the bank which issued his credit card at the end of the month, after the trip was over. He could pay off the entire amount with a written check at that time, or pay only a specified portion of the bill. The bank charges interest on the remaining balance, which would be carried forward to next month's statement.

After he hung up, Bill and Ellen hugged each other. "It's still going to be a great vacation," he told her.

Bill Taylor's rescheduled family vacation came off without a hitch, thanks to a computer reservations system that permits travel agents to make reservations on virtually all major airlines, hotels and car-rental companies in the United States in minutes from one terminal located in their offices. These travel services are available to everyone, whether traveling for business or pleasure. All of these same services are available for international travel as

well—whether for completely independent travel in foreign countries, or so-called "package tours" that include air travel, hotels, meals and escorted sight-seeing expeditions.

America's 200 million air travelers can buy their tickets directly from the airlines, of course, but many choose the convenience of travel agents. Travel agents are not employees of the airlines, but independent business people whose income comes from commissions paid by airlines, hotels and car-rental companies for booking travelers who use their services. Most travel agents have terminals hooked into at least one of the country's major computerized reservations systems.

Two major systems account for more than 70 percent of all flights generated by travel agencies: American Airlines' Sabre and United Airlines' Apollo. Sabre is the larger, with more than 50,000 terminals in 10,000 travel agents' offices, and accounts for 45 percent of the market. Apollo accounts for 29 percent. Other airlines have equal access to the huge reservations systems, paying the two airlines a small fee for each reservation booked: 232 airlines are available on Sabre and 183 on Apollo. Both systems can book virtually all the major international airlines, plus smaller U.S. regional air carriers.

Because most major hotel and car-rental companies in the United States have their own computerized reservations systems linked with the airlines' systems, travel agents can also reserve hotel rooms and rental cars for travelers, finding out instantly which hotels have empty rooms and precisely what cars are available in what city. One of the attractions of renting cars is convenience: in the case of a breakdown, for example, the traveler simply calls the rental company for a replacement, or else the company reimburses the traveler for the cost of repairs. The Apollo system even permits travel agents to sell tickets to events across the country through a hookup with a national computerized ticket reservation system called Ticketmaster.



It takes a lot of computer power to operate national computerized reservation systems. Sabre runs on six mainframe computers in Tulsa, Oklahoma, in the Southwest. Apollo runs on eight mainframes in the western city of Denver, Colorado.

Recently, a smaller reservation system, PARS, operated by Trans World Airlines (TWA), made its services available to personal computer owners throughout the United States. Now people owning their own computers can make reservations from the comfort of their homes, letting the computer search out the lowest fares and most convenient schedules.

Computerization helps travelers in other ways, too. AAA, which has always provided free maps and guide books to its 25 million members, also provides a Triptik that not only lets auto travelers page through a series of maps that track their intended route, but indicates where detours and highway construction zones are located so travelers can avoid delays. AAA keeps its information up-to-date with a national network of reporters who call in information about road construction. AAA also has travel maps for Canada and Mexico, where Americans don't even need passports, but can drive across the borders with only positive proof of U.S. citizenship.

Americans have always cherished the freedom to travel about their country easily. With the advent of computerized reservations systems, it's easier than ever before to exercise that freedom.

Don Picard is a Minneapolis, Minnesota, free-lance writer who specializes in travel and computer-related subjects.

ONLINE: THE NEW

By Alfred Glossbrenner

■ Seven years ago I had an experience that changed my life. I was working with a fellow writer, Timothy R.V. Poster, on a film script about automotive and industrial tires. Both of us were using personal computers. Suddenly Tim stopped writing, stood up, and plugged one of the cables sticking out of the back of his computer into a small metal box about the size of a large book. "What are you doing?" I asked.

"Getting ready to go 'online,'" he said.

"To go on what?"

"Come here. I'll show you."

As I watched, Tim typed a telephone number on his computer keyboard. I heard the sound of a telephone dialing and noticed that some of the lights on the little metal box had begun to blink. Next I remember seeing the words "Welcome!" appear on his screen. He typed a few more words, and like magic the latest industry production figures for automotive tires began to march up the screen.

What in the world was going on? I had to find out.

Welcome to the Electronic Universe

What I discovered was a field I quickly christened "the electronic universe." This universe exists just beyond the display screen of every computer. It is a place where messages streak across the continent or around the globe at the speed of light. It is a place where you encounter scores of interesting people you would never have met

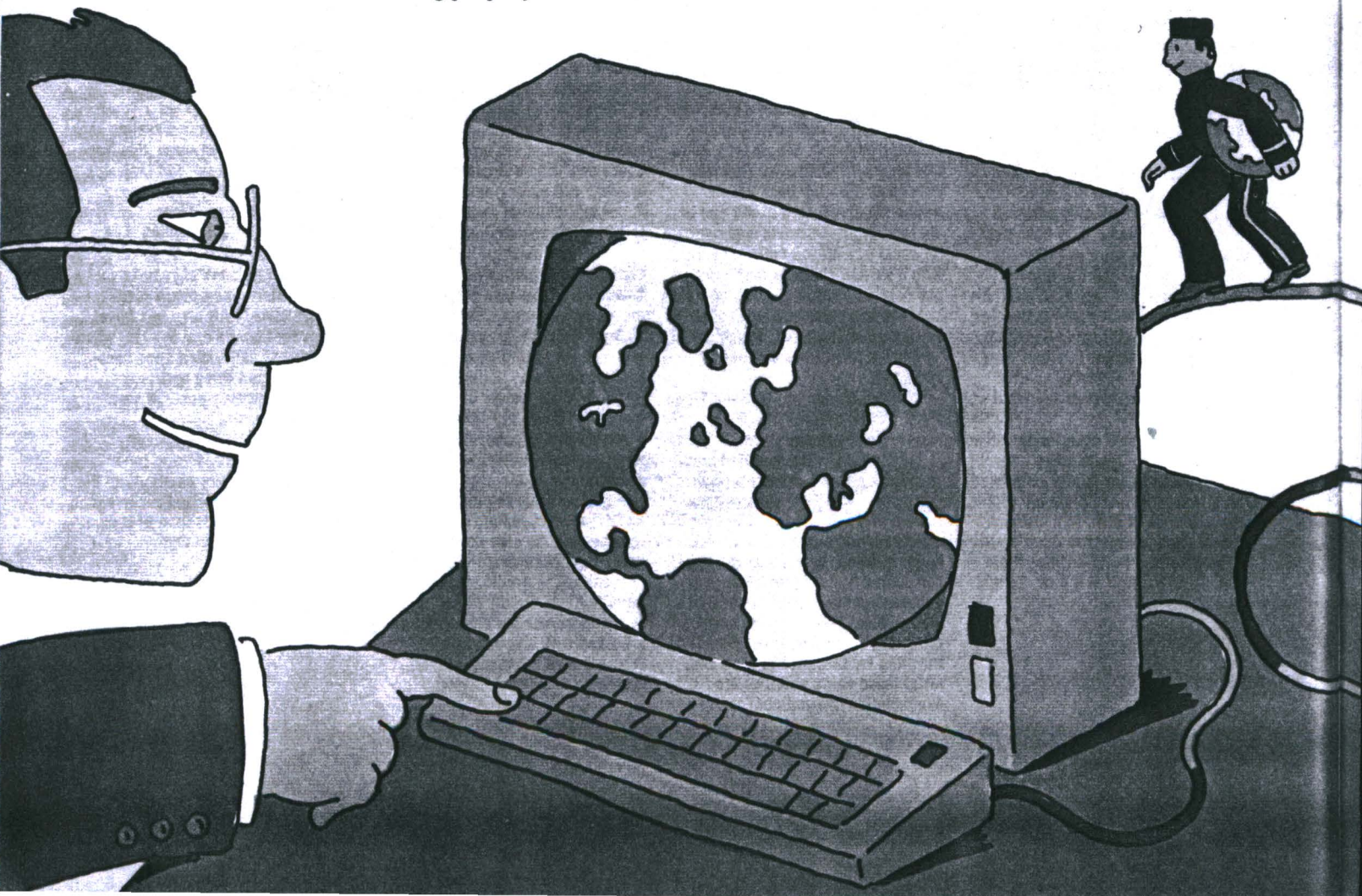
any other way. And it is a treasure house of information that gives you access to vast portions of mankind's collected knowledge—instantly, at any time of day or night, from any location in the world.

In short, the electronic universe is a realm of infinite possibilities destined to forever change the way we live, work and play. But most important of all, it exists today, and it's open to anyone with a personal computer and a telephone.

Computer Talk

The entire electronic universe is founded on a few simple concepts. The first is that computers can "talk on the telephone." To do this, however, they need an additional piece of hardware called a "modem," which is short for "modulator/demodulator." Its job is to translate a computer's internal signals into sounds that can be sent over the telephone lines, and vice versa.

You also need the proper software. Literally hundreds of "communications programs" are available at prices ranging from \$12.50 to \$100. Communications



programs make sure that the letters you hit on the keyboard not only appear on your screen but also go to the modem, and conversely, that characters coming in through the modem appear on your screen.

So, whom can we call? The answer is: another computer.

The computer we call might be a refrigerator-size "mainframe," or it can be another PC sitting on someone's kitchen table.

Size doesn't matter. As long as you call a computer with access to a telephone, your machine can talk to it. This is the second basic concept: Any computer, of any size, anywhere in the world can be equipped to talk to any other computer.

Once you are connected, there are two basic things you can do. First, you can transmit information from your computer to the receiving, or "host" system. You might do this by typing a command like FIND AUTO-MOBILE TIRES AND PRODUCTION, or simply a request for HELP. You simply tell the computer the name of the file you want to transmit, and it will locate it on your computer's disk and send it to the host system. This process is called "uploading."

The second thing you can do is exactly the reverse, or "downloading," in which you can ask the host system to send information to you. For example, you might enter a command that tells the host system to search through its files for information on SYNTHETIC RUBBER PRODUCTION. If the host system's storage devices contained a file on that topic, you could order the host to transmit the file to you.

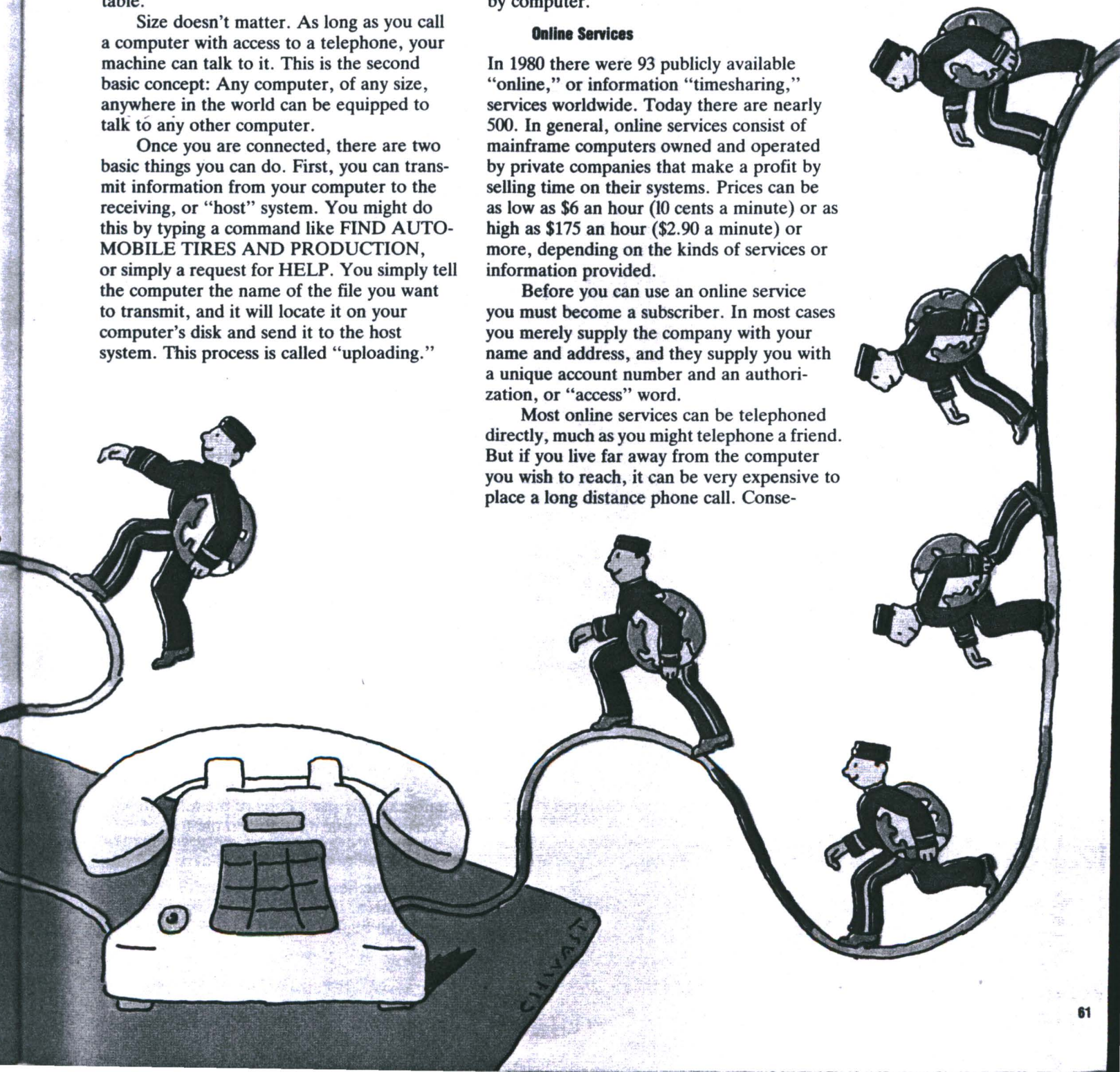
With the exception of a few operating details, that's all there is to communicating by computer.

Online Services

In 1980 there were 93 publicly available "online," or information "timesharing," services worldwide. Today there are nearly 500. In general, online services consist of mainframe computers owned and operated by private companies that make a profit by selling time on their systems. Prices can be as low as \$6 an hour (10 cents a minute) or as high as \$175 an hour (\$2.90 a minute) or more, depending on the kinds of services or information provided.

Before you can use an online service you must become a subscriber. In most cases you merely supply the company with your name and address, and they supply you with a unique account number and an authorization, or "access" word.

Most online services can be telephoned directly, much as you might telephone a friend. But if you live far away from the computer you wish to reach, it can be very expensive to place a long distance phone call. Conse-



quently, most services are connected to one or more special lower-cost telephone networks that are specifically designed for computer communications. These are called "data networks." Two of the leading world-wide networks are Telenet and Tymnet.

Because computers are able to use telephone lines and equipment more efficiently than people, it is usually cheaper to use the data networks than to use the conventional voice networks when you go online. Most important of all, even if the host computer is thousands of kilometers away, the cost of using a network to reach it is essentially the same. Distance doesn't matter. For example, MCI Mail's computer is located in Washington, D.C., a city 240 kilometers south of my home outside of Philadelphia, Pennsylvania. When I call MCI, a major U.S. telecommunications company, I use the Tymnet data network at a cost of \$3 an hour (5 cents a minute). A person using Tymnet to call MCI from Seattle, Washington, on the west coast of the U.S., would be charged the identical rate, even though Seattle is over 3,720 kilometers away.

Data network calls that cross international borders are more expensive, but they are almost always much less expensive than voice calls involving the same locations. This means that for both national and international communications, using a computer can be cheaper than placing a voice call.

Person-to-Person Communications

Now let's look at the first of the two major segments of the electronic universe: person-to-person communications. We'll start with what is called "electronic mail," or "E-mail," for short.

I subscribe to a variety of online systems that offer electronic mail services, including The Source (TCS772), MCI Mail (AGLOSSBRENNER), and CompuServe (70065,745). The letters and numbers are my account numbers on those systems and they serve as electronic mailbox addresses. These numbers are published in my books, and over the years I have received literally hundreds of electronic letters from readers in the U.S. and all over the world (France, Australia, Switzerland, Argentina, among other countries).

I enjoy meeting people online, but I also use these systems professionally. In my case, they are particularly useful for corresponding with magazine editors and for delivering finished articles to them. For example, I recently finished an article for a magazine whose editor lives in a small town in Vermont. To deliver it from the computer I wrote it on, I dialed my local Tymnet number, connected with the MCI Mail system in Washington, D.C., and signed on with my account number and password. I then entered a few commands to tell MCI Mail that I wanted to send E-mail, keyed in my editor's MCI Mail address, and told my computer to upload the article from my disk. The process took about two minutes.

The MCI Mail mainframe stored the article in a file under my editor's name. When he signed on to the system later the same day, the system automatically told him that there was mail waiting for him. He could then easily download my article to his own system.

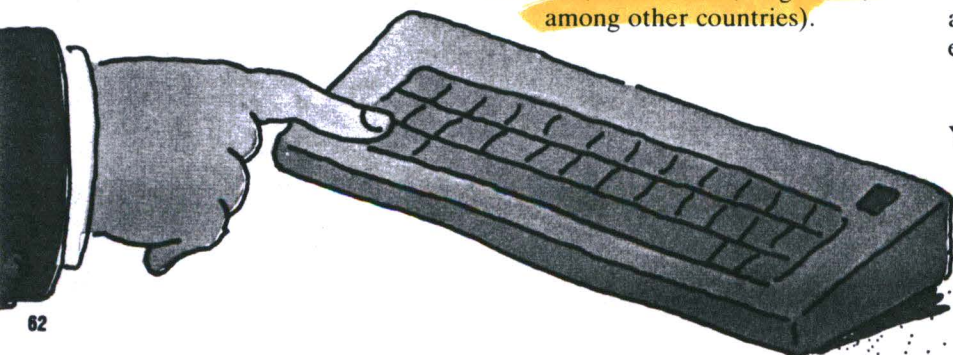
After my editor has downloaded the article, he can edit it with a word processing program, then transmit the article from his Vermont home to the magazine's offices in Boston. In Boston, his associates can transmit it to a computerized typesetting machine to produce the magazine.

Thanks to computer communications, I can have more time to work on an article and still meet my deadline; my editor can do much of his work without traveling to his office; and the magazine staff can produce typeset copy much faster. Portions of my draft may change along the way, but at no time does anyone ever have to sit down and re-type the entire article. The savings in time and money are enormous.

Electronic mail will never replace the conventional paper-based mail system or the telephone. But it does give you new options. For example, consider the idea of electronic mailing lists. On most E-mail systems it is as easy to send an electronic letter to 100 people as it is to send it to one person. First, create a list of E-mail addresses, or account numbers; give the list a name; upload your letter; and the system will automatically put a copy of the letter in every electronic mail box on the list.

Computerized Conferencing

You're the head of a committee of scientists. Everyone on the committee can benefit from the knowledge,



experience and comments of everyone else. But imagine if you could conduct an on-going electronic meeting in addition to personal conferences.

The answer is a computer system—linked by telephones and modems—in place of a conference table. I might sign on in the morning and see a comment that you had uploaded last night. I could type in my response and sign off. An hour later someone else might sign on, see both your comment and mine, and make a statement of his or her own. And so on. Everyone is “together” but no one has to travel anywhere. Furthermore, participants can add comments and review what others have said when it is convenient for them to do so.

Data Bases

A data base is a discrete collection of information in computerized form. For example, it could be a list of every book in a library, or it could be a list of every article dealing with mathematical research published in over 1,600 journals worldwide. There is simply no limit to the kinds of information a data base can contain, or the subjects that data bases can cover.

Most of the approximately 3,000 data bases worldwide are produced by private companies. These companies decide what their data base should contain, and they are responsible for collecting the information, putting it into computerized form, and keeping the data base current.

Copper Bolts in Ohio

Although it is a relatively simple process, online information retrieval can be an enormously powerful tool. For example, a reference work called Thomas Register of American Manufacturers contains listings for over 135,000 U.S. companies. The printed version occupies 20 volumes, but the entire publication is also available on the computerized service, DIALOG, as the Thomas Register Online data base.

Now suppose that for some reason I'm interested in bolts. But not just any kind of bolts. I want copper bolts, and if possible, I want to buy them from a company in Ohio. I can either go to my local library and page through the printed Thomas Register, looking for copper bolt manufacturers and copying down any who happen to be located in Ohio. Or I can search for the information “online.”

If I were to go to the library, I doubt that I could complete the job in under an

hour—if a library is nearby. By going online instead, I was able to obtain the information in less than three-and-a-half minutes, without ever leaving my home office. I simply signed onto DIALOG, selected Thomas Register Online, and entered a command that said, in effect, ‘Are there any copper bolt manufacturers in Ohio?’

The system then told me that there were a total of 10,123 companies listed for Ohio, but my online search revealed only four companies located in the state whose products included copper bolts. Here is part of the entry for the first company on the list:

ATWOOD INDUSTRIES, INC.:

Products: Abrasives.

Bits—carbide tipped.

Bits—diamond drill.

Blades—saw.

Bolts—aluminum.

Bolts—brass and bronze.

Bolts—copper.

Bolts—corrosion resistant.

The Expanding Electronic Universe

It is important to point out that the electronic universe is not without its problems. Sometimes data base producers do not update their products as frequently as they should; other online systems seemingly take forever to respond to a single command. In addition, despite the simplicity of the concept, no one would argue that the search for information is easy. It can be difficult, for example, to locate the data base most likely to contain the information you seek.

On the other hand, the electronic universe is still quite young. For all practical purposes, it is only a decade old, and like our own physical universe, it is constantly expanding. According to Cuadra Associates, publisher of an authoritative directory of data bases, an average of three new data bases becomes available online each business day.

There is every reason to believe that this trend will continue. Indeed, I have long been convinced that in the future, communications and online information retrieval may well be seen as the single most important result of the revolution in personal computers. Indeed, the electronic universe holds as yet unimagined possibilities.

Alfred Glossbrenner is the author of The Complete Handbook of Personal Computer Communication.

Facts Online

A few years ago, Julia Stam quit her office job as an administrative assistant and started her own business at home in the Chesapeake Bay town of Annapolis, Maryland. She bought a computer, attached it to her telephone through a “modem”—and instantly gained access to a universe of information available through data bases in the U.S. and around the world. She calls her business Facts Online, and she will seek out most any piece of information for her clients at the rate of \$25 an hour plus expenses. The data bases that she taps into are as varied as the questions she is asked: DIALOG, the Educational Resources Information Center (ERIC) and the National Technical Information Service (NTIS) are frequent sources; she can also use “gateway” services that allow users to check as many as eight different commercial data bases at one time without subscribing to each individual service. Sitting before her terminal at home, Stam has found answers to such inquiries as these:

—An author writing a historical novel wanted to know how 17th-century Puritans in colonial New England disciplined wayward members;

—A medical student requested references to the obscurely named Hirschsprung's disease;

—A neighbor was thinking of moving to a small town in Pennsylvania and wanted information on its population, job opportunities and schools; and

—A researcher needed information on the side effects of the popular no-calorie sugar substitute, aspartame.



GLOSSARY

ACCESS: The process of obtaining information from a computer, or obtaining instructions in the computer's operation.

ANALOG SYSTEM: A device that uses one kind of physical property to represent another. Contrasts with digital system. Example: The hands of a clock are the analog for the passage of time.

ARTIFICIAL INTELLIGENCE (AI): The capability of a computer program to perform functions that are normally associated with human intelligence, such as reasoning, learning and decision-making.

AUTOMATED TELLER MACHINE (ATM): Computerized machine, usually part of a financial institution, that dispenses money or personal account balances to an individual via a plastic encoded card which the user inserts. The ATM automatically adjusts the individual's account as it completes the transaction and prints out a receipt showing the new account balance.

BAR CODE: Also known as a Universal Product Code (UPC). A standardized system of lines representing 10-digit numbers used on commercial packages, such as bottles, boxes and other merchandise, so they can be identified by an optical scanner at a checkout stand.

BINARY: Numerical system using only the digits 0 and 1. The binary system provides the basis for all computer operations. Binary numbers are especially suitable for use in computers since many electrical devices have two distinct states: on and off. All numbers can be represented by various combinations of ones (on) and zeros (off). For example, the number 5 is represented by 101; 6 is 110. A standard code has been developed for representing letters of the alphabet as binary numbers; using this approach, the letter "A" is the binary version of "65."

BIT: Short for binary digit — represented as either 0 or 1. The smallest unit of information stored in a computer. See also BINARY.

BUG: A mistake that occurs in a computer program or in a computer's electrical system.

BYTE: An eight-bit sequence of binary digits. Each byte corresponds to one character of data such as a single letter, number or symbol. Bytes are the standard unit for measuring computer and disk storage capacity. Most computers have their storage of information organized in units of one, two, four or eight bytes (8, 16, 32 or 64 bits).

CABLE TELEVISION: The transmission of television signals via a cable instead of broadcast over the air. Cable TV systems typically sell a package of over-the-air TV channels and specialized TV channels, which they deliver to homes and communities for a monthly fee.

CAD - COMPUTER-AIDED DESIGN: Computer programs that permit the detailed three-dimensional creation of objects on the computer screen. The designs can then be manipulated, rotated or otherwise changed to determine how they will function. Example: Designing a bridge on a computer screen, then using the computer to simulate stresses such as high wind and heavy loads to determine the strength of the design.

CAM - COMPUTER-AIDED MANUFACTURING: Automated control of machines using computers. Example: Automated robots fitting parts onto a machine.

CELLULAR PHONE: Cordless telephone system that provides much greater range, flexibility and capacity than conventional radio telephones. A cellular telephone call travels through a limited geographical area, called a "cell," where it is "handed off" to the adjoining cell by computers that automatically select the best frequency. The process is virtually instantaneous, with no discernible time lag to the caller. Cellular phones can be used in automobiles, boats, or simply outside in one's backyard.

CENTRAL PROCESSING UNIT: Also known as CPU. Coordinates and controls all units of a computer and performs arithmetic and logical processes to be applied to data.

CHIP/MICROCHIP: See INTEGRATED CIRCUIT.

CIRCUIT: A circuit is a complete path for an electric current. Electrons will flow from the negative power-supply terminal through a conducting medium to the positive power-supply terminal.

COMPACT DISK: A means of storing and playing back sound and music, similar to a phonograph record. Unlike a conventional record, however, a compact disk stores sounds digitally, as a sequence of numbers, which are read by a laser beam instead of a stylus. As a result, compact disks are capable of extremely high quality sound reproduction, and resist the scratches and hisses associated with phonograph records.

COMPUTER: A machine which can accept data in a prescribed form, process the data, and supply the results in a specified format as information or as signals to control automatically some further machine or process. A distinguishing feature of a computer is its ability to store its own instructions.

COMPUTER LANGUAGE: A language which enables a programmer to write instructions for a computer. A compiler then translates programs written in a computer language into specific machine instructions.

CPU: See CENTRAL PROCESSING UNIT.

CURSOR: Symbol on the computer monitor that marks the place where the operator is working.

DATA BASE: Body of information or data stored in a well-organized format. A data base management system is a program that keeps the data up-to-date and allows access to information.

DENSITY: Amount of data that can be stored on one sector of one track of a disk.

DESKTOP COMPUTER: See MICROCOMPUTER.

DIGITAL: The process of storing and representing information in the form of numbers. In the case of computers, a digital system represents information as a series of discrete "bits," or binary numbers. See also BINARY.

DIGITAL COMMUNICATIONS: Information transmitted in a digital format, i.e., as a stream of numbers.

DISK: A magnetic disk is a computer memory device. Large computers store information on large disk packs consisting of several disks joined on one spindle. Microcomputers use floppy disks (diskettes) or hard disks. A floppy disk, which is made of more flexible material than a hard disk, looks like a small phonograph record, but is covered with a magnetic coating and encased in a square covering of plastic. Floppy disks are designed to be inserted and removed from the computer, but a hard disk is generally installed in the computer permanently.

DISK DRIVE: A device that enables a computer to read and write data on disks.

ELECTRONIC MAIL (E-MAIL): Transmission of documents by computer over cables or phone lines.

EXPERT SYSTEM: A software system that incorporates the step-by-step chain of reasoning used by experts to analyze problems in a specific field. In designing such software, the computer programmer consults a number of experts to achieve a synthesis of the problem-solving approaches they consider most reliable.

FIBER OPTICS: The technology of guiding and projecting light for use as a communications medium. The hair-thin glass fibers which allow coherent light beams, or laser light, to be bent and reflected are known as optical fibers.

FILE: A logical group of pieces of information labeled by a specific name, considered a single unit by the computer.

FORMAT: The arrangement or layout of data on a data medium.

GEOSTATIONARY/GEOSYNCHRONOUS-ORBIT SATELLITE: Satellite in orbit 35,880 kms above the equator which revolves around the earth with a velocity equal to that of the earth's rotation on its axis. The satellite therefore appears stationary above a fixed point on Earth.

HARDWARE: The physical components that make up a computer.

HOLOGRAM: An image created by a laser which gives the illusion of having three dimensions.

HOST COMPUTER: In a network, a computer that primarily provides services such as computation, data base access or special programming.

INFORMATION RETRIEVAL: A method for cataloging vast amounts of data using a computer, so that one can call up any or all of these data at any time.

INTEGRATED CIRCUIT: An electronic device consisting of many miniature transistors and other circuit elements on a single chip. Synonymous with chip or microchip.

INTERFACE: The hardware or software necessary to connect one computer device or system to another, or to link the human user with the computer system.

KILOBYTE: Often abbreviated as "K." One of the most common measures of computer and disk storage capacity. A kilobyte is approximately 1,000 bytes. In the binary numerical system, the number is actually 2 to the power of 10, which is 1,024 bytes, or slightly more than one double-spaced typewritten page. See also BINARY and BYTE.

LASER: A device able to emit a tiny beam of concentrated electromagnetic energy in the visible light spectrum.

MAGNETIC DISK: A flat circular plate with a magnetizable surface layer on which information is recorded. See also DISK.

MAINFRAME: A large computer occupying a specially air-conditioned room and typically supporting 100 to 500 users at a time.

MEGABIT CHIP: A chip that can store 1,048,576 bits of data (about 100 double-spaced typewritten pages) on a slice of silicon less than 2.5 square centimeters. See also KILOBYTE.

MENU: Programs, functions or other choices displayed on the computer monitor for user selection.

MEMORY: The internal storage of information in the computer.

MICROCOMPUTER: Also known as desktop computer, personal computer or PC. A small complete computer system, whose central processing unit (CPU) consists of a single integrated circuit known as a microprocessor.

MICROELECTRONICS: The technology, using semiconductor materials, which permits development of very small devices requiring electronic circuits.

MICROPROCESSOR: A chip which contains all of the logic circuitry of a computer's central processing unit (CPU). One of the principal components of the microcomputer.

MICROWAVE: Very short radio waves. Microwave transmission systems operate in the region of the radio spectrum between 3 and 30 gigahertz.

MINICOMPUTER: An intermediate computer system having a capacity greater than that of a microcomputer, but less than that of a mainframe or supercomputer.

MODEM: Short for "modulator-demodulator." A device that modulates or demodulates transmitted signals from one computer to another, used in connection with transmissions over telephone lines, coaxial cables, fiber optics or microwaves.

MONITOR: The TV-like screen on which the information from the computer appears and can be read. Also referred to as a video display terminal (VDT).

MOUSE: A small hand-held device connected to a computer via a cable. When moved on the surface of a desk, the mouse controls an arrow or cursor on the monitor, permitting the operator to carry out a variety of computer functions.

MULTIPROCESSOR: A computer system with more than one central processing unit (CPU).

NETWORK: Generally refers to a communications system — such as telephone lines, satellites or microwave relays — linking several different locations. Networks enable individuals, computers and electronic data sources to work with each other in carrying out various kinds of information exchange, computations and analyses.

ONLINE: User's access to a computer via a terminal. Also, part of a computer is online if it is directly under the control of the central processor.

OPTICAL DISK: See VIDEODISK.

OPTICAL SCANNER: A special optical device that uses a laser beam to scan printed material, which then can be stored in a computer as written or printed data. One of the most widespread uses of optical scanners is to read bar codes printed on packages in grocery and other retail stores. See also BAR CODE.

PARALLEL PROCESSING: The carrying out of computations simultaneously in a computer system having more than one central processing unit (CPU).

PC/PERSONAL COMPUTER: See MICROCOMPUTER.

PHOTOCOPIER: A device for photographically reproducing written, printed or graphic material. See also XEROX.

PIXELS: Any of the small discrete elements that together constitute an image (as on a TV or video screen.)

PRINTER: A computer output device that, when attached to a computer, will produce printed copy on paper.

PROGRAM/PROGRAMMING: Coded instructions telling a computer how to perform a specific function and designing those instructions.

PROGRAMMER: The person who prepares a set of instructions for solving a given problem by computer.

PULSE CODE MODULATION: A technique for converting an analog signal, such as voice, into digital "bits," or streams of numbers, for transmission. See also DIGITAL.

RAM - RANDOM ACCESS MEMORY: RAM is a data storage system that enables the computer to find any one storage location as quickly as any other location. RAM contrasts with other systems in which the computer has to search its memory in some particular sequence, such as the order in which data were entered. RAM generally refers to information and instructions that can be deleted and revised.

ROBOTICS: An area of artificial intelligence applied to the industrial use of robots doing repetitive tasks.

ROM - READ-ONLY MEMORY: A type of computer storage, or memory, whose contents do not change and cannot be altered. A computer's basic operating instructions are usually ROM.

SCROLL: Using the cursor to go up or down on the computer screen.

SEMICONDUCTOR: In materials called conductors, such as copper, electricity flows easily; in so-called insulators, like glass, the flow of electricity is blocked. On the other hand, partial conductors of electricity, such as silicon, selenium and germanium, are termed semiconductors. When processed in certain ways, semiconductors such as silicon can be made to carry positive or negative electrical charges in a highly controlled manner. Semiconductors are cheap, powerful, reliable and adaptable to a wide range of functions in computer and telecommunications technology.

SOFTWARE: The programs or sets of instructions that enable the computer to perform various functions.

SUPERCOMPUTER: Refers to the largest computers in terms of size, speed, cost and complexity. Modern supercomputers can perform millions of calculations per second and display the results instantly in dynamic graphic displays that simulate reality. Examples: modeling the formation of a thunderstorm, or the structure of a complex biological molecule.

SYNTHESIZER: A machine having a simple keyboard and using solid-state circuitry to duplicate the sounds of musical instruments and also the human voice.

TELECOMMUTE: Using a computer in an employee's home to link-up with his or her company's mainframe computer, instead of physically going to the company office to use the computer.

TERMINAL: A device capable of receiving and/or transmitting information over communication lines. Pertaining to computers, a work station away from the main computer that allows several users to have access to a single, mainframe computer.

TIME-SHARING: A method allocating the use of a computer facility among a number of operators by interleaving their use in rapid succession so that each appears to have simultaneous use of the facility.

TRANSISTOR: A small, low-power amplifier or oscillator which has replaced the vacuum tube by using electrical properties of certain materials, called semiconductors. Integrated circuits contain varying numbers of transistors. See also INTEGRATED CIRCUIT.

UPC: Universal Product Code. See BAR CODE.

UPLOAD: To send a file from a small computer to a "host" computer.

USER FRIENDLY: Hardware or software designed to help people learn about, and work easily with computers.

VACUUM TUBE: An electronic component consisting of electrodes placed inside a glass tube from which the air has been removed. Vacuum tubes work by using electric and magnetic fields to control the movements of electrons emitted by one of the electrodes. Vacuum tubes have been replaced by transistors and integrated circuits in modern computer and telecommunications equipment.

VCR - VIDEOCASSETTE RECORDER: An electronic apparatus that can be connected to a television set to record TV programs on videotape cassettes or for viewing previously recorded TV programs or commercial films that have been released on videotape cassettes.

VIDEODISK: Plastic-coated aluminum disk that stores and plays back high-quality images and sound, using the same digital technology as audio compact disks. The images are etched onto the surface of the disk in the form of microscopic pits, "read" on a special videodisk player by an enclosed laser beam passing over the surface, then displayed on a video monitor. Videodisks, also known as optical disks, can store enormous amounts of information — up to 54,000 color images on one side, and are used for computer storage as well as for video recording. See also COMPACT DISK.

VIDEOTAPE CASSETTE: A compact case enclosing a length of magnetic recording videotape that runs between two reels. The videotape cassette is put into the VCR to record TV programs for later viewing or to show previously recorded TV programs or commercial films that have been released in this form.

WORD PROCESSOR: A text-editing program or system that allows electronic writing and correcting of articles, books, etc.

XEROX: A trade name frequently used to refer to all types of photocopying equipment.