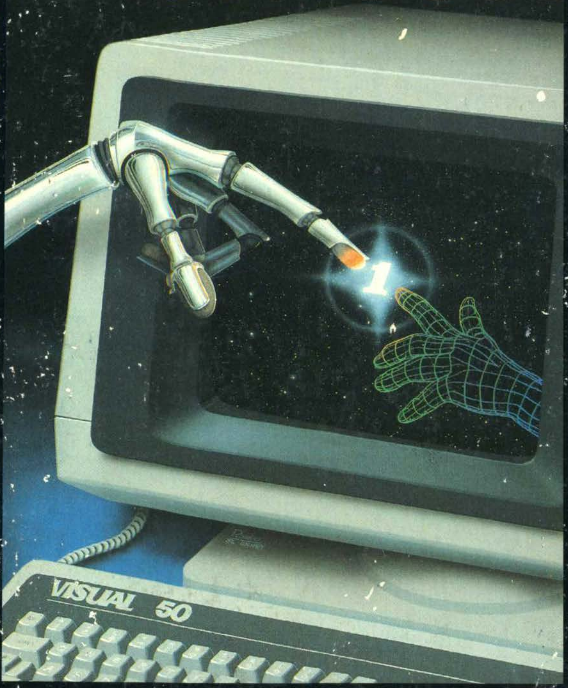
From the interface between man and machine rise...

The Silicon Gods



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William F. Hamilton III
10-27-84

HARDWARE, SOFTWARE . . . AND JELLYWARE

Jellyware, of course, is us. People. A human being is a computer running a computer, plus a whole lot more.

The action of the future is going to take place in the *human-computer* system, not just more and better hardware and software. Hardware is in continual progressive development. Jellyware isn't. The system must continue to operate with *Homo sapiens* Mark One for a long time to come.

Jellyware therefore isn't going to change in any physical manner, but the way jellyware operates or self-programs itself *will,* because of computers. There are serious forecasts by respected scientists who believe that human beings are creating their own evolutionary successors.

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The Silicon Gods

G. Harry Stine

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TO:
Dr. William B. McGrath

"First get it through your head that computers are big, expensive, fast, dumb adding-machine-typewriters. Then realize that most of the computer technicians that you're likely to meet or hire are complicators, not simplifiers. They're trying to make it look tough. Not easy. They're building a mystique, a priesthood, their own mumbo-jumbo ritual to keep you from knowing what they—and you—are doing."

—Robert Townsend
from "Up the Organization"
Alfred A. Knopf, Inc.,
New York, 1970.

CHAPTER ONE

DEUS EX MACHINA

The electronic digital computer is called the hallmark of our age and the shaper of our times. But what is yet to come in the development and application of the electronic digital computer during the remainder of the twentieth century is almost beyond our comprehension today.

There have been many forecasts concerning the fantastic future developments we will see in computer hardware, but in the immediate future the most interesting developments will be in software, especially that aspect of software called "user-friendliness."

One of the difficulties in learning and understanding any technical or artistic field these days is the extensive use of jargon by people working in that field. It's impossible to discuss or write about such a field without using its jargon. The jargon must be looked upon as shorthand, using a word or term in place of a much longer and more complex statement. The meaning of jargon is rarely the same as when the words or terms are used in other fields or in the vernacular. The same applies to acronyms or the use of the initial letters of a term. In order to keep this book from becoming totally unmanageable from the reader's standpoint, both jargon and acronyms are used. However, we'll make every attempt to define a jargon term of acronym the first time it's used and occasionally thereafter.

The "ware" jargon terms above are used by computer engineers to describe the various parts of the overall computer system.

"Hardware" refers to the actual computer itself—the electronic micro circuit chips, the plastic boards upon which the chips and other electronic components are mounted, the disk drives, the keyboard, the display screen, and the other "peripherals" or accessories that permit a computer to talk to humans through printers or to other computers via telephone lines, for example.

"Software" is the programming that makes the computer perform tasks for the human being who uses the computer as a tool. Programs are instructions written in electronic language that the hardware can understand. Modern programs allow a person to communicate with the hardware and the hardware to reply in something closer to human language. Programmers are people who write computer programs. As we'll see, programmers are an endangered species.

A third element, "jellyware," refers to us, human beings, ordinary people, the part of the overall system that the hardware and software are designed to serve.

In contrast to popular thinking, hardware isn't immortal; it becomes obsolete quickly. Jellyware is far more nearly immortal and, because of writing, painting, sculpture, and other jellyware activities, has the potential of becoming pseudo-immortal.

The semi-humorous "jellyware" (sometimes referred to as "wetware") alludes to the fact that the hardware, a modern electronic computer, is a device whose basic working parts are crystalline in nature while human beings are made up of subtances that are colloidal or jellylike.

These terms—hardware, software, and jellyware—succinctly define the three basic elements of the human-computer system.

There has been a plethora of claims and forecasts made about the future of computers. Many people have tried to look at what effect these strange new devices will have on our future lives.

A common forecast claims that computers will take over and run our lives. As we'll see, this is patently ridiculous. It makes the mistake of considering that a collection of silicon components with an evolutionary history measured in decades is "intelligent." It also presumes that a hundred million years of evolution in a highly dangerous and competitive world produced entities stupid enough to let their own inventions and tools supplant them.

Some scientists, forecasters, and writers have even suggested that we humans are creating our own evolutionary successors: intelligent, self-aware and immortal machines that will be able to expand conscious thought throughout the universe, where, they believe, it is difficult or impossible for human beings to exist, much less travel.

Some people have a mystical approach to computers born of a lack of understanding of both hardware and software. This leads them to consider computers omnipotent, omnipresent, and omniscient, like gods. To these people, computers now rule our lives just as their ancient, supernatural counterparts did and—in many places in the world—still do.

There are serious problems, drawbacks, irrational conclusions, and inconsistencies in this point of view. It must be dealt with now, while we are still in the early, primitive decades of computer development. And predictions based on it must be shown for what they are: poor forecasts born from misunderstanding and in many cases from fear born of that misunderstanding.

We must also try to take a fresh look at the human-computer system in terms of what each element *is* as well as what it is *not*. Then, grounded upon those answers, we might stand a good chance of making a realistic, rational forecast of the future of the human-computer system . . . and it turns out to be far more fascinating that most forecasters' predictions.

To understand the rationale behind these statements, and to lay a foundation for discussing the most likely potential of the human-computer system, we'll look carefully at what each of these three subsystem elements amounts to, and then at how they can meld together as an optimum system in a manner which leaves humans in control.

Actually, we have no choice but to put the overall system under the the control of the human element. We've learned our lessons about automatic machines and systems. At least, some people have. Those who have had to design, oversee, repair, and maintain automatic machinery and systems have a different and more realistic view of the situation than people who never pay any attention to such systems except to complain bitterly when they don't work.

Automatic machines and systems, something we'll call automatic devices, have been designed and built by the thousands in different strange and wild forms in the past. They are being used right now. An automatic device will do its job perfectly time after time after time—provided that the job doesn't change, that no new elements are introduced into the environment, and that the device has been told what to do in every conceivable circumstance.

Automating any job demands that the entire job and all its little elements and variables be totally understood by a human being at the start. It must be possible to perform an operation known as "writing the mathematical model." Every part of the task, everything that changes or might change, and every possible failure must be known and understood so that the task can be reduced to a mathematical equation, which is basically a written analog or shorthand expression relating to the real world.

It is extremely difficult to do this because of a number of factors, not the least among which is that we have an incomplete, albeit growing, understanding of the universe and the way it works. What we have in our science and technology is only an approximation of reality. As time goes on and we learn more, we get a better approximation of reality. There are very few tasks, operations, or techniques that we understand completely enough to entrust them totally to an automatic device.

True, we can build fantastic robots that can carry out complex tasks a billion miles away from the Earth or in the next room. *But* . . .

But there is nearly alway a human being somewhere around the device or in touch with the device who checks it occasionally or who can quickly shut it off or fix it.

At this point I wish to introduce a concept that isn't totally accepted by most theoreticians but which is part of the everyday life of any practical engineer, artist, mechanic, technician, or planner. It stems from the universal truth known as "Murphy's Law"—"Anything that can go wrong, will."

Murphy's Law has been expanded with various corollaries to extend into nearly every nook and cranny of human activity. It also may be extended to encompass anything in the known universe. But for our purposes here, the obvious corollary to Murphy's Law states:

Any entity that is self-contained, self-programmed, and therefore automatic will eventually break down.

In other words, there is no such thing as a "fail-safe" system.

That statement applies not only to hardware but to jellyware as well.

Even with automatic stops, over-ride limit switches, feedback circuits, and all the other tools of the systems designer, any system left to itself long enough will eventually encounter some situation that it has not been programmed or designed to handle or overcome, that its design didn't anticipate, or that is beyond the limits or range of its operating capabilities. When this happens, the system is destroyed. It may self-destruct, or it may be destroyed by the unforseen change in its environment, or it may just stop. Regardless, it quits working. For all practical purposes, it dies.

This holds true not only for hardware, but for us jellyware units as well. Death may be caused by a new, mutated virus or bacterium, or by overstressing the system (producing various diseases). Or it may be caused by an "accident," meaning that the laws of probability eventually presented it with a situation beyond the probabilistic limits the system was designed to cope with.

There are many examples of the truth of this "self-destruct" syndrome in the real world. We see them every day. Our lives are continually changed by them. If you stop to think about it, you probably encountered at least six situations in the last twenty-four hours that were unanticipated and required you to change your plans or activities in order to cope with them or with a changed universe that resulted from them:

The train was late.

The battery was dead and the car wouldn't start.

Somebody ran the stop light and almost hit you.

Somebody cut in front of you on the road or while you were walking on the sidewalk.

Somebody wasn't where he was supposed to be, when he was supposed to be there.

Somebody didn't do what he was supposed to have done or didn't deliver what he was supposed to deliver when he was supposed to do or deliver it.

The check didn't clear.

The check didn't come.

Somebody goofed and left you to straighten things out.

The most important letter, shipment, tool, device, etc. was somehow lost by somebody or something somewhere, and you can't find it or even learn where to place the blame or the responsibility.

Murphy's Law and its innumerable corollaries got to you.

It gets to everyone.

We wouldn't have sporting competition without it. Sports would be set pieces if there wasn't the chance that somebody would fumble the ball. If the performance of every horse on the card could be determined in advance by a thorough analysis of past performance, there wouldn't be a horse race. Of course some horses are faster than others, but the race always requires an answer to the question: which one?

Our lives would be incredibly dull without the reality of Murphy's Law, which operates because we are not omnipotent, omniscient, and omnipresent.

It's quite proper to automate as many systems as you possibly can. But you must always see to it that provisions are made for "non-linear" programming—i.e., putting a person in the loop just in case something goes wrong, which it will. In spite of all the research, study, thinking, and analysis devoted to something called "artificial intelligence" to date, the work has primarily served to tell us how little we know about "intelligence," much less what we mean by "intelligence."

Dr. John MacCarthy of Stanford University, one of the outstanding researchers in artificial intelligence, says that recently he thought he'd progressed far enough to build a robot which could, all by itself, assemble a color television set. However, when he bought the Heathkit, set it in front of the robot, and pushed the "go" button, his "intelligent computer" couldn't even open the box the kit parts came in . . .

We're a long way from artificial intelligence. We may never get there. Certainly, we won 't until we learn more about what intelligence is. In the meantime, there exists a perfectly good, operable, and tested system that can manage automatic devices and has done so in a reliable fashion for a long time: us.

Many years ago (much longer than I care to think about) there was a crudely-lettered sign in the guidance and control laboratories of White Sands Proving Ground, New Mexico, where guided missiles were designed, developed, and tested. Seeing the unpredictable way the missiles acted in flight, many of the engineers were drawn to the belief that they had little minds of their own. The engineers were just seeing Murphy's Law at work, except what they called it still can't be printed, even in these days of permissive publication. The sign read:

"Man is not as good as a little black box for certain specific things. However, he is flexible and much more reliable. He is easily maintained and can be manufactured by relatively unskilled labor."

My great distrust of automatic devices and my unwillingness to embrace the forecasts promising or warning of an automated future isn't a mind-set developed as a result of academic education or the opinions of others. They have come from decades of making perverse, balky devices that were designed and built with incomplete information work in the first place, start working again after they've crapped out, work the same way they did before they were repaired, and continue to work, period. I have never been accused or accused myself of possessing or exhibiting what Arthur C. Clarke terms "failure of imagination" or "failure of nerve." Nor do I qualify as an "elderly but distinguished scientist" under Clarke's First Law. ("When a distinguished but elderly scientist states that something is possible, he is almost certainly right. When he states that something is impossible, he is very probably wrong.") Herman Kahn has called me a "technological visionary," but the correctness of that accolade remains to be seen, and it will take fifty years or so to find out whether Herman was right. But at least he made the statement.

I owned and used computers during the years of their childhood. I own computers today, in their adolescence as a technology. Computers have changed in forty years. Oh, how they've changed!

All of us who studied science and technology prior to 1970 learned to use an analog computer called a "slide rule." I still have my K&E log-log trig monster, plus numerous little pocket slip sticks; they are relics, but they'll work when the power fails or when there are no fresh batteries around.

I designed and built a primitive relay-based computer to control rocket motor static tests at White Sands in 1954. Without the knowledge of my supervisor, my technicians and I built a few computers with which we could play simple games. So, surprise, surprise! Computer games aren't new. They're *different* from the ones we built using relays and incandescent panel lamps. But they operate on the same principles of logic.

I have used primitive, hand-cranked Monroe calculators, one of them partially automated with an electric motor in place of the hand crank. I worked in the pari-mutuel "tote room" of a dog racing track in 1949–1950, when odds and pools were calculated by dozens of men, usually accountants or bank tellers, armed with Monroe hand-crank mechanical adding machines. We finally got "tote machines" that dispensed better tickets and then reported their sales electrically to the tote room, where dozens of men still used dozens of Monroe mechanical calculators to determine odds and pools, based on the sales figures.

I can recall programming a 1960 computer using a peg board, the early manifestation of the patch panel programming method.

I bought my first pocket calculator in 1972 and was the first one to use such a device in the engineering firm where I worked at the time. This calculator would fit into a large pocket. It paid for itself almost at once because I got a hell of a deal on a new car by using it; I had rapid control over numbers while the automobile salesman had to sit there and work out the same numbers with pencil and paper. But I'll never have that chance again.

I've had Calliope, a microcomputer, since 1979 and, using it as a word processor, have written several million words with its enormous help. I carry a four-function computer on my wrist; it also tells time. I look forward to smaller, simpler computers that are easier to use.

And I look forward to doing all sorts of things with this new tool called a computer. I intend to talk directly to it and have it respond directly to me, not by means of VDTs or voice synthesizers or voice recognition circuits, but by means of direct linkage between my nervous system and the electronic circuits of the computer.

But I do not look forward to, believe in, or trust *any* computerized or automated device that does not have an over-ride that will permit me to cut it out of the system, that does not have some means for me to monitor its performance to insure that it's doing what I want it to do, and that does not have a switch that will let me turn it off and, essentially, kill it.

In spite of the enormous amount of human brainpower and intelligence that went into designing my word processor, I cannot walk away from it when it is printing out a manuscript. Despite its safety systems, fail-safe devices, and "failure mode reporting devices," it can and has printed page after page of garbled verbiage caused by a voltage transient on the power line. Or it has failed to print page after page because the ribbon slipped in such a way that the ribbon failure sensor wasn't activated.

There may be a god in this machine of mine. If so, it hasn't seen fit to reveal itself. I will make a flat forecast and you can hold me to it: The computers aren't going to take over. The silicon gods won't rule our lives.

Now I'll proceed to prove these statements and all the statements and contentions put forth thus far.

CHAPTER TWO

HARDWARE

In essence, all electronic digital computers are the same.

Don't let any salesman try to tell you differently. Don't let any computer design engineer try to convince you otherwise.

Although there are minor variations in design between one computer and another that enormously effect speed and capacity, they are all based on the same technology. They all operate with the same sort of internal logic. They all have the same kind of internal subsystems. They all have about the same level of reliability. They all do the same thing.

They are, all of them, nothing more than very fast adding machines.

Computers or their simpler counterparts, the calculators, have been used by people for untold centuries. Perhaps the earliest digital computers were the devices from whence the word "digital" derives: the fingers. A digital device is one that counts or presents information as combinations or multiples of a basic unit, "quantum," or counting element. Your ten fingers represent a digital computer operating on a number system with the base ten. In a digital system, you can't count half a digit, only a whole digit or no digit at all. Sure, you can bend a finger over and hold up three others to state, "Three and a half." But if you were counting only the tips of fingers, you'd have either three or four digits, nothing else.

Many primitive peoples didn't have words or concepts to describe any quantity more than two or three. They didn't need any, because they lived in a world of scarcity and shortage. This probably leads to what might be called Stine's First Principle of Computers: If you don't have more than one or two of anything, you don't need a computer that will keep track of a million items. As a matter of fact, those tribal chieftains who did have a large number of cattle, sheep, wives, etc. actually hired computers, people who were called "numerators." Their job was to invent ways of counting large number of items beyond the capability of the language to handle.

Each of us comes equipped with means to count as high as ten with our shoes on: fingers. You can do a lot of counting with ten digits. The Korean finger-counting method, chisanbop, permits addition and subtraction up to a maximum of 99 or any multiple thereof.

The Asiatics were the initial leaders in the field of digital computers. It's impossible, even in this day of growing Japanese presence in the digital computer field, to travel throughout the Orient or even in the Oriental sections of American cities without encountering a very ancient digital computer, the abacus. Something like the abacus was first used in Babylon more than 5,000 years ago, but the Chinese are responsible for its development into the present form.

An abacus counts beads according to their position on a harp of wires. It's an exceedingly simple device to make. Depending on how many rows of beads there are on an abacus, it's possible to add, subtract, multiply, and divide as many significant numbers as you wish. I have two abacuses. One is comparable to a pocket calculator with nine significant digits; it was sent to me as a promotional gimmick ("You can always count on us") by an early scientific computer company in 1957. The other is a desk-top model with 15 rows of beads. I can work an abacus, but it's a lot easier to use a pocket electronic calculator. However, an abacus has an important feature; it may boast only millisecond gate or response times in comparison to the nanosecond gate times of the pocket calculator, but it will keep on working as long as you can slap the beads back and forth. No batteries ever wear out. No Himalayan cottage should be without one . . .

We can't talk about how computers came to be without at least mentioning the Antikythera Mechanism, a highly corroded artifact found in a shipwreck in 1900 off the island of the same name near Crete. According to the Greek inscriptions on it, it may have been made about 80 B.C. Careful study and examination of the Antikythera Mechanism by Dr. Derek de Solla Price of Yale University revealed that it utilized gears. Since the first known clockwork mechanism utilizing gears wasn't made until 1575, the origin and true nature of the Antikythera Mechanism remains a complete mystery. It may have been an early computer but, if so, it didn't form the foundation for the development of other computers. Whatever the Antikythera Mechanism was, other devices like it didn't become as ubiquitous as the abacus.

All sorts of computers were developed from the 17th century onward—"Napier's Bones" and Pascal's adding machine among them. Charles Babbage is credited as being the first to develop a digital computer, although the Babbage Multiplier utilized gears and shafts. In 1728, the Jacquard loom was the first device to use a computer system—punched cards—to control an industrial process—a weaving loom.

The infamous admonition, "Do not fold, spindle, or mutilate," came about as a result of the invention of the punch card in 1890 by Herman Hollerith; many people call it an "IBM card," but it's true appellation is the "Hollerith card." In today's computer parlance, a Hollerith card could be called a "read-only memory" (ROM) device because information is permanently stored by the card according to the positions of the holes.

The first electronic digital computer was the 1946 "ENIAC" (Electronic Numerical Integrator and Calculator) at the Moore School of Electrical Engineering of the University of Pennsylvania. It used 18,000 vacuum tubes (this was before the invention of the transistor) and could perform an addition in 1/5000th of a second; this would be a "half-millisecond gate time" in today's computer jargon. It could store only 20 ten-digit decimal numbers. Its biggest problem was reliability. If the average lifetime of an individual vacuum tube in ENIAC was one year, its operators could expect it to operate 29 minutes before a tube failed. ENIAC occupied thousands of square feet of floor space, used kilowatts of electrical power, and required an expensive air conditioning system to remove the enormous amount of heat generated by the glowing filaments of the vacuum tubes. Because of the problems of size, energy consumption, frequent failures, very slow speeds, and extremely limited data storage capabilities, nobody built very many digital computers of the ENIAC type or its offspring, the original UNIVAC. You have more computing power and speed in a ten-dollar pocket calculator today. I wear a calculator wrist watch that includes a four-function digital calculator, something that was almost inconceivable forty years ago.

ENIAC and its progency are known as "first generation" computers. The "second generation" electronic digital computers used discrete electronic components such as individual transistors, capacitors, resistors, coils, etc. hooked together either with wires or by "printed circuit" boards which were chemically etched to leave metallic foil patterns on a plastic substrate; the foil patterns were the wiring. This level of technology is still found today in some large television sets, stereo components, and cheap transistor radios, but it won't last long because of integrated circuit technology.

Today's computers are "third generation" devices which achieve very high speed, small size, large memories, low energy consumption, and high capacity because of developments in integrated circuit technology.

Integrated circuits seem magical, but they're merely the further development of printed or etched circuit technology coupled with transistor production technology.

Transistors are crystalline growths of silicon to which, at various points in their manufacture, extremely tiny amounts of impurities are added which will affect their electrical characteristics. The silicon is said to have been "doped." This doping is not only done with fantastic precision but "contaminates," or adds dopants, in such small quantities that their presence couldn't even have been detected by the best analytical chemistry of fifty years ago.

The biggest part of a transistor was the wiring attached to it that allowed it to be soldered onto an etched circuit board. The next technological step was to combine several transistors in one unified component, along with connecting wires microscopically and other electronic components, all of them etched, grown like the crystalline transistor material, or deposited on the integrated circuit foundation. The first integrated circuits (ICs) were stumbled onto in the 1960s independently by Jack Kilby at Texas Instruments and Robert Noyce at Fairchild Semiconductors. The first widespread use of ICs was in the Department of Defense ballistic missile programs, where small size, low energy consumption, high reliability, and light weight were critical factors. By 1965, simple ICs were available to electronic buffs. In electronic technology, there are certain types of circuits that are used in a large variety of electronic devices, and these were the first to become ICs—amplifiers, voltage regulators, detectors, etc.

Engineers raced to jam more and more transistors and components on smaller and smaller chips. A digital watch requires a chip with 5,000 transistors while a pocket calculator has a chip with about 20,000 transistors on it. At this point, engineers no longer refer to them as "transistors" but as "gates," because these electronic valves open or close to permit or prevent electrons from passing through them. This now happens so fast—500 billionths of a second or 500 nanoseconds—that a critical factor in an IC-based computer is the length of the wires and cables connecting various parts of the computer; electrical signals travelling at the speed of light are *too slow* and the computer must wait for the signals to get through the wire!

The technology has now passed into the VLSI or "Very Large Scale Integration" phase, where as many as half a million gates are fitted on a microscopic sandwich of silicon only a quarter of an inch on a side. By 1990, chip engineers anticipate that VLSI chips will contain more than ten million gates.

The reduced size and increased complexity of chips means that computers will work faster, be able to perform more functions, consume less power, and be more reliable.

Some people will feel that this has gone far enough already. Today's version of the ENIAC will fit on your wrist, keep time, tell you the date, provide you with a stop watch, monitor your heart beat, watch your blood pressure, and tell you what the temperature is. Not very many years from now it will also contain your personal telephone which, working with satellites, will put you in touch with any telephone anywhere in the world at any time.

Faster computer speeds mean very little to most people. If a home computer operates with a speed of a half a millionth of a second and appears to respond immediately, why increase the speed by a factor of ten? The reason for faster speeds is, of course, increased versatility and the ability to handle more tasks in a given computer.

For all their complexity, each transistor/gate in each chip operates in only one of two modes: on or off. Yes or no. Black or white. Open or closed. Like the bead of an abacus or counting on your fingers, it is either one way or the other.

Although a computer can count and handle huge numbers, it recognizes only two: 0 and 1, off or on. We're used to working with ten numerals, a number system that mathematicians call the "decimal" notation or the "base ten." Computers work on the "binary" notation or the "base two." They also use multiples of the on-off binary system in which they group packages of binary numbers together into multiples of 8.

The basic computer number of 0 or 1 is called a "bit." The computer runs eight of these together and operates with them as a "byte" made up of 8 bits.

The computer also squirts on-off signals around inside itself in chains of bytes.

You don't have to know a damned thing about binary numbers, Boolean algebra, hexadecimal notation, or anything of the sort. In a fashion typical of the way human beings have handled the world for eons, we've designed and built computers so that they are compatible with us, not the other way around. Modern computers communicate with us in the familiar decimal system we understand. It's no problem for the computer to decipher and interpret it for us. The only reason the binary system and the hexadecimal system are discussed briefly here is to provide you with some background if you should ever wish to dive into the hundreds of specialty books that discuss in depth how computers work, or if you should ever succumb to the desire to program computers in their own language. (The computer programmer is a member of a dying profession, as we'll later see.)

A computer can talk to you in alphabetical characters as well as numbers because the internal program has assigned specific binary number groups to represent each alphabetical character. This happened in an unusual burst of harmony and co-operation between computer manufacturers that created a voluntary national standard, now widely used, known as ASCII (American Standard Communication and Information Interchange) and pronounced "ask-key."

The way a computer works is very simple, and all electronic digital computers work the same way—which is why this chapter opened with the statement that all electronic digital computers are the same.

If you had to sit down and design a computer, you'd have to approach it the same way that the computer engineers did. You'd have to ask the question, "What's the basic structure of any information handling device, human or computer?"

You'd eventually come up with something like the block diagram of Figure 2-1.

There has to be some way to get information and instructions into the device in the first place. This is the box labelled "Inputs." These inputs can be any or all of a number of things. In the case of a human being, the inputs are signals from the sense organs—eyes, ears, olfactory buds, taste buds, pain receptors, touch sensors, and kinesthetic or muscle positioning sensors. Inputs to a computer can be almost anything but are usually in the form of a typewriter-like keyboard, an ingenious device made possible by the same IC technology that permits the computer itself to exist. Depressing an individual key closes a switch that generates a specific set of on-off electrical signals which the computer recognizes. Somewhere inside the black box labelled "Inputs" is some sort of translator circuit gadget that converts the input into a form recognized by the computer.

Usually, all inputs are directed into some sort of holding system, which is the box labelled "Memory." Think of this memory box as a great big post office with thousands of letter boxes, each one capable of holding one piece of information. In the case of the computer, this piece of information will usually be the 8-bit byte. When the computer wants to get or save information, it pulls data bits out of the memory or puts them in. If the computer does lots of complicated things, the memory unit is large. Pocket calculators have very small memories, usually capable of storing only an 8-digit decimal

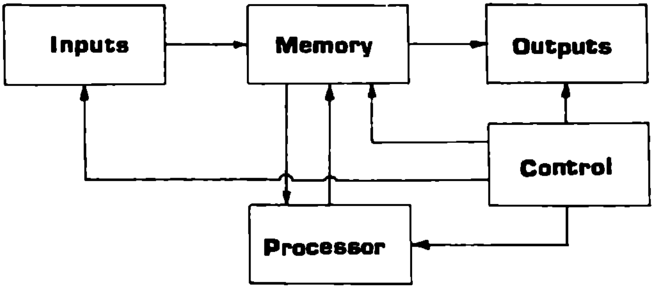

Figure 2-1: Basic Computer

number plus the basic instructions for arithmetic calculation. Personal computers have much larger memories. The simplest microcomputers have a "working memory" that will hold 4,096 8-bit bytes; this is known as a "4K memory" and is just about enough memory to allow you to play simple games with the computer. A microcomputer needs at least 48K (49,152 bytes) to be of real use in computing, word processing, etc.

The "Processor" box is the heart of the computer. This is where the basic handling of all the numbers and numbers-cum-letters is handled. The processor does the adding and subtracting of electronically coded numbers.

The computer must have an output if it is to report its findings to the outside world. This is the box labelled "Outputs." An output can be a TV screen, a printer, or a device called a "modem" (standing for "modulator-demodulator") that lets it talk to other computers over a communications link such as a telephone line, or an electronic circuit that controls other devices directly.

The computer must have an overall manager that will keep track of and exercise control over what the computer is doing. This is the box labelled "Control." It opens and closes the gates according to a set of instructions called a "program" that's stored somewhere in the huge memory of the computer . . . but the controller knows where the program's stored. In most modern microcomputers, the function of the Processor and the Control is combined in a single chip, the CPU (Central Processing Unit).

The first of these tiny, integrated circuit CPUs was the Z-80 developed by Intel Corporation. A CPU can contain more than 30,000 transistors or gates, plus a memory unit that tells it what to do, plus another memory unit in which it can store pieces of information it's working on, plus its own controlling unit that keeps track of what's going on. It has its own internal clock to time operations. It interrupts operations if necessary to let higher-priority operations take place. Generally, it acts as the manager of the computer.

All of the activity of a CPU goes on inside a piece of slightly-impure silicon less than a quarter of an inch on a side. This is where the silicon god resides.

Those five black boxes define a modern electronic digital computer. All computers have those five boxes, and the five boxes in all computers do the same job. How these black boxes do their jobs varies from computer design to computer design.

But you don't have to know anything at all about *how* these black boxes work. You should remember them because you may have to stop and figure out what your computer's doing from time to time, especially when it isn't doing exactly what you want it to do.

(As we'll see, it's very rare for a computer to do something wrong. Barring cosmic rays, line surges and such, a computer *always* does *exactly* what it's told to do. If it isn't doing what you want it to do, almost always that means you told it to do something else. But it's your mistake, not the computer's unless it's wrong–headed in a consistent sort of way; then it's broken.)

The arrowed lines running back and forth between black boxes in the diagram indicate the way information in the form of groups of electrical pulses move around within the computer. The CPU controller keeps track and runs the show, opening and closing electronic gates according to the instructions of its program.

You don't have to know *anything* about how the CPU does its job. Just be aware that it's there and that it's the heart of the computer. If it *doesn't* work right, the computer instruction manual will list a series of simple tests you can perform, the so-called "diagnostic" programs. Such diagnostics will inform you whether the computer's working right. If it's not, call the repairman because, unless you are an experienced computer engineer yourself, you can't fix it. Don't try. And refrain from testing it *ad nauseam*. If it's working, let it alone. Of course if you have one of the new, expensive modular units you may be able to locate and replace the faulty module—but never fix it.

The chances of the CPU, the memory, or any of the electronic parts of the computer going bad are slim. I have had Calliope now since 1979, and it's the most reliable device I own. I have had two major types of problems with Calliope, and both involved mechanical, not electronic, parts of the computer. We (my computer repairman and I) discovered two instances of poorly-soldered connections that somehow got past the final quality control inspection. And we have had to conduct periodic maintenance on the mechanical parts of the computer peripherals—the printer and the disk drives. In only one case has an electronic circuit board gone bad and it was due to a bad electronic part known as a capacitor, something big enough to see and large enough to require soldering to the circuit board as a discrete component.

If there is *any* area of computer technology where we can anticipate future development progress, it's in the area of eliminating from the computer system *all* mechanical devices and mechanically moving parts. In spite of their speed and sophistication, modern computer printers are nothing more than a kind of typewriter, one step removed from C. L. Sholes' 1867 machine. And disk drives are nothing more than the modern embodiment of the Edison phonograph.

The only computer sub-systems or hardware components you'll have to learn how to operate are these mechanical appendages from the late nineteenth century. They're also the ones you'll have to keep your eyes on because, being mechanical, they have the lowest reliability in the system.

The "Memory" box in the simplified schematic of the Universal Computer is made up of two basic types of memory: *ROM* and *RAM*.

The first of these means "Read-Only Memory". It is the permanent memory that resides in the computer and isn't affected if you turn the computer on or off. It's rather like your own deep-seated automatic memories that tell your body what to do even while you're sleeping—keep your heart beating, keep breathing, etc. When you wake up each morning, you don't have to tell your body what to do all over again to start the day (sometimes it just feels that way). It already knows. The information resides in your own personal permanent Read-Only Memory (ROM).

This ROM may be in the form of Programmable

Read-Only Memory (PROM) which is permanent but can be changed; it does keep its data when the power is off. Or it may be in the form of Erasable Programmable Read-Only Memory (EPROM), which is permanent from one programming to the next (unless exposed to UV radiation). This sort of filled memory is stored within electronic chips in the computer just as the other kind is.

The other kind is called RAM (Random Acess Memory). The computer stores both kinds not as series of on-off pulses, but as the condition of switches—on or off. These switches are the microscopic transistors in the electronic memory. A computer memory is like a huge bank of pigeon-hole post office boxes, each pigeon-hole containing one 8-bit number or byte. When the computer is instructed to "remember" something, it stores that something as a series of 8-bit binary numbers in a series of pigeon-holes and tells another part of its memory where it is—i.e., its address in the memory boxes. When a piece of data is required by the computer, the computer's program instructions tell it to go looking at the address for that piece of data.

You use the same method when you go to the library. First you look in the index card file which tells you the address of the shelf where the book is. Then you go to that shelf to find the book. In a library, the book can be gone, checked out by someone else; in your computer, that piece of data is where the computer put it when you told the computer to remember it—unless you've also told the computer since then to forget it or the computer has lost power, or something else bad has happened, in which case *everything* in RAM is probably erased.

There is a third sort of computer memory, a permanent type that can't be erased if the computer loses power . . . and is for the retention of what the *user* chooses to remember, as opposed to manufacturer—supplied ROM. A computer must also have some sort of long-term, elephant-like memory that can be easily modified. It may also require, or you may ask it to store, more information than it has room for internally.

This is usually the part of the computer shown when a TV show or motion picture director needs to display a computer doing something. A computer at work is highly non-photogenic. Watching a computer at work is worse that watching the grass grow; you *know* that the computer is doing its thing at a rate several orders of magnitude faster than you can think, but there's absolutely no indication of this. Gone are the banks of flashing lights that were originally intended to let the computer operators know that the machine was working. While computers are usually displayed as banks of whirling, jerking tape decks, these are early Stone Age versions of modern computer memory and storage technology. Everything done by these dual-reel Neanderthal devices can be accomplished today with a little tape casette albeit somewhat more slowly.

The tape casette is one of the cheapest forms of memory storage, but it suffers from the same drawback as the reel-to-reel tape memories: to get some date that's recorded on the last part of the tape, the tape must be read through everything until it gets to that strip of tape. You can't get access to a specific part of it easily. Surprising enough, computer engineers refer to this by the logical term, "access time." Tape suffers from slow access time. Its access time is so long that, for all practical purposes, it has been supplanted by disk storage.

A memory disk is like a record album, except that information is recorded on it magnetically rather than mechanically as it is for a stereo record. The magnetically-coated disk spins at a constant speed. A record-playback head is attached to an arm that moves radially back and forth across the disk's surface. The head can be lowered to ride on the disk surface to record information or to pick up the information stored on the disk surface. Information in the form of series of electrical pulses is recorded or stored on the disk in the form of tracks like those of a stereo record. But a stereo record track is a spiral leading from the outside rim of the record inward. On a computer disk, all tracks are circular and will simply pass under the recording head again the again until the head is moved in or out on its radial arm by a motor. Each circumferential track is divided into sectors. Thus, the computer will tag the location of a piece of stored data in terms of the track and sector it's stored on.

There are two basic types of disks: hard and flexible.

Hard disks until recently have been used only on large, general-purpose computers; they are now available for some microcomputers. A hard disk is usually 8 inches in diameter and has its rust-like recording layer deposited on both sides of a hard core made from glass or plastic.

One of the big breakthroughs insofar as microcomputers are concerned was the development of the flexible disk or "floppy." A floppy disk has a flexible plastic base rather than a hard, rigid base. It comes permanently sealed in paper enclosure or envelope. The inside surface of the floppy container is coated with a slippery, low-friction plastic. The whole assembly—disk and envelope—in inserted into the disk drive where the drive spindle clamps down on the large center hole and spins the disk inside the envelope. The record-play head contacts the surface of the floppy through a slit in the envelope.

Some floppies are designed to use drives that record on both sides of the disk. Others record on only one side. Soon, when something called "vertical storage technology" comes into play, floppy capacity will increase by from ten to one hundred times.

How does the computer know where the starting point for each circumferential track is located on the disk? How does it know where each sector begins? Early floppies were indexed by little holes located around the spindle hole. As each little hole passed a light and photo cell, an electrical pulse was generated. The pulse identified the start of a sector. Two holes punched very close together identified the "start" of each track. This is known as "hard sectoring," and hard-sectored minifloppies use either 10 or 16 sectors. Newer drives use "soft sectoring" where the start of each track and each sector is defined by an electrical signal recorded on the disk itself, a feature that **eliminates the light and photo cell.**

Hard disks can store more than *twenty million* 8-bit bytes. Even the smallest single sided 5-¼ inch minifloppy can store more than **140,000** bytes.

Just on the market is an even smaller version of the floppy called a "microfloppy." It is a result of the continual trend toward making things smaller in the computer industry. The new microfloppies or "shirt pocket floppies" are only about 3 inches in diameter, yet some of them can store up to 875 kilobytes, almost 75% more than the best 5-¼-inch minifloppy.

Access to data on disks or diskettes (as minifloppies are often called) is fast because once the computer tells the disk unit which track and sector it wants, the drive quickly moves the head-carrying arm inward across the disk to the proper track, then the system selects the proper sector.

The difference in access time can be better understood if you compare two "data sources" for your stereo system: your tape casette and your turntable. If you want to find a piece of music recorded on the casette, you have to run fast-forward to find that point on the tape where the song starts. This takes a lot more time that lifting the tone arm and running it inward to find the band or track on the stereo disk.

Unlike a stereo disk, however, a computer disk is like a tape recorder; the computer can not only read or play back what's already recorded on the disk, but it can erase what's there and record something new in its stead.

Finally, a computer must have some way of communicating with the outside world and with you. It does this by means of several output devices.

One of these is its video display terminal (VDT) which is nothing more than a television set. In fact, some inexpensive computers require that you hook up a TV set to use as a VDT.

Another output device is the printer, which gives you a "hard copy" (as compared to the "soft copy" residing on the VDT secreen). There are two basic types of printers now available for microcomputers. One of these is currently cheaper and is called a "dot matrix" printer; it prints alpha-numeric characters on paper as a collection of tiny dots. Although dot-matrix printouts are becoming more and more widely accepted, there is still a requirement for typewriter-like or "letter quality" printouts from the second type of printer, basically a computer-driven typewriter. Dot-matrix printers are faster than letter-quality printers, but both are pretty slow when it comes to the speed of the computer itself. Most of them, when they're working right, will pound out 500 words per minute. The computer, on the other hand, is capable of feeding the printer at about ten times that speed, so the computer feeds the printer a line, waits, engages in the computer version of a yawn of boredom, and stands by to squirt another line of data when the printer signals that it's ready to receive it. (Recently extensive buffers have become available (sometimes simply in the form of RAM configured by software) that soak up several pages worth of data flow as fast as the computer can squirt.)

Computers may not possess emotions, although some computer engineers believe that computers have sneaky little minds of their own. But the interaction between a computer and the outside world of human beings proceeds at an excruciatingly slow rate. The computer is so much faster than its input and output devices, as well as the human being who's working with it, that if it did possess emotions, it would probably be *bored.*

But this will only last a few more years.

CHAPTER THREE

SOFTWARE

All you really have to know about a computer is how to turn it on and off, and how to put the software into it.

All the rest of the complicated business of running a computer is done by the software, especially if it's the new "user friendly" software. At most, you may have to learn to use a few command code letters so the software can make the hardware work. But you can learn these simple codes in a matter of a few hours.

All because of the software.

After all, you learned to drive a car, operate a stereo system, run a microwave oven, use a typewriter, and work the direct-dial telephone system. All the little quirks and commands and codes involved in these procedures are a lot more complicated than the commands for using a computer with well designed software. Driving an automobile is one of the most demanding skills in the world, and if you don't do it right it can kill you.

Using a computer (as opposed to programming one) is child's play in comparison, which is perhaps why so many children not only use computers well but enjoy doing it. (You mean that seven-year-old kid is *smarter* than you are because he can use a computer and you're *afraid* to? Shame!)

Software, as mentioned in the first chapter, is the term used by computer people to describe the instructions given to the hardware so that the hardware will do things.

By itself,a computer does nothing except sit there and quietly eat electricity. To be useful, the computer must be trained. It's just like a puppy; to transform a puppy into a guide dog for the blind, for example, the puppy must be trained. In order to make a computer into a useful tool, it too must be trained, or "programmed."

Computer hardware operates completely logically because it was designed to work that way by human beings. It had to be designed that way because of the basic way it works electronically.

The basic module of the hardware, the bi-stable gate, has one or more inputs, one or more outputs, and a supply of energy in the form of electricity. This basic module can exist either of two states: on or off. When this electronic gate receives one input signal, it opens and permits the signal to go through. When it's closed, it blocks the signal. When the signal goes through the gate, it can then serve as an input signal to another electronic gate.

Stack enough of these electronic gates together in the proper sequence, and you've got an adding machine like the beads of an abacus. Or its internal arrangement—and therefore its internal "logic"

—can be arranged so that it subtracts. It can be made to multiply because multiplication is nothing more than sequential addition. It can also divide because division is only sequential subtraction. Every other mathematical operation—exponents, roots, trig functions, logarithms, hyperbolic functions, inverse functions, etc.—can be carried out using mathematical techniques in which only addition and subtraction are used. The computer program contains the information to tell the computer how to do this.

Because of its on-off gate operation, the guts of the hardware can be arranged to conduct such logical operations as:

AND (A AND B)
OR (A OR B)
NOR (neither A NOR B)
NOT (A BUT NOT B)
And other logical operations.

This little exercise is a short, quick example of a method of mathematical notation known as "Boolean alegbra" after the English mathematician and logician George Boole (1815–1864). If it hadn't been for this nineteenth century ivory tower academician who liked to fool around with ways of writing down logical expressions, today's computer probably wouldn't exist.

You don't have to know anything at all about Boolean algebra to use software that uses Boolean algebra. However, it helps if you know and understand just a little bit about programming and what it's all about because it will help you use a computer better. Furthermore, it will help you overcome technological anxiety—the fear that the computer is smarter than you are, which it isn't.

A program is nothing more than an instruction to the computer in a manner, a "language," that the computer will respond to. Most software is written in "high level languages" that humans can understand because it is made up of instructional words reminiscent of English. However, in order to get this to work inside a machine that only recognizes zeroes and ones, on or off, open or closed, requires "low level languages."

A "low level language" is a programming code that operates right down at the basic on-off logic of the computer elements. Most low-level languages are written in machine language—that is, in a series of zeroes and ones. Most of the whole series of low-level programs required to get a computer to sit up and take notice are built into the CPU or permanently into the ROMs when the computer is designed in the first place. These are really basic instructions that tell the CPU what to do down at the very lowest level of operation.

If you have a computer, you should also get a disk, diskette, tape, or ROM module with a program known as an "assembler" if you think you'd ever want to try writing a program in machine language some day. An assembler language is usually tailored to the particular make and model of the computer and is sort of a half-way language, partly low-level and partly high-level. Knowing assembler language, you can address the computer partly in human language terms and partly in computer language. It's useful if you want to come up with a program that you can't buy anywhere or that would be too big, too long, or too complex to run under any of the higher level languages.

Low-level software is stacked on top of itself, each increasing level giving more complex instructions until we reach the point where the software can be called "high level" because we can understand it.

There are several high level languages around for use in programming.

BASIC is perhaps the simplest; it uses English words and nearly-ordinary mathematical notations. BASIC was developed to be used by busy people who don't have time or the need to learn a more complex or specialized language. It has since evolved into a quite powerful if somewhat clumsy tool that is used by millions.

FORTRAN (standing for "formula translation") is a great high level language for scientific purposes and storing data that you want to "massage" or analyze. [Over-awe of the non-FORTRAN programmer; except for complex variables and computed GOTO, it has no real advantage over BASIC].

COBOL (common business-oriented language) is a high level language especially designed for business programming such as accounting and inventory control. COBOL was designed to be useable by a non-programmer such as a busy executive, manager, or supervisor who doesn't have programming background, didn't have to time to acquire it, and couldn't care less anyway.

Pascal is a recently-developed language of greater computing power than FORTRAN that is noted for its elegant structure.

The U.S. Department of Defense (DoD), which is one of the biggest users of computers, has been faced with a serious problem of co-ordinating all their computers which are programmed in different languages. Some of these computer languages are significantly different from any of the above commonly-used high level languages. DoD is developing a new high level standardized language called "Ada" for their future computers. Ada is based on 16-bit CPU technology (that is, a 16-bit environment is a minimum requirement) with provisions for expansion into 32-bit CPUs, larger memories, and faster gate times as these become available from the DoD-supported Very Large Scale Integration (VLSI) super-chip development projects. Anybody who does any work for DoD will probably use Ada, and it's a fairly certain bet that Ada will find its way into non-defense uses since a lot of computer technology filters down into the domestic scene through the technological "spin off" process.

The "state of the art" in both computer technology and software these days has progressed to the point where most current programs are "user friendly," —i.e., you don't have to know *any* programming techniques in order to get the computer to do what you want it to do. The software environment is growing richer by the day.

You can get word processing programs that will turn your computer into a very fast, very flexible, and very time-saving super-typewriter. Your computer keyboard becomes a typewriter keyboard, and as you punch letters into this "keypad," the appropriate letter or number, lower case or capital, appears on the VDT before you. The basic word processing program is simple in concept; each of the 52 letters (lower case and upper case alphabet) and the various punctuation marks is assigned a number recognized by the computer; you don't have to know what this number is, and the word processing program instructs the computer to store it as a number but play it back as a letter either on the VDT or to a printer. Whatever you type into the computer is stored temporarily in the computer's working memory. The software lets you move whole blocks of writing around, delete portions, change spelling, and do all of the writing, revision, proofreading, and changing *in the computer's working memory*. When you've got it written the way you want it, you tell the computer to store it permanently on a disk. You can recall it from the disk at any time, make changes, and re-record it on the disk.

I would find it extremely difficult to go back to an ordinary electric typewriter now, to say nothing of an ordinary manual typewriter. And the idea of having to write something in longhand never occurs to me—that form of writing is so primitive that editors won't even accept handwritten manuscripts any longer. Back in 1950, my writing coach, Robert A. Heinlein, told me that a professional of any sort must learn how to use the tools of the profession. For a professional author this tool was, at that time, the typewriter. Today, the primary tool of the professional author is the word processor.

The microcomputer in its word processor avatar is *fast*. Because nothing exists on paper until I tell my computer, Calliope, to print out what's in its memory, enormous amounts of time and paper are saved. The image of the prolific author surrounded by piles of crumpled, discarded sheets of paper is obsolete; the only paper I'm now surrounded with is that sent to me by other people. I don't even keep "hard copies" of my manuscripts any more. Why store it on paper when I can store it on a plastic disk, a disk that takes far less physical storage space than a full printed manuscript? Some non-computerized editors are baffled by the fact that I can't lay hands on Page 47 until I turn on the computer and pull the material off a disk.

After writing more than two million words on Calliope, I've lost only about 200 words because of a stupid mistake: I kept working during a local thunderstorm, the power went off, and I lost the 200 words that were in Calliope's working memory.

A useful software adjunct to a word processing program is a dictionary program. Such a program will let the computer search through what you've just written into working memory and find any word that's not listed. Spelling dictionaries with as many as 50,000 English words are now available on floppies. Basically, the program tells the computer to search through the strings of numbers it's stored as words and to compare each number set against a standard in the program. When it discovers an unlisted word it tells you on the VDT and corrects the spelling unless you tell it to leave it be. The better spellers allow you to add words to the list as well. Sometimes while using jargon or writing in the vernacular for dialogue, an author *wants* to have a word spelled differently or deliberately misspelled . . . or he just wants to leave something for the copy editor to change, thereby permitting him to believe his job's justified. Other software is now available that flags dubious usage.

These spelling and grammar programs are typical of what might be called "comparison software" —i.e., the computer is instructed to compare something against something else, then do something with the result. This process has many uses in business, science, and engineering. A marketing manager may want to compare last year's sales against this year's. Scientists may be looking for a ratio or a numerical comparison. Engineers may also be looking for comparisons between numbers for any of a large variety of projects. The executive may be looking for a trend.

Note: It is perfectly possible, rational, and logical to compare apples and oranges *if* they are compared as fruits, if their relative nutritional value is compared, or if any of a number of physical factors such as individual fruit weight is matched. It's possible to compare *any* two items. The number of sun spots can be matched with an enormous variety of other variables such as the wheat crop in South Dakota, the length of women's skirts, stock prices, the number of migrating wild fowl, etc. Only a minute number of these comparisons yield correlations and most of these are pure and simple coincidence; some may not be. But until you look, you'll never know. Until the advent of the cheap computer capable of making *fast* comparisons or correlations between apparently unconnected arrays of data, it took too long and cost too much to make comparisons. But the computer's ability to do this is one of the unforeseen consequences of widespread computer use that prove the contention that *all* information is valuable some time, somewhere.

The speed and number-crunching capacity of even the most modest microcomputer today allows us to analyze, compare, and study things that involved far too much dog-work before computers were available. For example, to compute the flight of a rocket is simple if the effects of atmospheric drag, the semispherical shape of the Earth, and change of gravity with altitude are ignored. To include all the variable factors in the calculation meant hours and hours of tedious calculations done over and over again, the answer from each step being used in the succeeding step in a process known as "iteration" or "re-iteration." I used to work a great deal with model rockets, and calculating a fifteen-second flight of a small model required more than four hours of reiterative calculation. Using a very slow form of BASIC, the same calculation can be done in a little less than two seconds. If I want a print-out of the flight performance every tenth of a second during the flight, the computer calculates it fast but the printer takes a minute or so to bang out the table of numbers.

Since engineering involves an enormous amount of time fiddling with finicky numbers to get something to come out right so the bridge doesn't fall down, so to speak, even simple pocket calculators were eagerly embraced by the engineering fraternity as quickly as these primitive computers became available. Engineers never really suffered from technological anxiety about computers. These days, they're happily using the friendly software now available, and we're seeing innovations in engineering design that weren't made before because it was too damn difficult and time-consuming to re-calculate and previous designs had to be used because of the pressure of deadlines.

Business has also profited by friendly software. Before small computers, the only number machines commonly seen in business offices were adding machines. Some of them could perform more than addition and subtraction; miracle of miracles, they could be made to multiply and divide as well. Many of them were based on mechanical movements such as gears. The treasurer, controller, or financial department were the biggest business users of calculators, although you might find one or two in the sales, inventory, and shipping departments.

The only things that the business controllers and treasurers were interested in were dollars, and desk calculators of the time were literally geared to this use. But today the desk calculator and even the small computer has moved into the executive suite. Today, the executive, manager, or marketing person without a computer is growing obsolete because the all-important driving force in any business, *the competition*, is using computers to analyze and compare not only financial matters but also trends in marketing because comparison programs can be used to forecast.

Forecasting programs operate on the same rationale as human forecasters: "If this goes on . . ." If you've got a historical record, you can establish a trend. Any trend can be extrapolated into the future using a number of variations—i.e., constant rate of growth or decline, exponential rate, S-shaped Gompertz trend, etc. Computers can't play fortune teller with a crystal ball and actually foretell the future, but they can crunch the numbers and make the comparisons to extrapolate trends into the future so that humans can do a better job of *forecasting* the future.

(One of the reasons why neither computers nor people can accurately predict the future is based on the same rationale that prevents us from automating everything and turning the world over to robots: Nothing can be automated unless all the variables and their mutual effects on one another are totally understood.)

We're dealing with something that computer software can handle a bit better than a human being: the so-called "decision tree," such as is shown in Figure 3-1.

Even a simple "either-or" decision tree becomes enormously complicated after about the fourth branching, which is about as far as a human being can track one. If you make a yes-no decision now, the next branching will have four potential yes-no decisions. The third will have eight. The fourth will have sixteen. The number of potential future options in a decision tree increases by powers of two if it's a simple either-or decision tree. If each level of decision involves three or more possibilities, the decision tree rapidly becomes totally unmanageable. Gamblers like to guess on the eventual paths through complex decision trees; sometimes they guess right, and sometimes they guess

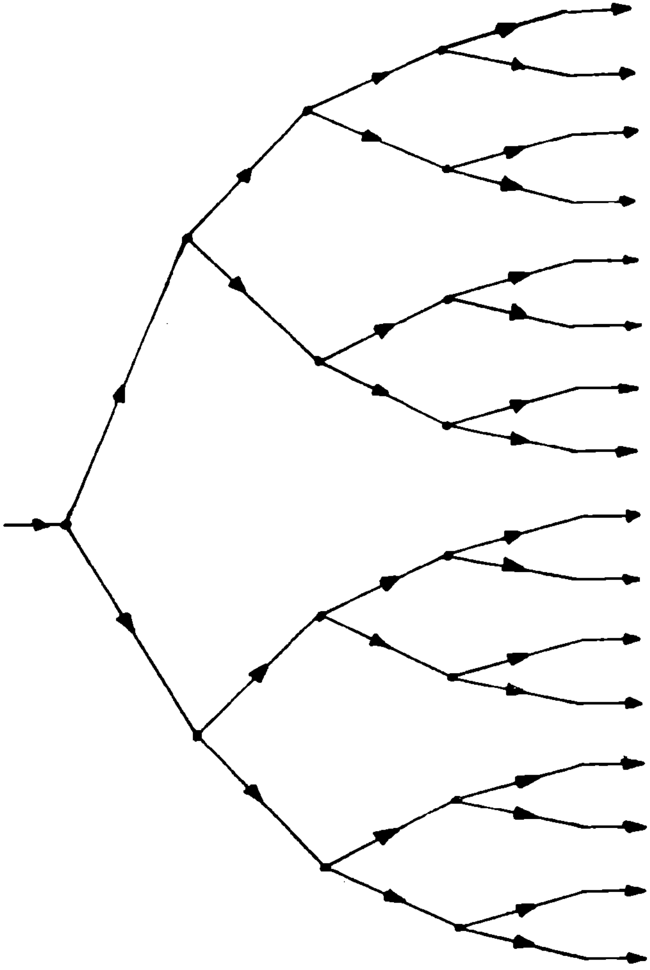

Figure 3–1: 4-Branch Decision Tree

wrong. The more options available at each decision point, the greater the possibility that they'll be wrong.

A computer with gobs of memory and the proper software can take a decision tree out a very long way. This is the sort of software that's used in such game programs as chess. It's difficult for a human being to see four moves ahead in a chess match. Some software can look further down the decision tree than that. So can some chess masters. Bridge, blackjack, and other card games work much the same way because cards are counted, kept track of, and played on the basis of what's gone before and what could occur in the future. "Zork," "Adventure," and other computer games make use of such decision tree software. It's tough to beat such programs not only because the computer is so fast but because it can remember more and recall it perfectly every time.

Although the hardware is getting faster, smaller, more versatile, and cheaper, it's just hardware without the software to make it work. The competitive drive for user friendly software has forced human programmers to study the psychology of jellyware.

CHAPTER FOUR

JELLYWARE

The jellyware portion of the human-computer system is both an extremely important part of the system and a unique system-within-a-system itself.

Jellyware, of course, is us. People. *Homo sapiens*, if you want to know our full scientific name.

As jellyware, a human being is a computer running a computer, plus a whole lot more.

Without the jellyware, there's no reason for the hardware and the software to exist.

And because of the nature of jellyware and the nature of the differences between hardware and jellyware, this is where the action of the future is going to take place in the human-computer system, not just more and better hardware and software.

We've got to look at a human being as jellyware in the context of the human-computer system because of this. The interface between the jellyware and the hardware is where the great changes and future progress lie, and it will be because of changes in hardware, not jellyware. And it will be to the benefit of jellyware, not hardware.

Hardware is in continual progressive development. Jellyware isn't. The system must continue to operate with *Homo sapiens* Mark One, Model Zero, for a long time to come, recombinant DNA research notwithstanding. (Want to start an argument? Start asking what parts or characteristics of human beings ought to be improved using recombinant DNA research!)

Jellyware therefore isn't going to change in any physical manner, but the way jellyware operates or self-programs itself *is* going to change because of computers. That's part of the nature of the future action in the field.

Hardware is going to change because it's the part of the system that can be changed and because it's by far the most primitive and backward portion of the system.

To gain some understanding of why this is so, we need to review why we are using the semihumorous 'jellyware':

Hardware is made up of a crystalline form of silicon with various impurities added to it here and there to cause it to conduct electricity or not, depending upon whether some nearby part of the crystal is or isn't conducting electricity at that moment. Electricity amounts to the movement of electrons. In a crystal, electrons move on an atomic level between the atoms of the crystal that are bound together in rigid relationships. Thus, electrons moving in crystalline substances can move quickly over short distances. Computer hardware built on a crystalline base has an information-transfer mechanism based upon the movement of electrons between atoms.

Jellyware, nervous tissue, is made up of a gelatinous organic material, a colloid, with the consistency of a gelatin dessert. In a colloid, information is transferred by the movement of electrically-charged atoms between molecules which are randomly distributed throughout the mass. The movement of these atoms can be enhanced or inhibited by chemicals. Information transfer time is slower because it's chemical in nature rather than atomic. It may involve the movement of electric charges from ionized gelatinous molecules to others, or by the movement of ionized molecules within the gelatinous mass. Or it may consist simply of the chemically-induced movement of molecules from point to point. Jellyware is slower than hardware by at least six orders of magnitude (one million times) at present. This time-response gap is likely to increase dramatically in the next decade as faster hardware is developed. Energy efficiency may also be a factor in future human-computer systems, and in this regard the energy demands of the hardware are decreasing as the hardware response time gets shorter. We require enormously more energy for information transfer because of the slowness and massive nature of the molecular information carriers.

Jellyware also operates on a similar binary or on-off system as hardware, but on a different level. The operating module of organic systems is the neuron or nerve cell which can be made to gate or burst once and then requires time to relax and renew its charge.

Hardware usually works by *serial* techniques—i.e., on-off data bits follow one another in sequence in the channel or wiring between one part of the hardware and another in accordance with the instructions from the software.

We appear to work by *parallel* techniques. That is, a complex signal that's too big or too complex to be sent down the strictly limited information channel of a neuron chain is split into a number of smaller signals which are transmitted down parallel or side-by-side channels simultaneously or nearly so and are recombined at the other end of the channel.

Our basic gate element is the neuron, which is significantly different from the solid-state crystalline semiconductor gate because a neuron can be gated by ten or more other neurons and can itself gate or inhibit gating of multiple neurons. This is the basis for the incredible parallel operational complexity of jellyware.

The response of relaxation time of a neuron is about 20 milliseconds. It transmits one bit of data, then can't transmit another until about 20 milliseconds have passed and it's had time to reload or re-cock itself.

Hardware response times are now measured in nanoseconds, or 0.000000001 seconds, about a million times faster. As hardware grows smaller and more complex, hardware relaxation time can reasonably be expected to decrease by another three orders of magnitude within this decade. This is why hardware can operate in serial fashion while jellyware must operate with parallel channels.

The human-computer system is now thought of in terms of information theory that was first developed by Claude E. Shannon at Bell Laboratories in 1948. According to information theory, an information source generates messages by emitting a sequence of symbols. An information processing system must then cause these symbols to be collected continuously and to flow efficiently through the system to enable decisions and responses to be made by the system in an appropriate sequence of timing. This is a subject all to itself, and it's so involved and theoretical that we only mention it here because it is part of the foundation of the human-computer system. You don't need to know what information theory is all about, but you should be aware that such a thing exists as the basis for much of what follows.

As an aside, information theory researchers have concluded that the English language, quite apart from its apparent inconsistencies and semantic difficulties, is quite efficient in spite of its very high level of redundancy. A lot of what inefficiency there is lies with the vowels. The information content of consonants is 50% higher than that of vowels. Humans can communicate reasonably well without them, and as a matter of fact, many slavic languages (Polish, Czech, and Serbian, for example) actually exhibit this vowel-elimination feature, especially in written form. In English, vowels can be and are slurred and often un-voiced without deterioration of the information transfer. Listen and be surprised at this.

In spite of the basic differences between hardware and jellyware, both types of systems operate with basically the same procedures. This is because one conceived and developed the other. If hardware ever really gets around to creating and developing itself, we might discover that the hardware has invented a newer system that suits itself better. But self-replicating computers may well be out of the immediate picture because of the software matter.

I have a friend who lost his job to a robot. He's now making robots.

Jellyware has all the basic black-box features of hardware—inputs, memory, CPU, outputs, and energy source—or vice-versa. But they're slightly different.

The jellyware inputs are extremely complex and have the benefit of about two billion years of trial-and-error empirical development. Those jellyware units that didn't possess suitable inputs didn't do so well in the race to replicate. The human eye is far more complicated, far more versatile, and has far wider dynamic range of response to stimuli than the photoelectric or laser character reader of the computer in the local library or supermarket. The same holds true of the ear versus the microphone and voice programming gadgets. Or the sense of touch as opposed to the capacitive or inductive sensors of a keyboard. Or the olfactory sense as compared to an ion detector of a smoke alarm. Of course the rate of evolution for mechanical systems is incredibly fast as compared to biological ones, so we can look forward to hardware sensing systems that progressively approach and then surpass our own.

The stimulus-receptor-sensation relationships in jellyware are exceedingly sensitive, as indicated in

Table 4-2. However, the item possessed by jellyware that makes these relationships so versatile is the jellware CPU, the brain.

Human memory as compared to hardware memory may be equal in some areas and not so equal in others, but one must be careful in such an evaluation because the memory technologies are different. The punched-card and paper-tape memory of hardware can be extremely long-lived, but so can the paper-based memory storage techniques called "books." Both jellyware and hardware have short-term working memories and long-term storage memories. Long-term hardware memories never forget a data bit unless the basic material of the memory unit deteriorates with age—i.e., the paper deteriorates because of sulfite content which causes it to oxidize, the iron oxide coating becomes remagnetized or re-oriented as a result of continual exposure to changing terrestrial and man-made fields, the plastic substrate suffers age embrittlement because the plasticizers evaporate, or the electric charge leaks off. Long-term human memory is widely recognized for its "data drop outs" or capability to forget, and human memory of both the long-term and short-term types can't be counted upon to play back the same way twice. Whether this is due to aging of the memory units themselves or the fact that the jellyware system distorts the data as it proceeds from the memory through the CPU to the output is not yet well understood.

Unlike the case for hardware, the mechanism of memory storage in organic systems isn't fully understood yet, either. It could be chemically stored or stored in a loop. Or it may be stored as a physical arrangement of molecules. And it may even be stored all over the body, not just in neural tissue. And strangest of all, from time to time data turns up in organic long-term memory that shouldn't be there at all.

Table 4-1
Relative Superiority In Various Activities

Jellyware	*Hardware*
Flexibility	Physical strength and power
Multipurpose adjustment	Speed of sensing
Multipurpose response	Speed of recognition
Redundancy	Speed of certain performances
Multipurpose sensitivity	Bandwidth or band rate
Self-programming ability	Speed of computation
Judgement	Constancy of performance
Inductive reasoning	Repetitive performance
Understanding of essentials	Reliability
Establishing hypotheses	Endurance
Risk-taking capability	Stability of memory
Problem solving	Short-term memory capacity
Pattern interpretation	Long-term memory capability
Decision making	Complete erase capability
Ingenuity and intuition	Conformity
Bisociative synthesis	Reaction time
Utilization of external means	Sensitivity to certain environmental conditions
Design and construction of machines and equipment	Insensitivity to certain environmental conditions
Ingegration of internal and external stimuli	Simultaneous activity
Drawing conclusions	Maintainability

Table 4-2
Stimulus-Receptor-Sensation Relationship in Jellyware

Stimulus	*Receptor*	*Sensation*
Electromagnetic waves 10^{-5}-10^{-4} cm	Photoreceptors	Light, color
Electromagnetic waves 10^{-4}-10^{-2}	Skin thermoceptors	Temperature hot to cold
Mechanical oscillations	Inner ear cochlea	Noise, sound
Pressure	Skin tangoreceptors, body pressoreceptors	Touch, weight, acceleration
Linear acceleration	Otoliths	Equilibrium, change of motion
Angular acceleration	Otoliths	Turning, rotations
Chemicals in solution	Taste buds	Sweet, bitter, sour, salt
Gaseous chemicals	Olfactory cells	Smells
Chemical and mechanical inner changes	Proprioceptors of muscles and c onnective tissue	Internal tension and pressure
High-energy effects	Free nerve endings of sense organs	Pain

The human brain isn't well understood yet but this unique three-pound mass of colloidal neurons has a packing density of gates that far exceeds the capacity of any hardware yet built. There appear to be in excess of 4 billion neuronal gates in the jellyware CPU, and many of them are multiple gates whose operation enables or disables many other connected circuits. How the brain and central nervous system manage to function and apparently to self-program itself under certain conditions remains a mystery. There is no correlation between the weight or size of this organic CPU and its ability to perform high-level synthesizing programs known as creative activity or "intelligence" (whatever that word really means, as we'll later see). However, the ultimate human-computer system may give us part of the solution to this great mystery.

Human outputs, primarily the peripherals, are far more versatile and highly developed than their hardware counterparts, because of the benefit of two billion years of steady, evolutionary development.

The human hand—perhaps it might be called an "end effector manipulation peripheral" in computer/robot jargon—is an enormously complex and versatile device. With a bit of practice (programming), each finger can be moved independently of the other fingers. It is incorrectly stated that the opposable thumb—i.e., the ability of the thumb to reach across the palm and touch any of the other four fingers—is unique to *homo sapiens;* other primates share this trait. But what *is* unique is the human wrist linkage that joins the forearm and the hand. The wrist may be bent an an angle approaching 90° to the forearm and thereafter rotated almost 180° around the axis of the forearm. While this is being done, each of the fingers of the hand may be moved independently to manipulate or to grasp. No other animal on Earth can do this.

It's possible to design a robot wrist that will accomplish the same actions, but human designers of such robot arms have been forced to duplicate the basic human mechanisms in order to do it. As a result, in comparison to the amount of force or torque (twisting force) that the human arm/hand can exert on its work, such robot duplicates still tend to be rather large and clumsy. Not very many of them as yet can feel out and pick up a dime while doing the dual rotational bit.

This appears to be typical of most end effectors, peripherals, and other non-human output devices. Engineers can design devices that will duplicate anything that any human peripheral can accomplish, and the mechanical counterpart will do it faster, more precisely, or more reliably. The mechanisms are well understood thanks to a synthesis of the knowledge of human anatomy and of machine elements. But engineers cannot yet build peripherals that are as *versatile* as their human prototypes or as small and compact.

However, the primary virtue of human beings isn't their ability to perform physical work. And certainly people can't perform as consistently as hardware can. Also we humans must rest and must perform a variety of actions irrelevant to our primary work tasks, except insofar as they keep us able to do them, i.e., recreation and maintenance. All work and no play makes jellyware non-functional in a long-term situation. Just the opposite is true of hardware, which can go on working endlessly without rest as long as it is properly supported with energy, software, and data. We on the other hand have a 24-hour cycle of requirements for rest, energy input, and work. For very long-term operation, this diurnal cycle should be broken into thirds, with one-third work period, one-third relaxation period, and one-third complete rest period. Under certain conditions, a shortened cycle known as "watch-on-watch" or four hours on, four hours off, can be accepted by some.

On the other hand, we *must* function at our highest level of activity regularly or we deteriorate. The jellyware system actually suffers software degredation as a result of idleness and lack of inputs. Whereas hardware can wait in standby indefinitely as long as it is provided with energy, lack of stimuli causes humans to exhibit "sensory deprivation" syndromes.

Thus jellyware would seem to be both the weakest and most important part of the human-computer system.

Our role in the human computer system can be broken into a number of sub-tasks:

1. Logistic support—make sure that the hardware gets fed the necessary and proper sort of electricity, software, and data.

2. Monitoring—ensure that the hardware is working properly, doesn't get into a "looping" situation where the hardware finds itself trapped in reiterative, circular calculating programs, and generally monitor the program execution—i.e., are the outputs of reasonable nature considering the value of the inputs; is the answer "in the ball park?"

3. Maintenance—The hardware can tell the jellyware that it's sick, but the hardware can't yet cure itself. There is no viable program yet for "Computer, heal thyself."

4. Construction—in spite of concerns about this sort of thing, the hardware can't yet reproduce itself. The day may be coming, and it may not, but certainly it isn't here now.

5. Modification—Hardware is "set in concrete,"

so to speak, and cannot make viable changes to itself; we must do this for it. The only modifications that hardware can make to itself are destructive—i.e., a part such as a capacitor is modified by a high-voltage spike, develops a hole in the dielectric, and thus ceases to function as an operable, synthesized part of the hardware.

6. Decision making—the hardware doesn't give orders. Only the opposite is true. The hardware can only report the logical consequences of initial programming assumptions. GIGO—Garbage In, Garbage Out.

The big changes and the most fantastic progress in the future will come as a result of the differences between hardware and humans and of the efforts to make them more compatible for the specific purpose of improving the hardware-software elements of the overall system into a better tool for human beings.

CHAPTER FIVE

WHAT THE HARDWARE/ SOFTWARE WON'T DO

These days, most computer books are devoted to telling you how to make friends with your hardware and software so it will work for you, or waxing enthusiastic about the fantastic potential of the hardware/software.

There are serious forecasts by respected scientists who believe that human beings are creating their own evolutionary successors. These savants believe that computers will eventually take over the universe because humans are too puny, weak, sensitive, and earthbound to journey either inward or outward beyond their familiar surroundings on the planet Earth.

There are even more urgent forecasts claiming that the personal computer as we know it will reach its peak of development and market penetration by the year 1990 and be replaced thereafter with "dumb terminals" connected by communications networks to large "mainframe" master computers elsewhere.

Both of these forecasts seem to me to be in error, based not only upon what we already know about the human-computer system but also what is already going on in the back rooms of computer companies and in the basements of computer inventors.

In the first case, *unless hardware and software as we know them are redefined,* we've already discussed why this is unlikely to take place.

In the second case, it's a failure of imagination or nerve in forecasting and a presumption that the forecaster knows everything there is to know about the subject whose future is being forecast. Things are moving very fast in the hardware field. The future is going to see all sorts of new hardware, some of which we'll talk about once we've disposed of the fantasies surrounding the future of the computer.

In this regard, it's also becoming apparent that there's going to be a lack of a future in the software department.

Other forecasts of the potential of the computer appear to have been made by people who haven't lived with and worked with a computer of their own. I have. I've had a constant daily companion, Calliope, who's only a very small, very slow, and very limited personal computer. Even keeping in mind Calliope's limitations and realizing that I could up-grade her to more memory, new software, and a modem for networking, to say nothing of the possibility of replacing her with a more recent computer with more memory, I already know that neither Calliope nor any other general-purpose personal computer could possibly do most of the things forecast for computers in the near future.

On the other side of the coin, there are some forecasts of potential computer uses that would appear to be unnecessary or superfluous. Some tasks don't need a computer to make them simpler, quicker, or easier. In fact, computers make those tasks more complex, expensive, and subject to hidden errors in programming or data inputting.

For example, a computer will balance your check book. So will a pencil and a piece of paper, which are a lot cheaper. A check-balancing program costs money, and it is still necessary to enter the data for each check written. If you already own a computer and would enjoy automating your checkbook, what the heck, but please don't think of it as a major benefit.

As banks go to full electronic fund management, it will be worthwhile to use a microcomputer linked via a modem and the telephone line to the bank's computer for the purposes of checking balances and transferring funds, the sort of thing that you now can do with the automatic teller machine outside the bank building. This automatic teller machine is nothing more than a dedicated terminal connected to the bank's computer. The only thing you would not be able to do with a microcomputer connected to the bank computer is to make deposits and take cash withdrawals; these transactions still require the exchange of slips of paper.

Electronic funds transfer—the completely computerized financial and banking system—is generating a lot of controversy at the moment because of fears of loss of privacy, mistakes, etc. I've got news for you if you don't already know it: Your bank account isn't private. Federal and state government tax collection agencies can gain access to it. Lawyers can get information about your bank transactions by means of legal action. If you really think that your bank transactions are privileged information between you and your banker, you're living in a dream world. And if you knew how much banking is already totally dependent upon computers without a single slip of paper changing hands, you wouldn't be concerned about electronic funds transfer.

Insofar as gaining access to your account is concerned, it can be done right now if your bank is equipped with one of the automatic teller machines that accept your bank credit card or banking machine card. You have a confidential number that protects your account, but anybody with your card and your number can get to that account, too. In the face of all this, the system appears to be working right now, in spite of the fact that thousands and thousands of cards are lost or stolen weekly. Ask your merchant or bank to let you look at the weekly booklet listing, in very small type, the numbers of all the lost, stolen, cancelled, or otherwise dishonored cards.

So electronic funds transfer is indeed coming and, to some extent, is here today. Paychecks, social security checks, and other checks for income are mere figments of imagination if you already have them automatically deposited to one of your bank accounts. Some financial institutions today offer the service of paying bills by telephone; in this system, the touch-tone pad or dial of a telephone is used as your terminal to input the data to the financial institution's computer, which automatically transfers funds from your account to the payee's account.

Home computers will indeed simplify personal banking in the very near future. It's inevitable not only because most of the technology as well as the hardware and software are already in place. but because financial institutions are being drowned in a sea of paper.

If your computer can run BASIC, there are already programs that will type out your checks for you. It only takes a small change in such a program to keep track of checks written, the account balance, etc. And it would take only a modem to link your home computer to the bank's computer. In fact some banks are already offering the service, both directly and via services such as The Source.

But if you just want to balance a simple domestic check book, using a computer is like using a sledge hammer to swat a house fly.

There's a lot of over-computerization going on right now as people search for ways to put their computers (their personal ones and the ones they are trying to sell) to work. Another one is setting up your home computer to monitor and control your household energy useage—electricity, water, heat, etc.—and thereby save you money.

What the computer salesmen and their fellow travellers don't tell you is what this little trick costs.

First of all, your computer won't run your house or apartment all by itself. The dwelling place must be wired so that the computer can get data from the dwelling and give commands to furnaces, air conditioners, etc.

This should be no problem in a new house under construction; just string twisted-pair cables all over the place as though you planned to install a super-stereo system. In existing dwellings, wiring the place for computer control is almost like the problem your great-grandparents faced in wiring their nineteenth-century house for electricity. I can still remember the mess when in 1937 my parents ripped out the old coal-fired steam radiator heating system and installed a neat, new, gas-fired forced air heating system; they practically had to tear the house apart to do it.

Once the wiring is in place, you've got to install the sensors to feed data to the computer and controls that the computer can control. You won't be able to just modify the thermostat; you'll have to install a whole new thermostat with a data link to the computer. Insofar as electric power is concerned, the only way to limit the amount of power you use is to either turn things off when they aren't being used or have the computer issue orders to a load control system that will prevent appliances, lights, and other electrical devices from being turned on. This is extremely expensive when compared to your own ability to turn off a light switch when you're not using that lamp or schedule your electrical power use so that you don't run the dishwasher, clothes drier, garbage disposer, garbage compactor, electric space heater, electric clothes iron, and maybe the air conditioner all at the same time.

Even in the case of homes constructed with computer control in mind it's quite unlikely that your personal computer itself will be used. The sort of progress we're seeing in the way of hardware indicates that home-control computers will be specialized micro units—i.e., a special chip installed in a thermostat, another installed next to the electrical distribution and circuit-breaker panel to control loads and priorities of circuits, etc. This approach offers technical reliability as well because the failure of one chip can't mean that the whole computer-controlled system would go down at the same time. Furthermore, the use of micro units with small batteries for stand-by power eliminates the problem of what happens if the bigger computer loses power.

Computers are a lot like government: If you want efficiency, reliability, logic, and truth, don't depend upon a monolithic centralized unit or system, but break things up into elements that can use smaller and more efficient control units.

This is the way home computerization appears to be moving anyway. If you own a microwave oven, chances are that it has its own integral, dedicated microcomputer. If you have one of the new dishwashers, clothes washers, or refrigerators, it's probably got its own dedicated microcomputer inside. So does the video casette recorder, the stereo, the TV, the electric blanket, the telephone, and even the thermostat (if you'll concede that a timer-controlled thermostat is a very crude control computer).

You're already living in a computer-controlled home. The future of this dwelling doesn't lie in wiring it for your expensive personal computer, but in continual up-grading of the systems and appliances in the dwelling with new and improved units containing microprocessor chips and improving ROM programs for them.

You won't be able to predict the future with a computer, but you'll be able to make a better guess about things to come. A computer isn't omniscient or precognizant. It can't predict the future any better than you can. As a matter of fact, you can probably do a better job of predicting the future because a human being is excellent at the difficult task of drawing conclusions from insufficient data. This is a human trait that's meant the difference between survival and death, success and failure, wealth and poverty, etc. People can and do guess and take enormous risks by betting against tremendous odds. Sometimes they win; sometimes they lose. Admittedly we hear mostly about the winners and tend to forget the losers, but there are plenty of winners, nonetheless.

Human beings, using their colloidal computers, do this by both extrapolation and a statistical trick called "gambler's chance."

Extrapolation is a word that's mostly been used in mathematics but is part and parcel of future forecasting. Basically, it means that if you know where something's been and how it got from where it was to where it is now, you can determine where it's going to be in the future. You simply extend or extrapolate its performance, movement, etc. into the future by means of extending its known past performance. That will at least give you a "surprise-free" forecast which is a helpful point of departure.

But you've got to keep in mind that there's no such thing as a "surprise-free future."

Computers can do surprise-free forecasting very well if the software is good. Remember Robert Townsend's admonition that a computer is nothing more than a fast, dumb, adding machine. It can also be instructed (programmed) to compare factors and utilize one or the other in upcoming calculations. If you know where your business has been, what its sales figures are, and how its performance has behaved in the past, your computer can digest all this data, make comparisons, and spit out answers in the form of columns of figures or graphic outputs. This is all (all!) that the impressive business management programs do.

Computer projections and forecasts are only as good as the data available on past performance. GIGO (Garbage in, garbage out). And the further back in time the performance data extends, the more likely it is that the computer can project future performance. In that strange area of mathematics known as statistics, this is known as "working with a sufficiently large statistical universe." One year's business data may be meaningless when it comes to forecasting the following year's likely performance, although there may be numerous mitigating factors that would tend to make this statement incorrect. But don't count on mitigating factors. In personal business, past performance data is usually insufficient for projecting future performance unless you have at least five years' good, solid data on hand. For forecasting the performance of large economic systems like the national economy, ten years' worth of data may be necessary or you may have to dig out a century's worth, depending on what you're trying to forecast. (There are so many little irregularities or "glitches" in these performance data that you may have to be very careful when you go to "smooth" them out in order to determine long-term trends. The extent to which you're correct is probably directly related to your success in forecasting, which, if you're playing games with the economic system, is in turn reflected in your net worth.)

Both jellyware and hardware run into profound difficulties in handling "discontinuous" trend data. This is best exemplified by the process of making jellyware. If, in the eighth month of new production, past trends of size, weight, etc. were projected into the future, the situation would appear to be untenable. By the end of the eighth month, the new unit is filling up most of the production space; by the ninth month, the production space is full; projections would therefore indicate that by the tenth month the situation will be completely out of hand and impossible. Which it is because there is a discontinuity, something mathematicians call a "cusp," somewhere during the ninth month. There are many systems that behave in this manner. They have led to the development of the controversial mathematical area known as "catastophe theory" developed by the French mathematician Rene Thom. Computers can't handle such discontinuous operations because we can't; when we learn more about such crisis phenomena, we will be able to write the proper software so that the high speed and large memory capacity of hardware can help us forecast cusps, crises, and other situation where everything undergoes a sudden and widely variant change.

When it comes to handling "gambler's luck," the capabilities of the jellyware and the hardware can be comparable, depending upon the abilities of the jellyware and the software available to the hardware.

Gambler's luck is epitomised by the evaluation of statistical probability in the statement, "The last nine coin tosses have come up tails, so there's an excellent chance that the next toss will come up heads. So I'll bet on heads."

This may or may not be the case, but that's what makes crap games, poker games, and other games of chance that some people delight in playing against each other and against the universe.

Humans mostly play this sort of game by guess and by gosh, using hunches and working with incomplete evaluation of insufficient data. Some people are very good at this. They're called "lucky." They have gamblers' luck.

Hardware can and does play this sort of game very well, but on a totally different basis. One of the features of any respectable computer these days is a circuit that generates random numbers, or, more precisely, "pseudo-random" numbers. Basically, the hardware is programmed to do the computer equivalent of shooting craps. The hardware generates numbers at seeming random. It can't really do this, but it can spit out a string of numbers that don't repeat themselves within a sufficiently long period of time (even from the viewpoint of the hardware cranking along at two million computations per second). Unfortunately it will always be the same series, unless a human or cosmic ray trigger is used to start things . . . randomly.

Thus the closest thing that hardware can do to approximate the hunches and guesses of jellyware is to generate a raft of pseudo-random numbers and pick one to work with. This appears to be luck, hunch, and guesswork on the part of the computer, but it's only appearance. The hardware is working with impeccable logic—as it always does. It can't guess because it's incapable of doing such a thing. It picks a number at "pseudo-random" and then acts on the basis of what the software tells it to do if it is odd or even, divisible by two or five or six, contains five sequential identical binary digits, etc.

Given enough data on past performance, hardware governed by good software can forecast a "surprise-free" future, but it can't predict the future.

A suitably powerful computer run by the appropriate software will appear to have doped-out a system to win at black jack, craps, or roulette in Vegas. At best, it may even equal the performance of jellyware on a hot roll (you should pardon the expression).

Computers (hardware + software) won't straighten out a system or organization by themselves, that is by taking over the management of that system. They will only make it worse; if humans are having trouble controlling a system, that means they don't understand it yet. Therefore, any software will contain all of the non-understanding, misunderstandings, prejudices, and incorrect or incomplete data that is screwing up the system in the first place.

Anyone who's had to make machinery of any sort—physical or social—operate properly knows full-well that the bigger any system becomes, the more difficult it is to control because of the increased number of variables involved. More things can happen. More things can go wrong. You may be able to juggle three balls in the air and do a good job of it; increase the system to thirteen balls, and the chances for something going wrong increases enormously.

Industrial engineers are faced every day with large, complex systems. They will tell you in no uncertain terms that they will refuse to automate *any* system in one step. They will automate the system a step at a time, make sure that everything works, then proceed to automate a little more.

To a mathematician, the industrial engineer is performing an act known as "empirically determining the mathematical model of the system." The industrial engineer is automating one variable at a time to discover its effect on the rest of the system. The mathematician or the theoretical (as opposed to the empirical) industrial engineer will attempt to "write the mathematical model" of the system first. In short, to write the program.

But it's damned difficult if not impossible to account for all the variables in any system. That's why empirical industrial engineers still have jobs.

There are a very large number of systems that have been fully automated successfully. There will be more that succumb to automation in the years to come. Right down at the roots, computer hardware amounts to an extremely complex system, and programmers have managed to learn how to automate it so I can use Calliope as a supertypewriter, for example. My computer is an extremely complex system that's fully automated except for its requirement that I feed it energy, instructions, and data.

Soon—sooner than most people think—the current phase of hardware and software development for computers will be completed. Computers will have reached a technical plateau. All the hardware for a given task in a given price range will be just about the same. All the software to do almost any job you'd care to call upon a computer to do will be written and available. A few programmers will continue to be required to handle special, "one-of" programming jobs. What will happen then is that these unemployed hardware experts and software writers will discover that they can put their hard-won know-how to work automating other very complex systems.

But, in the meantime, don't think that you're going to get out of the mess you're in by computerizing your screwed-up household accounts, business inventory, or other personal system that's giving you trouble. If you don't understand it to the extent that it's gotten messed up, you won't be able to program your computer to do any better than you can.

However, once you understand the system (and admittedly attempting to create a software model of it is a good way to study a system) you want to automate or computerize, you can turn it over to a computer to run so that you can go on to do things more interesting and fascinating than the repetitive tasks of keeping the system running.

If you haven't already gotten the message, it's just this: A computer is an intellectual tool to permit you to use your mind more efficiently and effectively just as a crow bar is a tool that will help you move a balky or heavy object. A computer won't do anything that you can't do for yourself, but a computer can do it quicker and never forget it as long as you feed it peanuts of energy and don't scramble the permanent program or data storage.

Although there are a lot of things that computers won't do that you've been told they would do, they will do a lot of things we've never anticipated they might, especially when we start to think of them as intellectual tools for extending brainpower.

CHAPTER SIX

GAMES OR COMPUTER AWARENESS?

There is only one person who foresaw even the faintest glimmerings of the connection between the heavy use of computers and the human penchant for playing games against everything: Robert A. Heinlein in his science-fiction novel, "Beyond This Horizon," originally published in 1942. One of the book's heroes utilized an enormous computer to manage the world's economy while the main character made a very good living by developing computer games. In spite of this prognostic book, however, computer developers charged boldly ahead making computers that were primarily designed to solve knotty mathematical problems in various areas of technology. It wasn't until *toy companies* discovered what could be done with computer technology in the 1970s that the modern computer (hardware *and* software) based on the microprocessor on an integrated circuit chip was developed into the first of the true personal computers (as distinct from the number-crunching pocket calculator). By 1983, millions game-playing computer "toys" were in American homes.

All this has not escaped the attention of such authorities as the Surgeon General of the United States of America and others who are loudly expressing an unwarranted concern born of computer ignorance: That young people are becoming extremely agressive as a result of playing computer games.

A discussion of the significance of this introduction of computerized "toys" into the home and of the gloom-and-doom reactions of the usual "view-with-alarm" people is an integral part of the development of the theme of this book: the nature of the growing use of the computer as an intellectual tool for human beings.

Let's take the latter first, the hue and cry about the dangers of computer games with respect to the mental health of young people.

Dr. William B. McGrath, the doyen of psychiatrists in the American Southwest, believes that from the psychological point of view, computer games are a technological substitute for masturbation. But it may go further than that.

Most of the violence rendered by human against human through history has been conducted by young people less than twenty years of age. They may have been led by people older than this, but even Alexander the Great undertook his most violent wars and conquests while he was still in his teens. The physical violence of war was and still is a young person's activity because of the sheer intensity of the physical actions required. Warriors are young, usually still in their teens. Knights of the

Table Round and other fealties were mostly teenagers. So were most of the adventuresome kings and princes of legend. Not only did they have to be young to have the physical strength, health, and endurance in a world without the benefits of modern public and private medicine, but they possessed what nearly *all* prepubescent, pubescent, and immediately post-pubescent human beings, particularly male human beings, apparently have built into their genetic makeup and reinforced by cultural training: the strong tendency to utilize physical force and violence to coerce other human beings. The more recently developed techniques of politics, diplomacy, tact, protocol, and manners require a great deal more time and effort to learn. It's easier to take it than talk about it. And young people are just as much mammalian animals as their parents; they follow the biological Law of Least Effort because we all do.

Young people—children from the earliest walk-talk period up through post-adolescence—are violent hunters, fighters, warriors. Most of their playground games are based upon or derived from the violent history of their forebears. The very love of games themselves is an expression of their hunter's legacy to compete for the best parts of the kill, the best hunting grounds, the best mates. This is not a cultural thing since all existing human cultures have derived from the basic hunter culture of 50,000 years ago. Ontogeny recapitulates phylogeny—i.e., the development of an individual organism recapitulates the development of that type of organism, its racial history if you will. Each individual human being therefore goes through the same physical and mental development periods, stages, or phases as the total human culture and civilization to date.

In reply to the objections of pedagogues and the cries of anger from right-thinking, peace-loving, liberal-minded people everywhere to this statement of the basic violence of children, I merely request that the activities of children at play be observed carefully from this viewpoint. I have raised three children (with a lot of help from my wife) and have been the glorious leader of numerous youth groups ranging from local clubs to national organizations. The children turned out to be good citizens, and the organizations appear to have done some good and are still around. I must have been doing something right, even with this apparent aberrant philosophy about the innate violence of young people. (What I did, of course, was to accept the tendency toward violence and then channel it into paths that weren't physically harmful to others.)

I would be greatly worried if young people *didn't* embrace the violence of computer/video games. Something would be wrong if they didn't like them. They would be skipping over an important part of their development that *can't* be skipped if we expect them to grow up to be adults who are capable of learning the fine and highly advanced arts of politics and diplomacy as a means for settling disputes instead of war.

Isn't it just great that young people can vent their violent tendencies on a video screen rather than with weapons in the streets?

Nobody gets physically hurt, wounded, maimed, or killed playing video games with computers.

I'd like to see every child in the world have a video game capable of playing "Dungeons and Dragons" (the old fairly tale game) or "attack/defend" (war games). Maybe then they wouldn't get mad at the kid who lives across the river and go to war with him.

Computer video games are surrogate fights. As very realistic simulations of actual situations, they can take the place of the real thing just as effectively as the big brothers of these games, the flight simulators, do for airlines pilots and astronauts. And for the same reasons. Airplanes and spacecraft are expensive to fly, and if a student makes a mistake it can be deadly. Fights and wars are expensive and also deadly. If computer video games are simulators for fights and wars, their use should be encouraged *not* in order to train warriors but to provide a safe, non-harmful outlet for the basic violence inherent in all human beings.

The availability of relatively inexpensive computer video games has had the effect of bringing small, modest computers into the home while at the same time getting young people familiar with computers themselves. When you've played realistic games with a computer programmed to seem almost human, it's hard to be afraid of them.

Toy tools fabricated from wood are still made for children. One of the most popular toys of all time has been the "pounding bench," a wooden rack with wooden pegs installed with a tight fit in rack holes, plus a small wooden mallet. The objective, if you can call it that, is to pound the pegs through, turn the rack over, and pound the pegs back again. Children love it. It makes noise.

It lets the child do something physical in which results are immediately forthcoming. It also teaches the child to use a very ancient tool: the hammer.

Believe it or not, video games are teaching children—and their parents—to use computers in a fun, game-playing setting where, win or lose, there are no serious physical consequences, only a psychological situation involving perhaps a temporary boost to or loss of ego. When the children get older—and when the parents discover computers in the office or factory—the computer games become more serious and are played for keeps.

"But computer games don't teach anything about computer technology or programming!"

As we discussed in an earlier chapter, who needs to know computer technology in order to make a computer work? Who needs to become knowledgeable in programming to get a computer to run a program already written? I haven't the foggiest notion of what this computer's word processing program looks like, nor do I really care. It works when I run it. It's a tool, and, once I learned how to use it, there was no need to know the intimate details of its workings, only a matter of idle academic curiosity on my part, a desire (but not a need) to know a little bit about what it was all about.

If you own and drive an automobile, you don't have to know how the engine works in order to get to the office or the store. If it won't start or quits running, it's nice to know a little something about it because that may save you some time, money, and trouble.

In the case of my computer, however, its reliability is several orders of magnitude better than any automobile. And when my computer does go down, which is seldom, at least it doesn't strand me on the side of a lonely two-lane road in the mountains during a snow storm. It may strand me in the middle of a literary gem with my Editor screaming in my ear about a deadline, but that's the normal condition of a writer anyway, and we can usually sweet-talk the editor.

The video game computer in the home plays much the same sort of role as the automobile, the stereo, and the other domestic devices born from technology and industrialization. If we grow up with these things, we get to know them as familiar gadgets and even as mechanical friends. They take on all the trappings of human personality. This of course is nothing more than anthropocentrism, we humans attribute human personality to our technical toys and gadgets, despite the fact that these devices can't possibly have such human attributes.

But tell that to anyone who has owned and cherished an automobile or a computer. These reasonably complex creations of human intelligence and labor seem indeed to take on personalities of their own. I am on friendly terms with my cars, my airplane, my computer, and even the dishwasher. I know they're not intelligent machines, yet each of them often seems to have a mind of its own, particularly when something goes wrong and I'm trying to find out what and fix it. And when I'm driving, flying, writing, or otherwise using these technological tools of mine, there seems to be a mystic, almost existential relationship between myself and the gadget. It doesn't invade my mind or soul.

Quite the contrary, it seems that I extend my senses and nervous system into the machine so that it becomes a friendly, helpful extension of myself.

With this sort of mystic relationship, it's not necessary to coddle the device, but one must indeed care for and cherish it—i.e., maintain it properly, repair it promptly, and use it well within the limits of its design. Occasionally, it becomes necessary to push the device to its limits, but one doesn't run a gadget balls-to-the-wall continuously and then expect not to have trouble with it. (The same philosophy also works with people, by the way.)

In 1965, I bought a new Plymouth Barracuda Formula S and decided that I'd see how long I could keep it if I just followed the instructions in the owner's manual for routine maintenance and if I kept the machine in good running condition. I still have that car. Above and beyond the regular maintenance—oil changes, new oil filters, and lube jobs—that you have to perform with any car, my records show that I've spent an average of $200 per year on repairs, including one major overhaul of the engine.

I grew up with automobiles; there were always cars around me. I was taken by auto from Niagara Falls, New York, to Denver, Colorado in an open Hudson touring car in 1929. The first piece of complex machinery I owned was a 1927 Dodge coupe. I'm not afraid of cars, nor do I believe that they will take over and control human beings. This feeling of technological friendliness with automobiles is common. As a result, we're people on wheels and, by and large, we are friends with our vehicles. On the other side of the coin, I know other Americans who didn't grow up with cars because their childhood and youth were spent in dense urban areas. They have trouble with cars and with mechanical devices in general; they also seem to be a bit afraid of technology.

The same holds true with my relationship with aircraft. Airplanes have been a part of my life. The city where I grew up, Colorado Springs, boasted an airplane factory, the Alexander Airplane Company, manufacturers of a lovely biplane called the "Eaglerock" (looked like an eagle, flew like a rock). I can recall my first airplane ride in a Ford Trimotor. I can recall my first ride in a small plane, a Stinson 105. It was more or less accepted that I'd learn to fly, and I can remember my first flying lesson in 1943. I am not afraid of airplanes because I grew up with them.

I am not afraid of household machines because I also grew up with those.

I have a number of good friends in Europe, including people who live behind Eastern Europe's "Iron Curtain." I've been to their countries and to their homes, and I've taken some of them around the United States and hosted them in my own home here. Most of them are scientifically and technically trained and educated. And most of them have an outlook on machinery totally different from that of Americans. These people don't grow up with technology as Americans do. Owning an automobile in their homelands is a privilege that requires special dispensation from their governments, even in the western European nations. There are exceptions to this, of course, as in the cases of

Germans and automobiles and Britishers and aircraft. These exceptions tend to prove my point: that people who grow up with technical devices around them tend to be friendly with those devices and see them as extentions of themselves.

One friend from an eastern European country was fascinated with racing automobiles, so I took him to a drag race in California. He'd read about such things and seen pictures of them, but had never watched them. He remarked that there was nothing comparable in his country. I told him that his country possessed an outstanding automobile industry with a long and illustrious history of racing behind it, and I suggested that there could be drags there if enthusiasts wanted them. (His government encouraged such technical activities.) He replied that they "didn't have the engines for it." This surprised me because we don't either; drag enthusiasts *make* their engines—through extensive modification of existing ones. It's not necessary to have an extensive parts and accessory industry backing up hot rodding and racing; you can do a lot with a good machine shop, and I knew there were such things in his country. What was lacking was a lifelong intimacy with machinery such as automobiles, an intimacy that is almost taken for granted in the United States because we grow up with cars, planes, and technology.

Now children are growing up with computers. In the twenty-first century—or even before—this lifelong intimacy with computers will exhibit a profound effect on how these citizens apply computer technology and how they utilize computers. The United States may not lead the world in hardware production then, but I am almost certain that the United States will be far ahead of the rest of the world in knowing how to apply computer technology and how to use computers most effectively. And that's where the real action will be.

The upcoming computer generation—we only think that today's computer designers, programmers, and technicians are part of the computer generation; the next generation will exhibit the traits of a true computer generation—will have their equivalent of the hot rodders, radio hams, stereo buffs, experimental aircraft enthusiasts, and amateur technologists of all types that exist today. They'll be performing the equivalent of "hot rodding" computers as well as using computers in ways that we can sometimes only guess at today (and probably very conservatively at that). All of us are at a disadvantage in this regard; we haven't grown up with computers.

The new computer generation will have a handle on the world that we can only dream about. This is because they'll be using their computers as tools to extend their intellects.

Think of it in this simple analogue: You're building a fine piece of cabinetry using a rock to drive nails while this new technical generation will be using a hammer, staple guns, and other tools that are extensions of their abilities. Who's going to be able to build a better piece faster and with greater beauty, design freedom, and utility?

Furthermore, they'll be taking their new recreation—computer gaming—into their future with them. We are engaged in playing several games—against and with nature, other people, and other organizations. Some of these are deadly and getting deadlier. The computer generation that's grown up playing video games with computers will be playing adult games with and against computers and other people who also have computers. Those of us who don't know or have computers will be at a severe competitive disadvantage; even if we know and use computers to the best of our abilities, we still won't be able to offer real competition to this computer-using generation.

It's going to take some time for other nations and cultures to catch on to this because they're still playing the centuries-old games that are deadly and that no longer need to be played. Furthermore, these ancient games are destructive of both this planet and other people. However, these non-computer cultures won't stand a chance against those who use the powerful new tools of the intellect that are the computers. The computer generation will be able to out-think, out-plan, and out-maneuver those without computers because of computer simulations which will allow the investigation of a wide variety of options.

There's an additional factor that convinces me the computer generation is going to win, and it's a consequence of computer video gaming and the general introduction of the computer into the home that accompanies this recreation, and it's already starting to happen.

CHAPTER SEVEN

WINNING THE RACE WITH CATASTROPHE

Herbert George Wells observed in his monumental work, "The Outline of History," in 1919 that "history is a race between education and catastrophe."

Education is winning that race.

Computers not only increase the odds of education winning but provide the means to insure the victory.

There are two basic technological factors in the education race: handling information and communicating it.

The means are already in hand to communicate any information in a wide variety of formats to any spot on the surface of the Earth with the near instantaneity of the speed of light. The United States now possesses the finest communications systems in the world, and these systems are spreading and growing to cover the entire world. By the end of the twentieth century, Arthur C. Clarke's "central nervous system of mankind" will be totally in place.

Even today, it is possible to make a direct-dial three-minute telephone call to any other telephone in 86 countries plus ships at sea from any dial telephone in the United States at any time for less than $5.00—and there is one telephone for every two people in the United States. The only continent that cannot be reached by telephone is Antarctica, and that's only because there is no telephone service on that frigid chunk of real estate.

If people can talk to other people on this communications system, computers can also talk to other computers, people can talk to computers, and computers can talk to human beings. This network then becomes a communications/information network, or comm/info net.

The primary technological breakthrough that has made this possible is the communications satellite. The exploitation of space, thought by many people to be a money-wasting boondoggle, has already paid off far beyond the most sanguine dreams of the space pioneers and far beyond the comprehension of most people. More than one billion dollars is made every year as a direct result of communications satellites, and communications satellites have more than repaid their initial investment.

Communications satellites are taken for granted today, and hardly anyone ever thinks about them. But they're there, they're working, and we'll use them along with the computers to win the race between education and catastrophe.

When people can talk to people, there's less chance that they'll fight over trivial matters.

When diplomats can communicate instantly with their home capitals, there's less chance that a misunderstanding or miscalculation will result in armed conflict.

In a world of instant communication, where it's possible to learn of atrocities, looting, killing, and destruction within a matter of minutes rather than months, and when those responsible can therefore be quickly apprehended, there is a greater deterrent to doing these things. It isn't true that absolute power corrupts absolutely, but it is true that absolute immunity corrupts absolutely. Immunity from responsibility in the past could be achieved by the passage of time. If months went by before the news of an act reached others, the perpetrator could be and usually was long-gone into the hills or the madding crowd. And the immediacy of the act was lost in the process. Time heals most wounds. Time also can cause festering of old wounds which lead to hatred between people who don't communicate with one another.

We therefore have the technology, most of which is either already in place and ready to work or is almost immediately achieveable with a modest amount of capital and effort.

An inevitable question arises: Just because communication is possible, is that any insurance that anybody's going to listen? Of course not, just as there's no insurance that anyone is going to pay the slightest attention to a commercial on TV or read this book. What is communicated must be of interest to the listeners; it can't be rammed into their minds.

The key to communicating educational material to the other people of the world and getting them to listen, remember, and use the information communicated is a task for the field of marketing as it has been developed in the United States during the twentieth century.

Marketing isn't the sort of thing most people believe it to be. There have been some fast-talking con artists in the marketing business who have unfortunately given a bad name to a field that in reality is quite useful and effective.

Today, the art of "marketing" is something more than offering a product or service. Marketing is more than just "sales" or a group of salesmen calling on potential customers. Marketing involves every aspect of any business from product development to warranty and service. It seeks to answer a plethora of questions: What are we selling? To whom? For how much? How do we get the message to the customer? In what form? With what content? Are we charging too much? Are we charging too little? Are there others who would buy it if we presented it in slightly different form? What form? How many others?

Marketing can be approached from two directions: (a) product/service-oriented marketing, and (b) market-oriented marketing.

The first method is used to bring a product or service to market in the best manner. It means identifying who might be interested in it, how to get the information about it to them, how many people might be interested, and what they might be willing to pay for it. If an insufficient market exists, a market can be created by means of advertising. This is quite the opposite of the old adage of the better mousetrap; the world doesn't beat a path to the factory door any more, not even in these times of rampant consumerism. Nor can the old Henry Ford marketing philosophy work; people want the freedom of choice and want products in many colors other than black.

The second type of marketing has become possible because of technology itself. We can now create products and services that have never before existed. But one cannot go on forever creating neat new technical products without thinking about the marketplace. "We have learned to our cost," said Richard Hiscocks of the National Research Council of Canada in 1976, "that the spur to industrial progress is in the marketplace and not simply in developing new technology." Therefore, the second type of marketing was developed: One goes looking for a desire. (Not a "need;" there is a difference between a "want" and a "need.") Somewhere, some one wants something and is willing to pay for it. The marketeer's job is to discover and identify that market, analyze it, determine the product or service it will buy, analyze whether or not the potential market is large enough to warrant the time, money, and effort involved, and then turn the technologists loose to develop the product or service.

There are pitfalls in marketing as there are in almost any field of human endeavor. Ford Motor Company would probably just as soon forget the Edsel, but they'd like to have another Mustang. Most Japanese firms are now doing excellent marketing because they've read the American market correctly and their sales show it; no amount of protectionist legislation can or will redress the mistakes of poor decisions made from improperly-done marketing.

One of the favorite stories in the marketing area involves the meat-packing company that had a lot of left-over by-product as a result of their canning operations. Some bright marketing lad came up with the notion of converting it into dog food. The company's food technologists developed a dog food using the left-overs. The advertising people came up with a great ad campaign. The sales department placed advance orders for thousands of cases of this new dog food because the wholesale and retail buyers were putting their confidence in the good name of the meat-packing company. The production lines started up and cranked out warehouses full of the new canned dog food. Initial sales in the retail outlets were brisk. The sales department geared up for the re-orders . . . and waited . . . and waited . . . and waited. No re-orders came in. On the contrary, soon unsold cases of dog food were being returned to the factory in truck-load lots. It was a good product attractively packaged and aggressively promoted. But dogs wouldn't eat it.

Marketing know-how, properly applied, is the real secret to the ultimate success of hooking the small computer to the worldwide comm/info net for the purposes of human education.

From the marketing point of view, education, or training everyone to utilize his mind to the limit of its capabilities, is the service to be offered.

We know there is a "need" in the world for education. However, there isn't necessarily a "want." Some people are perfectly happy the way they are:

living in poverty and privation because they don't know anything different. The old ways are familiar and comfortable, even though the old ways include death and destruction, hunger and privation, pain and suffering. Their lot hasn't changed since the beginning of written history because the only things they know are the empirical techniques and know-how passed down orally from generation to generation. Most of these people have been caught in the backwaters of human progress; they can't communicate with the rest of the world. When they learn how, as they have been doing for the past fifty years, they want the "something better" in the worst way. They don't know that they have to make it themselves and cannot take it away from those who have it. The only way to solve this basic human problem is through education.

Marketing can and must be used to determine the educational needs of various peoples around the world and then used to design the advertising program that will make them want it and the educational programs that will provide the education itself. We're likely to discover that, by and large, the educational wants of most people everywhere are pretty much the same—the necessary know-how to increase their potential for survival by permitting them to feed themselves, provide themselves with shelter and clothing, and improve their health. We shouldn't automatically assume that each group of people has widely different needs because of its location or cultural background. We've actually sold refrigerators to Eskimos because when Eskimos get insulated dwellings with central heating, they don't want to go outside into the natural refrigerator any longer. They're no dummies, and they're as lazy as the rest of us if technology can do a job for them. That portion of marketing known as "advertising" can create a desire out of a need.

We can now communicate to everyone, on a one-way basis. The basic system includes a television set, satellite communications receiver, and a one-meter parabolic dish antenna. The whole works can be powered at first by a bicycle-driven generator; it won't be too many years afterwards that someone builds a sun-powered unit, hydro-electric generator, or even a steam-driven power plant using what he's learned from the bicycle-powered TV system.

Now arises the question: *What* do we provide in the way of information? How do we educate billions of people in thousands of cultures, each with their ancient taboos and rituals, each speaking a different language?

This can't be left up to the individual or even the leader of the local village or tribe. There are several reasons for this.

First off, an individual doesn't know what he needs to know. Educational research was conducted by Bell Laboratories back in the 1940s and 1950s because they had to find out how to train thousands of people to install and service the increasingly complex AT&T telephone network. What they discovered was and is quite at variance with the theories of professional educators and pedagogues. In order to perform any task or practice any trade or profession, a person must be taught all that needs to be known about that task, trade, or profession. A student cannot be permitted free choice; there is certain information that *must* be learned. (Imagine being treated by a medical doctor who has decided in medical school that anatomy was unimportant because he was interested in blood chemistry. Or living with the end product of a plumber who never learned how to sweat a joint in copper piping because he liked to thread galvanized pipes better.) A person must be taught a lot of things that may not appear to be important at the time. And it may be very difficult to get a person to remember these apparently unimportant facts or techniques.

And the village, tribal, or *national* leader can't make the decision on what to learn and what to skip over. Besides the reasons that should be apparent to any reader (unless he's ignorant of what happened in Germany from 1932 to 1945 or what is happening in the Union of Soviet Socialist Republics even today), the glorious leader doesn't really know what his people need to know, either. Or, if he thinks he does, it's probably incomplete. Knowledge itself isn't and never has been dangerous, but incomplete, censored, or "cleansed" information always has been. Alexander Pope was right in *Essay on Criticism,* Part II: "A little learning is a dangerous thing/Drink deep or taste not the Pierian spring:/There shallow drafts intoxicate the brain,/And drinking largely sobers us again."

Getting past these two obstacles to worldwide education is the major problem. It appears to be paradoxical.

Of course, we aren't going to achieve this sort of open, worldwide education until it become adundantly obvious to national leaders and governments that it's absolutely necessary. And the way to do that is to start educating where it's possible to do so; the nature of the competition that comes from the educated peoples will force the issue. Robert A. Heinlein: "Never appeal to a man's 'better nature.' He may not have one. Invoking his self-interest gives you more leverage."

Education is a two-way communications channel. There are only a few things that can be learned from a lecture, which is the classical one-way communications channel. If the student doesn't hear or understand the information as the master proclaims it, there's never a chance to ask for a playback or pose a question that might clear up some misunderstanding on the student's part. Real education takes place most effectively in a one-on-one environment with the sought-for but rarely obtained student-teacher relationship. This is technically known in the information sciences field as a re-iterative process or a feedback situation.

This is where the hardware/software of the modern computer can perform its magic in the education process.

A student needs a teacher to teach him what he doesn't know he needs to know.

There aren't enough teachers to go around to educate several billion people.

And teachers can distort information. They are only human, with human likes, dislikes, phobias, philosophies, and priorities.

When a computer acts as a teacher, it presents the same information to everyone in the same way. And the way in which it presents that information is open to scrutiny. Furthermore, the computer acting as a teacher—overtly or covertly—provides the means for interaction, reiterative presentation, and even playback of any portion of the lesson.

Add a computer with a reply link in the communications system—nothing more than a small transmitter that uses the same antenna as the receiver—to the in-the-field hardware package, and the total system becomes an electronic schoolhouse. The teacher—the master computer—may be half a world away, but it can communicate with the student and the student can talk back to the master computer. The student can record the educational material in memory for later playback so that the lesson can be studied as it was originally presented. It also permits the master computer to remotely program the student's computer with a total lesson, homework so to speak. The total system becomes a true teaching machine.

Crude attempts at teaching machines were made in the '60s, but this was before technology had made computer hardware small and inexpensive, and before software became "user friendly." The early teaching machines were simple mechanical devices that failed because there was no possibility of real student feedback to the machine. With the modern computer there is.

A computerized educational program is going to combine a lecture format—one-way presentation of data—with the modern version of the Socratic method, wherein the computer asks the student a number of questions that lead the student toward the knowledge he needs.

This sort of software is a direct result of the development of video game software. "Dungeons and Dragons" or "Zork" in all its now-varied forms is an excellent example of this. So is a computer game called "Psycho" in which the computer acts like a psychiatric patient and can be programmed to be an "easy" or "difficult" case. In the case of Zork, it's possible to learn the maze. If you've ever played Psycho, you know it's almost impossible to tell that you're communicating with a computer rather than another person. Modern software development has finally permitted the hardware to pass special-case instances of the Turing test.

The Turing test is named after the English mathematician, Alan B. Turing, who in 1936 proposed a functional test of machine intelligence: if you couldn't tell whether you were communicating with a machine or with a human being over a remote communications network then consider it "intelligent." (This is a somewhat simplified exposition, but it will suffice for our purpose.)

And, of course, using the comm/info net, it's possible to link libraries (databases, in computer terminology) into the system as well, so that, eventually, as the contents of libraries are scanned and converted into digitized formats amenable to computer memory storage, the knowledge of the world is available to everyone.

When all the pieces are thus put together, it becomes apparent that we can indeed tackle the worldwide educational problem. The hardware is now available and can be obtained for a reasonable price (which is coming down all the time) and operated with modest power requirements (which are also being reduced). The means for communicating data are in place with land-line telephone networks, microwave networks, and the all-important communications satellites. The basic research on education and training has already been conducted at Bell Labs, and we only have to use this hard data rather than depend upon the empirical and highly theoretical educational guesswork of pedagogues. And the information itself is there, libraries full of it, expanding at the rate of ten typewritten pages of new information every minute of every day, so that the total amount of human knowledge is now doubling every five years. The marketing techniques from commercial practice can motivate people to give up their age-old beliefs.

It's a big job, but it's only the beginning of the long-range use of hardware and software as the ultimate intellectual tool of us jellyware units.

Successful marketing, however, also implies the customer's ability to pay. And there is far more unsuccessful marketing than successful. Marketing is anything but the science he would have us believe. Frankly, I find this concept ludicrous. For one thing, who pays for and distributes the hardware? Who teaches the "students" to use it? And, most important and not touched upon, who decides what is to be taught?

CHAPTER EIGHT

MEGS AND SQUIDS

If the computer is indeed to become an effective intellectual tool, the "interface" between the hardware and human will have to be greatly improved. Otherwise, we won't be able to use fully the speed and infallible memory of the hardware. It's like having a car perfectly capable of safely and economically travelling 110 miles per hour but restricted to a mere 55 mph speed . . . or less. Or a color television receiver but no color TV program transmission in the local area.

For over a decade, banks and other organizations have been using magnetic character readers that sense the shape of symbols printed with magnetic ink on paper such as checks and other documents. A recent innovation is the optical character reader, an array of lenses and photoelectric cells that can pick up the information contained in the bar codes now printed on the outside of nearly every product available in retail stores. Other computerized character readers can decipher the shape of ordinary printing such as this. These character readers then present their information to suitable computer input circuits which in turn digitize the information for computer memory storage. This sort of input is extremely valuable in the immense task now facing us: the digitization and computer storage of whole libraries of information—books, periodicals, stories, scientific and technical papers, etc.

But the basic and most-used means of communication with the computer is through a typewriter-like keyboard consisting of a series of keys or switches, each of which will send a single symbol to the hardware circuitry. The keypad may serve to punch a paper tape or to instruct the hardware to draw on a memory peripheral such as a disk, diskette, tape, or casette.

This is extruciatingly slow when compared to the capability of most computers to assimilate data. Calliope, my trusty micro, will accept data at a rate of 100,000 bytes per second. Punching my keyboard as fast as I can creates an input rate of perhaps 10 bytes per second, considering that each key depression generates 8 bits. On the average, it might run 1 byte per second over a period of several minutes while I stop, think, review, etc. in my own mind before entering another symbol into Calliope via the keypad. Thus, I am in a sense *under-utilizing* Calliope's potential by 5 to 6 orders of magnitude (100,000 to 1,000,000 times)! I'm sure that if Calliope possessed emotions, she'd be immensely bored when I talk to her through her keyboard. She's so much faster than I am that unless I'm making severe demands on her computational abilities she seems to work almost instantaneously.

This is because I'm strapped with eye-brain-hand system circuitry and its associated long action times. The reception of a visual stimulus from the computer's VDT requires about 20 milliseconds (0.020 seconds). Its transmittal through the nerve fibers and synapses to my brain takes about 2 milliseconds. The excitation of my brain's cortex by the stimulus requires about 13 milliseconds. This adds up to about 35 milliseconds (0.035 seconds). It takes me—and you—that long to realize that something has been seen! Under less than ideal conditions with lots of background noise, distractions, and stress, this delay can be as much as 100 milliseconds.

The eye-hand reaction is perhaps the fastest reaction mode of jellyware. From the time a visual stimulus is presented to me, approximately 195 milliseconds elapse before my hand can move in reaction to the stimulus.

In the same time, a modern home computer can perform about one million operations and deliver 25,000 bytes to an output port.

If the hardware could somehow be linked more intimately with the user, it appears that the hardware would still have little trouble keeping up, except when engaged in heavy calculations or large scale retrieval from outside data bases. In fact, it could do this with lots of time left over for conducting its own housekeeping operations.

But can the hardware actually be linked? Can the two systems, crystalline and colloidal, actually be "interfaced?"

It turns out that this can be done.

The first concept that occurs to most people is something like direct wiring of the computer to the human brain. This conjures up the image of a person walking around with a multi-contact electrical connector coming out of the top of his head.

But that's not necessary. Human beings are versatile, general-purpose organisms who didn't rise to the top of the evolutionary ladder on Earth because they'd developed highly specialized physical or mental characteristics. The developed as *unspecialized* organiams. Humans then learned how to make devices help them without having to modify *homo sapiens* Mark I Mod 0 in the process.

People regularly swim beneath the oceans with fish, but they don't have surgically-implanted artificial gills; they use scuba gear they can put on before the dive and remove afterward.

People also regularly fly through the air, but they don't possess surgically altered skeletons or wings and feathers arising from recombinant DNA technology; they climb into the cabin of an airplane or strap on a hang glider.

Through the use of these "non-intrusive" tools, people can move across the landscape faster than a cheetah, lift and carry loads far heavier and larger than any elephant, dive far deeper beneath the oceans than any fish, and top "the windswept heights with easy grace where never lark, or even eagle flew."

For this same reason, we won't wire computers directly to human beings, thereby creating "cybernetic organisms" or "cyborgs." We don't need to.

The neural activity of the human nervous system generates electric and magnetic fields. Electric fields were first detected in the experiments of natural philosophers (as scientists were then called) in the late eighteenth century. In the nineteenth century, experimenters such as Henry, Faraday, Ampere, and others discovered the nature of electric and magnetic fields. The Biot-Savart Law formulated: A moving electric charge produces a magnetic field. Today's electrical generators and electric motors make common use of this phenomenon.

The neuro-electric activity of the human brain doesn't produce strong electromagnetic fields, but they can be detected. It was first demonstrated in 1929 by Hans Berger of Jena, Germany. The technique is widely used today for neurophysiological and psychiatric diagnosis and monitoring. It's called "electroencephalography." Since that's a tongue-twisting word, it's usually abbreviated as "EEG," and that's the term I'll use henceforth.

The EEG technique uses small metal sensor or pickup disks placed on the skin of the head. These electrodes pick up the electric fields induced in the skin by the neuroelectric activity in the brain. Typically, these electrical potentials are never more than about 100 microvolts (0.0001 volts). The signals detected by the skin electrodes must be amplified by electronic circuitry. The typical EEG equipment used in the medical profession is three generations or more behind the current state of the art in electronics and virtually harks back to the glass-bottle radio tube days. The circuitry is primitive. The chart recorders with their mechanical pens writing on strips of moving paper will record the amplified "evoked potentials" on the scalp with a frequency range from 1 to 100 hertz. We already know the human brain has a unit gating time of 2 milliseconds (0.002 seconds)—which would generate a bit rate five times higher than the EEG equipment could possible detect!

However, EEG was a start in the direction of detecting, monitoring, and analyzing neuroelectric activity or "evoked potentials." The implications of being able to obtain a direct signal from the brain is that each of us could produce signals that could become input for a computer. But EEG had its own little problems.

One of these is the fact that an EEG measures the consequences of neural activity, the electrical potentials induced in the skin as a result of electromagnetic fields. These fields are generated by the movement of electrons along certain neurons buried in a mass of other neurons and shielded to some extent from the outside world by a rather massive and contiguous organic bone structure, the skull. As a result, EEG techniques sense gross neural activity but cannot accurately pinpoint it. Furthermore, because EEG depends upon induced voltages in the skin, the technique can't really be counted upon to detect and measure what's going on deep within the mass of neurons. To get that sort of data, neurologists *must* invade the organism with intrusive probes.

EEG equipment is so limited in performance that for years I wondered what sort of signals might be present if someone took a look with EEG equipment capable of sensing, amplifying, and recording the bandwidth of an ordinary, television set. That bandwidth is 4 megahertz or four million bits per second. We had to be missing something because of limited equipment performance. It was rather like trying to determine the progress, lap times, and relative standings in the Indy-500 with a calendar rather than a stop watch.

Somebody did, I think, but I can't get too much information about it because of who did it and who paid for having it done.

For about thirty years I've been plugged into the UNUNLBS—Unofficial Nonexistent Unauthorized Network of Little Black Spies. It has no dues, no membership cards, no meetings, no regular publications, no officers, no headquarters, no staff, and no real existence in the real world (I just said it's unofficially nonexistent). Its unofficial unmembers pass along documents and tidbits of information just because "I thought you might be interested" or bearing the cryptic "FYI" (For Your Information).

In 1978, a little black spy sent me a document entitled "The Department of Defense Advanced Research Projects Agency (DARPA) Fiscal Year 1979 Program for Research and Development." It's not classified but such documents are sometimes hard to get if you don't know the right people (or belong to the UNUNLBS). The slender document—about 46 pages long—is full of lots of numbers and government language. It has a section entitled "Accomplishments" where it talks about such military technology developments as high-powered lasers, long-range imaging radar, lightweight optics, advanced warhead technology, ceramic turbines, and a small and final series of paragraphs quietly entitled "biocybernetics." This last part is fascinating because of what it says and even more fascinating because of what it doesn't say.

"There have been a number of major accomplishments," it states, "in the biocybernetics program for extracting useful information from the electroencephalogram (EEG) and other nonverbal signals." It other words, the research contractors developed a technique for deciphering EEG signals to get more information than just the neurological state of health of the human subject. The report states, without going into details, that a technique has been demonstrated for measuring components of an EEG associated with decision-making and action.

They've discovered that if the signals involved in decision-making end before the signals involved with action based on the decision begin, probability is high that the person will take the correct action. However, if the decision-making signals persist after the action signals begin, the probability of error is high. Obviously; if you're not sure you've made the right decision, you'll continue to worry about it while you're taking whatever action seems to be immediately appropriate.

They also came up with a new method of measuring a person's assessment of probability from the EEG data. Basically, from EEG data it's now possible to determine whether or not the probability that you guessed correctly is high or low . . . or non-existent.

There is another component of this DARPA report that we'll talk about shortly, so don't forget about DARPA yet.

Two important signals come through to us as a result of this old DARPA report:

One: Somebody has looked at EEG data from the viewpoint of trying to find the link between an EEG signal and the way we're thinking.

Two: If EEG patterns can be correlated with our thought processes, it then becomes possible for a computer to use the EEG machine as an input device. The computer can then be programmed to recognize these patterns.

In short, a human can communicate directly to a computer. The possibility for direct, non-intrusive linkage between the jellyware and the hardware exists!

But an EEG signal is a gross signal and reports only on what the outer layer of the human cortex is doing. It reflects the induced potentials in the skin of the scalp, not the actual neuronal activity in the brain itself.

A neuron does its job of transmitting one bit of data by the chemical movement of an electric charge along its external membrane, the myelin sheath. The Biot-Savart Law tells us that a moving electric charge produces a magnetic field. But in the case of the brain, although there are billions of moving electric charges there all the time, the magnetic fields are extremely weak.

The inordinante weakness of these biological magnetic fields has been the historical barrier to detecting, much less measuring, them. The magnetic field of the human brain is about 0.00000000001 (10^{-12}) teslas while the Earth's magnetic field—which itself is so extremely weak that a compass needle must be suspended on very low-friction bearings to visibly respond to it—is roughly 0.00005 (10^{-5}) teslas or *ten million times as strong*!

Add to this the environmental electromagnetic "noise" generated even by the 120-volt 60-hertz electrical wires in a home, office, or laboratory, and the problem appears to be insoluble.

Detecting extremely weak biological magnetic fields against the relatively powerful background of the terrestrial magnetic field plus the man-made background noise was finally made possible by the development in the 1960s of the SQUID—Superconducting Quantum Interference Device—which consists of specially-wound coils of superconducting niobium wire immersed in liquid helium. This permits very weak magnetic fields to be detected by the superconducting wires. By means of proper arrangement and orientation of the coils, the effects of the terrestrial magnetic field as well as environmental background "noise" field can be eliminated. The SQUID coils are small—only centimeters in extent—and the biggest part of the unit is the container for the liquid helium. The inherent noise in a SQUID is more than one order of magnitude (ten times) less than the magnetic field strength of the brain. A SQUID can therefore be used to detect neuromagnetic activity.

In 1968, David Cohen used a SQUID to measure the magnetic fields generated by spontaneous neural activity in the human brain.

In the years since that original breakthrough in "magnetoencephalography" (MEG) measuring the magnetic activity of neural processes, SQUIDS have gotten smaller (and will continue that trend). The electronic equipment required to amplify the

SQUID signal has gotten better, cheaper, and smaller.

Researchers such as S. J. Williamson, L. Kaufman, and D. Brenner at New York University have begun to map the neural magnetic activity of the brain using SQUIDS and MEG techniques. As of 1977, the neuromagnetic activity of the visual cortex has been mapped and deciphered. In other words, these researchers found out where in the brain (the occipital lobes, as had been anticipated from anatomical studies) the visual stimulus was processed into visual information for the brain. And they learned what the neural activity was when various patterns were presented as visual stimuli.

If the response of the brain to visual stimuli can be located, the neural activity mapped, and the patterns of neural activity in response to various stimuli determined, then the response of the brain to other stimuli from other sense organs can also be determined. It would be very surprising if in the time since 1977 this had not been done or was not underway.

Whether or not some or all of the current MEG brain mapping is being conducted under the auspices of DARPA (the mapping of the visual cortex was carried out with the support of the Office of Naval Research), we can be absolutely certain of one thing: the neuromagnetic fields, patterns, and outputs of the human brain either have been, are being, or soon will be thoroughly mapped and deciphered.

What does this mean in terms of the human-computer system and, in particular, the human-computer interface?

Primarily, it will eliminate one of the slowest parts of the system: initial use and input. In other words, *direct* programming and data transfer from human brain to computer!

This is no futuristic dream. As you are reading this, thousands upon thousands of industrial computers are monitoring and controlling industrial machinery on the basis of sensor signals from that machinery. The technology not only exists but is in use that will permit *any* type of signal from any device to be properly digitized, entered into a computer, recognized by the computer, and thereby cause the computer to do whatever its program instructs it to do in response to various inputs.

The output signals of a SQUID or MEG can be digitized for computer use with off-the-shelf equipment and proven techniques now being used in the very active field of computerized industrial measurement and control.

This means that a human being can directly control a computer.

The jellyware can link with the hardware.

The result: Speed, ease of operation, and greater accuracy and reliability if the hardware has the proper software (is properly programmed) and if the human is trained (is properly programmed).

It would eliminate the keyboard, an extremely slow data input mechanism.

And with the advent of *real* "user-friendly" software, it won't be necessary to use programming language. Just think to the machine.

This is perhaps the ultimate in human control over the computer as an intellectual tool. It goes part-way towards turning the computer into a true intellectual tool, instead of a remote assistant.

But that's only half of what's likely to happen in the forging of our new neuroelectronic intellect.

CHAPTER NINE

THE HARDWARE TALKS BACK

Hardware already talks back in a number of widely accepted ways and in a growing number of new ways. But the best is yet to come.

Currently the most common hardware output or reply device is the Video Display Terminal (VDT) with a cathode ray tube (CRT) about the size of a television (TV) screen. Or the VDT itself may be a TV set drafted for the VDT job.

If you haven't noticed yet, every area of technology is full of acronyms. There's no way out of this. Otherwise, reading or talking about that area of technology would become excruciatingly cumbersome and even downright boring. Acronyms are a form of linguistic shorthand. Try to discuss a technical subject without acronyms, and the talk becomes almost childlike in nature. If you think this is bad, try to talk to a government bureaucrat sometime! They've taken acronymics to absurd lengths. In their case the purpose is not (generally) to communicate but to obfuscate. But back to our discussion:

A VDT lets us see symbols representing part of what's in the working memory of the hardware, but not all of it because the VDT screen isn't big enough. Generally, you wouldn't want to see all of the contents of the computer's working memory any more that you would want to see the total contents of a printed book cut out and pasted up on a big wall. Too hard to read. Too much at once. Data overload.

A "hard-copy" printer resembling a keyless typewriter is another common and very expensive output device. This mechanical monstrosity is a direct descendant of a "writing machine" invented by William Burt in 1829 and of a device invented to print sequential numbers on tickets by C. L. Sholes, who was working for Thomas A. Edison at the time. Sholes' invention was bought by Philo Remington in 1873 because he wanted something that could be mass-produced and take up the peacetime slack in his gun-making business. Down the decades, this mechanical joke continued to be developed and improved—but even the most "improved" ones still operate in jerky, halting, intermittent fashion, printing a single symbol and then indexing a space to print the next symbol.

Most modern super-typewriters still use the same foundation technology developed by Burt and Sholes and are the slowest parts of the hardware system. Most of the "letter quality" or typewriter-like printers operate by printing out about 750 words per minute, which is about 35,000 bits per minute or 600 bits per second. A printer is so much slower than the computer that it forms a serious bottleneck, unless the output is buffered either to a storage device in the printer or into a reserved segment of RAM in the machine itself.. "Dot matrix" printers that form symbols as an array of small dots are faster but don't produce hard copy that looks as good to the visual sensors of jellyware known as Editors.

Faster high-quality printers for micros are on the drawing boards and may even be on the market by the time you read this. A good, fast, letter-quality printer can cost as much as the rest of the computer hardware put together. Low-cost, fast printers will become a reality soon, and I will be one of the first customers because it took a "daisy-wheel" type of letter-quality printer about four hours to print the manuscript of this book.

Speaking hardware is all around us already in the form of talking alarm clocks and vocal peripherals. Vocalizing turns out to be reasonably simple once there are enough gates available on a chip. If language had been simpler, technologists would have been able to get the hardware to talk a long time ago. As it is, it's a fairly recent innovation that many futurists have been considering and even writing about for a long time.

Most of vocal communication comes about as a result of shaping sounds by the nasal cavities, the mouth, the tongue, the teeth, and the lips. These elements put little time delays and phase shifts into the basic sound, and this creates human speech patterns.

This sort of thing can be duplicated by a chip that creates a basic buzz and then acts to shape the sound into human speech patterns. Machinery can now verbalize, and it is only a matter of time before it's able to speak like a United States senator.

Even though the hardware can now talk, its verbal communication consists only of basic word groups with few of the nuances of inflection that convey so much meaning. A talking computer sounds artificial. But not for long. As the complexity of IC chips increases and as various vocal peripherals grow more sophisticated we can look forward to the hardware talking in sexy, sensual, breathless tones if that is one's desire. Some odder bits of jellyware will get its kicks from the seductiveness of hardware voices.

As a matter of fact, the common practice of using tape recordings of conversations as legal evidence will shortly become inadmissable; hardware using the proper software will soon be capable of duplicating the sound patterns of specific voices. Hardware can already do this trick for any musical instrument, including some that don't exist! You won't know whether you're talking to a real live friend, or just a computer, on the telephone. Right now, if it were not for the jerkiness of the female voice on the telephone, you wouldn't know that it's just pre-recorded words on a disk somewhere. "I'm sorry, the number you have called, seven, six, four, three, four, three, two, has been disconnected . . ." Did you know that it's the legendary Ma Bell herself, the huge, nationwide computerized telephone system, who's talking to you?

Hardware vocalization output is an anticipated extension of the hardware's capability to communicate via printer. And it's still slow not only because of the computer time required for the hardware to convert the output into vocal format, which is compressable, but also because of the extremely long aural reaction time, which is not. Although this is *slightly* better than visual reaction time—about 15 milliseconds as compared to 20 milliseconds for visual response—it still amounts to an eon of time to the hardware, and anyway, people can read faster than they can talk.

Is it possible to link the hardware's output directly into the nervous system in a non-intrusive matter similar to the "mind reading" technique discussed in the last chapter? Can the hardware link directly?

Yes, it can.

And, yes, we know how to start doing it now, although it hasn't, to my knowledge, been done yet.

This is something more than utilizing bone conduction to impress a computer-generated voice upon the cochlea of the human ear. That doesn't bypass the jellyware's auditory sensing system. It's just another way to use what amounts to a loudspeaker.

There's another way to do it.

In 1800, Count Alessandro Volta—the Italian electrical pioneer after whom the electrical unit, the volt, is named—discovered a phenomenon called electrophonic hearing. This was the sensation of sound created by the application of small electrical charges to the human skin. It was believed for more than 150 years that this phenomenon was merely the action of the muscles being electrically stimulated and thereby affecting the ear by means of muscle vibration.

In the 1950s, an unknown electrical inventor rediscovered electrophonic hearing, perhaps by accident. If the output from a hi-fi audio amplifier is put into another audio output transformer hooked up backwards—i.e., the low-impedance loudspeaker windings hooked to the amplifier's loudspeaker output—and the high-impedance side of the transformer wired to a pair of copper scrub pads placed in individual plastic bags, a sensation of sound could be "heard" if a person put the insulated copper pads on each side of his head. But the sound is badly distorted and almost unrecognizable.

In New York City, Drs. William Lawrence and Henry Puharich began an investigation of this phenomenon at the same time as a fourteen-year-old amateur scientist, Gillis Patrick Flanagan, began experimenting with it quite independently in Bellaire, a suburb of Houston.

Lawrence and Puharich discovered that the basic electrophonic hearing system worked better if the pads were copper electrodes applied directly to the skin, but that no sound was "heard" unless the uninsulated copper electrodes were rubbed across the skin.

Flanagan discovered, on the other hand, that the sound produced by the insulated pads was greatly improved if the transformer was electrically overdriven so that the audio signal was distorted by the "ringing" of the transformer. Flanagan also measured the impedance of the human + electronic circuit and discovered that there was a resonance at about 30,000 hertz. However, the resonant frequency appeared to be extremely dependent upon a person's mood, state of health, and emotions.

Flanagan also discovered that the quality of the sound was greatly improved by using a 30,000 hertz carrier frequency that was amplitude-modulated by the audio signal.

I heard about Flanagan from John W. Campbell, Jr., then editor of *Analog* magazine, who was also a member of the UNUNLBS (see previous chapter). At the time, I was the assistant director of research for Huyck Corporation (pronounced "hike" and now a wholly-owned subsidiary of British Rubber). The director of research, Dr. William O. Davis, and I had the responsibility for looking into new areas of technology that might lead to new products for the company. I got in touch with Flanagan and hopped a plane to Houston. On the evening of July 24, 1962, I first "heard" Flanagan's device—he calls it a "neurophone"—in his attic workshop in his parent's home. It worked then, and it works now. I could "hear" audio signals played into the neurophone by placing the insulated pads on either side of my head and, after some experientation, *anywhere on my body*, including the soft tissue of my torso and legs, thus convincing me that what I was hearing in my head didn't come about as a result of bone conduction.

I was the prime investigator for the neurophone at Huyck Research Center from 1963 through 1965. When the corporate officers decreed a change in policy and folded the research laboratories in an economy move, Flanagan soon found other research assistance from Dr. Wayne Batteau at Tufts University. Under a U.S. Navy contract, Batteau and Flanagan showed that the neurophone wasn't working by bone conduction and that it was indeed stimulating the nervous system directly. Further proof of this came when the neurophone permitted persons who had become nerve-deaf—i.e., their cochleas and auditory nerves had ceased to work and atrophied—to hear once more.

Flanagan filed for and eventually received U.S. Patent Number 3,393,279 on July 16, 1968. He sold the patent rights to Drs. Lawrence and Puharich. But the U.S. Food and Drug Administration (FDA) wouldn't permit the neurophone to be sold as a hearing aid because it used a 30,000 hertz radio-frequency (r-f) carrier. The FDA was wary of any potential unknown harmful effects of such an r-f carrier. So Flanagan developed a new neurophone that didn't use r-f frequencies. He made the big mistake of calling it a "speech scrambling device" in his patent application. The representative of the Defense Intelligence Agency caught this as the application came through the Patent Office and automatically issued Secrecy Order 756,124 against the patent application, effectively locking it into limbo. Flanagan succeeded in getting this secrecy order lifted. The patent examiner didn't believe the neurophone would work, so Flanagan had to demonstrate it. U.S. Patent Number 3,647,970 covering the new neurophone was granted to Flanagan on March 7, 1972. In 1980, he had transistorized the neurophone and offered it for sale as an experimental listening device. I have one; it works, and hundreds of other people have "listened" with it.

There appears to be a stubborn refusal of the medical profession and the neurological researchers to study and analyze the neurophone because it obviously can't work. It flies in the face of all existing theories of neurology.

Regardless of all of this, the neurophone exists, it works, and it shows that the human nervous system can be directly linked by nonintrusive means of electronic circuits. If nothing else, the neurophone is therefore a proof-of-principle device. Whether it is or isn't more than that will be know in due time. Too many people are now aware of the neurophone, and there are nearly a thousand neurophones now in use. Some researcher will eventually look into why it works, and then we may know how we hear, see, feel, taste, smell.

If direct electronic linkage will work for hearing, it should also work for all the other human senses as well. The neurophone is a breakthrough in the best sense of that term.

The neurophone seems to confirm what isolation stress tests have shown: that the human nervous system is set up to detect *change* and *rate of change.* Put a human being in an environment of total sensory deprivation and he soon begins to *create* false sensory inputs that simulate change. A study of human eye movements indicates that the constant motion of the eyes to create a constantly shifting visual pattern is absolutely necessary for proper vision.

Investigations on hearing with the neurophone, including many that I've conducted myself both professional and as an interested amateur scientist (which is all I qualify as at the moment) indicates that the nervous system doesn't work well with constant input signals, works better with signals that change, and works best with signals with a high rate of change. The circuitry of the present neurophone tends to support this.

For those of you who are technically interested, the neurophone circuitry takes the input audio signal, double-differentiates it, amplifies it, clips it to a square wave, puts it through a zero-crossing detector, and then runs this high impedance 20-volt signal directly to one-inch-diameter electrodes made of lead zirconium titanate, which has the same dielectric constant as human skin. The sound seems "scratchy" at first but becomes of better quality as time passes. Users have found listening to the neurophone a very pleasant, relaxing experience. It doesn't produce headaches or any other harmful physical or mental symptom.

Using the neurophone principle, can a computer "talk" directly to a human being? Can the hardware link directly with the jellyware? There appears to be no reason why this can't be done.

The initial experimentation would involve utilizing a vocalizer or vox peripheral and then feeding the output of this to an ordinary neurophone which would then input the computer voice directly into the nervous system of the human operator. This sort of linkage wouldn't of itself be any great improvement in speed over using an ordinary loudspeaker and the human ear, but it would be the first step, the proof of principle.

The hardware doesn't necessarily have to "speak" in a human-understood language to the jellyware.

Most modern personal computers use a 4 or 8 megahertz oscillator in them to provide a time base. Without this, the CPU can't keep track of itself and of the priority of information flow commanded by the software—program steps such as "get information from memory location X, transfer it to operating location Y, stop the output of data from Z for 20 nanoseconds, then transfer the data from Z to X." The time base permits the hardware to assign priorities and keep track of signals moving through the system, causing some to wait for a certain period of time in a given location before proceeding elsewhere.

That 2 megahertz timing signal can spray out all over the locality like a radio signal. It also has harmonics at 4, 8, 16, and 32 megahertz because the computer doesn't have to meet the FCC criteria that prevents other gadgets like a TV set from doing the same thing. I can pick up the "voice" of Calliope, my computer, on the shortwave radio that sits on my desk right atop Calliope's mainframe.

Calliope sings over the radio. Sometimes it's a warble. Sometimes it's a series of chirps. I have grown to learn what she's doing by the sounds she makes, and this has been especially helpful when I'm having her run a memory diagnostic, for example, just checking the integrity of her memory circuits, or when I'm asking her to test the recording integrity of an old diskette whose surface may have become worn and therefore questionable. For example, when the warble changes to a series of chirps, she's transferred data from the diskette into working memory and is executing the computational program. When the frequency of the chirps changes, she's ready to load the printer's line-by-line memory.

With enough experience or with actual training, there's no question that I could monitor Calliope by the sounds she makes over the radio.

Put a neurophone in the link, and she's talking directly to me!

Yes, it may be slow at first because she'll have to talk my language or I'll have to learn her language.

But eventually, there is no reason why the proper software couldn't become available that would interface the two computer systems directly. This will mean, however, that we are going to have to learn as much about our own low-level "machine language" as we know about the hardware's machine language.

We don't yet know the machine language for the colloidal computer circuits that create the sensation of sound, even though Flanagan appears to have accidentally or serendipitously cracked the aural code. We still don't know how the nervous system recognizes the neurophone signal as sound when the signal is applied via elctrodes to the torso and the ankle. Is the skin, our oldest evolutionary sense organ, actually acting as an ear? Or does the nervous system accept any input and transmit it to the brain where the brain recognizes the signal as an auditory one and then switches it to the auditory brain center?

What changes to the input signal would make the brain recognize it as a visual signal? Assuming that Russian scientists aren't falsifying their data, a number of repeatable and very solid experiments have been carried out in the Soviet Union. These indicate that some people can "see" and actually read text with their fingertips. Some experimentation along this line was carried out in France between 1930 and 1960 by Dr. Henri M. Coanda. Apparently, some people can "see" by means of what would otherwise be the tactile or "feeling" sense.

What is the nature of the nervous system signal that transmits a given sensory message to the brain? There don't appear to be "dedicated" nerve fibers, neurons and neuron chains whose job it is to transmit only touch or muscle kinesthetics. True, some complex sensory data does have dedicated circuits—vision and part of hearing, for example. Are there actually different coded signals going through the nervous system, with the brain serving as a switching center or the colloidal equivalent to an 8086 CPU chip? Or is it a dedicated system with each sensory input having its own neuronal network to the brain?

The brain itself appears to be fairly universal as a CPU and memory unit. When large parts of the brain are damaged or surgically removed, in many cases other portions of the brain can and do take over the functions of the damaged or missing parts. The heroic recovery of James Brady, President Reagan's former press secretary, is an example. There have been others.

It certainly looks like the development of hardware and its software will drive the investigation of our own processes, doesn't it? This is something we'll have to talk about once we proceed further here on how all of this relates to the continuing development and improvement of the electronic computer as perhaps the most powerful intellectual tool mankind has yet developed.

CHAPTER TEN

THE FIREFOX SYSTEM

The idea of direct linkage between electronic computers and human beings isn't new. It was the theme of the excellent science-fiction novel, *Firefox*, written by Craig Thomas and published in 1977; the novel was made into a motion picture in 1981. In the story, the protagonist is sent to hijack a Soviet MiG-31 Firefox, a fictional fighter plane whose weapons systems are controlled by thought impulses from the pilot, a technique that would greatly speed up the ability of an aircraft such as a supersonic interceptor to carry out its mission.

In common with many other science-fiction stories, the technology in "Firefox" isn't totally fantastic but may be current technology or at least emerging technology. This was also true of "The Andromeda Strain" in which all the wondrous biotechnological equipment was actually off-the-shelf gear.

To a large extent, the progress in biotechnology has been generally ignored by the news media because most journalists don't even understand the older technologies, much less the mathematical tools used in those fields. Few reporters know what makes their automobiles run, much less how the portable TV minicams work; they're reporters and leave the gadgetry to hired technicians. As for mathematics, most of them can't balance a checkbook, much less understand simple algebra. Having worked as a science consultant for a major TV network as well as a science reporter for a radio network, these statements come from my own experience and observations.

As for the reporting of science and technology, the situation is bleak. Most reporters and writers have an ideological axe to grind, and this interferes with the strict reporting of science and technology. All of the really good science and technology reporters in the United States would fit comfortably in a Volkswagen. I do not consider myself as being among them because I am not a science reporter, but a science writer. I do have an axe to grind: the preservation and expansion of the human freedom of choice through the utilization of science and technology. But I digress.

There are indications from such sources as the DARPA report referenced in Chapter Eight that research was progressing in the area of biocybernetics (the interface between human beings and computers) as long ago was 1978. Undoubtedly, considerable progress has been made in the years since. And because there hasn't been much of it reported in such encyclopedic periodicals as "Science News," it's quite likely that the military implications of direct linkage have shown themselves to be important enough to warrant security classification of the work.

However, non-classified work in biocybernetics is going on, supported by such organizations as System Development Foundation of Palo Alto.

Even though biocybernetics appears to be moving slowly, if at all, this is where the real future of computer technology lies, not in the development of ever more sophisticated hardware and more and more "user-friendly" software.

Consider the implications and impacts of even a primitive and rudimentary direct linkage.

If, according to the indications of the 1978 DARPA-supported work and the investigations of Kaufman and others in the development of MEG brain mapping, various neural and brain functions can be localized and their electromagnetic patterns determined, and if the Department of Defense, notably the Air Force, is already testing voice-actuated computer circuits in F-16 aircraft, it takes no great leap of the imagination to extrapolate this capability to the point where, a few years hence, the hardware can accept input directly from the user without the need for an intermediate device such as a keyboard or even voice command circuits.

And, if such devices as the neurophone are indeed linking electronic circuits directly to the human nervous system as all experiments thus far appear to indicate, then it also takes no great stretch of the imagination to forecast that the direct linkup will work both ways: a duplex or two-way mode.

Does this possibility of direct two-way (duplex) communication necessarily mean that the hardware is going to come out on top?

No, it doesn't and it won't.

We've been over some of this ground in earlier chapters. But because people who fear this sort of thing are reacting with the Frankenstein Syndrome, we'll put to rest whatever fears remain once we've had the opportunity to look into the possibilities, potentials, and consequences of the direct human-machine linkage.

When you get right down to it, it won't be that much different from working with hardware today.

But your nervous system won't be "hard-wired" to a computer through a 25-pin RS 232 connector implanted in the top of your skull. There are a number of reasons why this is a bad idea.

First, all computers don't have the same peripheral wiring, and the state of the art has always moved so fast that there's been little standardization in this area. Therefore, your plug might not be able to interface with any computer except your own.

Second, it would require surgical intervention to change the plug as the state of the art progressed and what minimum standards there are got changed.

Third, it's not healthy for the plug, which will get dirty in spite of everything, wet when you take a shower, and possibly dinged, cracked, or broken; the jellylike environment is filthy as well as physically demanding, and most hardware components simply aren't designed and built to withstand it.

And, as the pedantic professor remarked, forty-fifthly, ladies and gentlemen, it's downright unhealthy to have the skin broached, as well as to have a direct hard-wired low-resistance electrical circuit between the jellyware circuitry and the external world which is full of electromagnetic fields as well as biologically hazardous voltages.

Because of the SQUID, MEG, and neurophone technologies, connecting the jellyware to the hardware will be as non-intrusive as hooking up an electrocardiograph and an EEG. After all, we want to follow the procedures that have worked out well in the past, and this means changing the machine to fit the human being, not the other way around. One Model T Ford is enough.

(For those readers who've never seen a Model T Ford, much less driven one, it was an anthropometric and ergonomic nightmare. There were three pedals on the floor, all more or less alike; they had to be pushed by foot in definite sequences because, although the Model T had the same sort of planetary gearing that's in all automatic transmissions today, it wasn't automatic but manual. The throttle was on the steering column along with another lever for adjusting the ignition timing. The speedometer was located in the center of the dashboard, not in front of the driver. In short, the Model T really wasn't designed for people; it was designed to be quickly and easily built. Henry Ford didn't want it good, he wanted it cheap. And the human operator therefore had to adjust to the machine.)

But even applying electrodes can be a messy job, as anyone who's ever had an EEG will agree. Gooey electrode jelly is used to insure a good electrical contact. There may be several electrodes that have to be placed with reasonable accuracy on the body. And there's always the tangle of wires and cables that's a mess.

Illustrations from old science-fiction magazines probably show the sort of thing that will become standard for direct linkage: a soft helmet-like cap with the necessary electrodes and wiring already sewn in place.

However, it may turn out that a more complete linkage is required, necessitating electrodes along and on both sides of the spinal column. This in turn may require something like a reclining dentist's chair with the necessary non-intrusive circuit elements in the chair padding and with perhaps the helmet as an additional piece of apparel.

When direct linkage is necessary in a vehicle such as a car, airplane, or space craft, the hardwiring for the hardware could be built into the operator's seat.

Or, if it's necessary for the jellyware to move around, it may be built into operational clothing such as a flight suit. Most military aviators are used to wearing g-suits and partial pressure suits with communications cables and oxygen hoses trailing them around.

However, it isn't even necessary to have hard wiring in the form of cables. It would be possible to use something like a multi-channel walk-around remote microphone of the same sort as those worn by TV reporters on site.

The first such direct-linked systems won't be very complex. Basically, they will have simple data transmission channels in each direction—human to hardware and hardware to human. Because of the natural tendency of engineers to be conservative, taking one step at a time and basing each increment of progressive development on what's learned in the previous step, this Mark I system will basically involve eliminating the slow, mistake-prone interface through keyboards and VDT displays. The direct links will be based on well-known and thoroughly proven techniques. While the first such systems may be developed and used for military purposes because that's where the money is to fund such work, even military researchers in this country are extremely reluctant to risk human life and health. And if it's done on a non-defense basis, researchers will be even more reluctant to try new things on human beings.

Actually, the first such primitive direct linkage experiments have already taken place and were the subject of a great deal of news media attention. In late 1982, a paraplegic used a computer to take her first steps. The computer picked up nerve impulses from her upper central nervous system, signals that couldn't get to her legs because her neural circuits or pathways had been severed in an accident. The computer then issued the proper electrical commands to her leg muscles. In effect, the computer was used to bypass non-working portions of her nervous system to relay nerve inpulses to her legs.

While this was a spectacular demonstration of a human-hardware interface, linking the human being and the electronic computer, the jellyware and the hardware, is going to take place in discrete steps.

Initially, the channel will be a simple EEG sensor system using non-intrusive EEG sensor electrodes. It will be nothing complex. The hardware will incorporate an EEG pattern recognition system capable of detecting and analyzing the EEG waves from the jellyware. The recognition of certain patterns will cause the hardware to perform predetermined actions. In essence, this is the "Firefox System." It's based on what has already been done as long ago as 1978 with DARPA research support.

Basically, this Firefox System allows us to "think" an action and the hardware to recognize it and then carry it out.

Actually, "think" is the wrong term to use when talking about direct linkage. The hardware will be programmed to react to some change in some EEG function. In the absence of firm data on what EEG changes DARPA researchers have identified, let's take a gross example which may not be the sort of thing that an EEG-recognition computer might react to at all, but which will serve as an example for our purposes here.

Perhaps the hardware reacts to a change in alpha wave frequency. Alpha waves are one of the basic components of an EEG and probably represent one of the brain's basic rhythms, serving a function somewhat like the 2 megahertz clock in a computer. With a little training, most people can change their alpha rhythms at will.

Upon receipt of such a signal—and here a "signal" is considered to be a *change* in an already dynamic system, the brain—the hardware would be programmed to initiate some sort of action through any one of a number of peripherals.

While control of mechanisms by biological action isn't new—the Army's AH-64 "Apache" attack helicopter uses the pilot's eye movements to direct the pointing of its rapid-fire 30-millimeter chain gun—neuro-control *a la* Firefox is.

But the Firefox System is an "open loop" system. The jellyware gives a neurologic command which is picked up by the EEG sensors and recognized by the hardware which then causes action to take place. The only report—the only "feedback"—is the visual or audible indication that the machine has done the proper thing. This may be the sight or sound of the gun firing or the machine, whatever is it, carrying out the intended action. Or it may be a visual or audible indication on an instrument panel—the blinking of a light, the swing of a meter needle, or the squawk or peep of a sounder.

Some pocket calculators have such a report-back mode. When you punch a key and the calculator receives the signal, it peeps. When the function key is activated and the calculator carries out an arithmetic command, it gives vent to a longer, drawn-out peep.

Such crude and primitive open-loop, non-feedback systems can be used primarily for non-critical activities or to carry out actions in which "all or nothing" is a sufficient command. Such open-loop systems may also act as triggering systems; the proper action is obvious.

But they're useless in applications where fine, delicate, time-rate, or time-dependent actions are needed.

This is why a report-back data transfer link is required. Such a feedback link is extremely important because it's the factor that keeps the hardware from running amok.

As long as there's a hardware-to-human feedback link, the hardware cannot take over. Without it, there's nothing to prevent the hardware from doing something unwanted and undesired because of a misunderstanding of the command, an error in programming, or an actual hardware malfunction. In effect, the feedback loop gives the option of pulling the plug on the hardware.

This is where the neurophonic principle can be used. With Calliope running and my short wave radio turned on, I can listen to what she's doing. Replace the radio with a neurophone and its two little non-intrusive output disks resting on my head, and I could do the same thing.

Or simply put a vocalizer module, a voice box, in the feedback loop so that Calliope reports to me in a sensual female voice that she's carrying out my command. (Female operators may prefer a sensual male voice instead, and that option should—and doubtless will!—be made available.)

An interesting sidelight: Back in the 1950s, the United States Air Force began using a recorded verbal pre-flight check list to insure that the pilots of the complicated "Century Series" fighter planes performed all the necessary pre-takeoff checks. USAF psychologists discovered that the female human voice was far more effective for this work for two reasons: (a) its frequency range was such that it could be understood in a high noise environment, and (b) male fighter jocks were far more inclined to listen to a female voice.

Or the hardware can use the computer-generated equivalent of the operator's own voice, thus making the hardware seem to be only an extension of the operator's own system. This is not because a lot of people like to hear themselves talk, but a technique to enhance the sensation that the hardware is an extension to their own capabilities.

However, it's an important point because of the fear of computers taking over the affairs of people. Computer companies have used voice modules to "humanize" computers, to make them seem to be less formidable, and to give them what the computer people call "user friendliness." Voice reporting circuits are being used in some 1983 automobiles. A machine that talks certainly seems less alien and fearsome. And when a machine talks to you in your own voice (or what you perceive your own voice to sound like), it subconsciously becomes a part of *you*.

The ability of a human being to consciously or subconsciously extend human senses, control capabilities, and "feeling" into an otherwise non-feeling, non-living, "dumb" machine is the secret of good racing drivers, good pilots, good astronauts, and good operators of any type of machine. The machine becomes an extension of the ego of these people. It becomes an extension of themselves that permits them to do things they couldn't do without the machine. People with this sort of ability are having no trouble with modern computers. And they'll be the people who will be among the first to use the direct-linkage techniques that are with us now and will be a growing part of the human scene very soon.

Giving a human voice to computer hardware is also only an extension of what is known as "anthropomorphism" or the attribution of human traits to non-living, non-human machines. I do it all the time. My computer is "Calliope." Robert Heinlein calls his "Gay Deceiver." This isn't because machinery, and a computer in particular, acts as if it has a nasty little mind of its own. But machines do seem to possess some personality traits. People have a strong tendency to humanize their machines. Some pilots still name their airplanes (although this phenomenon is usually at its ebb during peacetime). United Airlines and Pan American still name their airplanes, a humanizing touch from the early days of air transportation, that lends a homey flavor to what has otherwise become a system for herding large groups of people from here to there. Railway engineers used to name their locomotives before the front office decided it wasn't "businesslike." (This got started as an economizing move back in 1880 when Commodore Cornelius Vanderbilt decided to save money by having all the locomotives of the New York Central painted a uniform black over all. It's only in the last 25 years that the situation was reversed by corporate brass who decided their locomotives should be brightly colored for corporate identification. Thank heavens this drab uniformity hasn't taken hold in the airline industry, although the full expression of machine individuality through individualistic paint schemes wasn't totally accepted when it was tried by the former Braniff Airlines in the 1960s.)

We could have this basic Firefox System today. It may already exist in some super-secret government laboratory. As I cautioned at the beginning, it would be only the first step toward the ultimate computer. But once this first step in direct linkage is take, an unbelievable range of possibilities open up for the extension of human intellect with the help of the computer.

CHAPTER ELEVEN

SENSING AND PERCEPTION— THE COMPUTER TOOL

A computer that you can think instructions to and that talks to you through your skin is only the first step toward the ultimate use of the electronic computer as an intellectual tool.

If a computer can detect, recognize, store, and manipulate data derived directly from human sensory inputs (and it looks as if this can be done, judging from the early results previously mentioned), the consequences of this technology alone are staggering.

Arthur C. Clarke, a writer with remarkable foresight, forecast a technology that was capable of deciphering and recording the full range of human sensory input as well as the emotional reactions of a human subject; the recording could then be played back through a similar set of non-intrusive contact electrodes and would duplicate those recorded sensory inputs and emotions in the "listener." Human nature being what it is, the characters in this short story immediately saw the market for such a device in the personal entertainment field. *Really* personal and *really* entertaining! His fictional promoters immediately went to the best "houses" in Paris, Istanbul, and other fleshpots, acquired the services of the finest ladies of the evening in these places, recorded their own experiences with these experts, and put the recordings on the black market. In 1979, Lee Correy used something similar as a "throwaway" background idea in a science-fiction short story, "The Remodeling of Eve," to indicate a twenty-first century culture in which such things were a normal part of the life style among the "jet set" of that time period.

On the basis of our discussion herein, is it now possible to begin to consider such concepts as potential realities?

Yes.

If a DARPA EEG can be deciphered by a computer to "read the mind" of the human subject, that's just a first step.

If university researchers, using the MEG, succeeded in mapping the neural activity of the brain's visual cortex as long ago as 1978, they may now be well along on the task of mapping the neural activity of other parts of the human brain for such sensory stimuli as hearing, touch, smell, and kinesthetic muscle sense.

The neural activity associated with emotional states is also amenable to being mapped and recorded.

A very conservative forecast indicates that even with modest effort and financial support—to say nothing of what might be accomplished if massive infusions of funding were provided by government intelligence and military agencies—most of the neural activity of the human brain could be mapped with MEG techniques by 1990 with a tolerance of minus 3 years and plus 5 years.

Thus, the electromagnetic field activity associated with human thought processes will be mapped, known, and capable of being recorded.

This means it can also be digitized or converted to the on-off digital signals that computers can accept and store in their memories.

This in turn means that what a human being sees, hears, smells, and feels can be recorded in digital form in a computer memory. Human sensory sensations will become less subjective and more objective.

If these sensory data can be handled by computers, these same data are also anemable to some computer manipulative techniques of the same sort used by NASA's Jet Propulsion Laboratory to produce beautiful pictures of the outer planets from what otherwise might be over-exposed, under-exposed, washed-out digitized photographs. Once information of any sort can be transmitted and recorded for later playback, especially in digitized form, it can be deliberately "distorted." The signal can be enhanced. Noise can be removed. Frequencies and levels can be equalized, amplified, emphasized, and de-emphasized using common, plain-vanilla electronic techniques that have been well-known for more than half a century. The signal can be changed in any number of interesting ways to produce a remarkable end result.

When I was in college working in my spare time as an engineer-announcer—a combo man and deejay—for a local 250-watt AM radio station, we could play these sorts of tricks with signals even then using equipment that would be considered primitive today. Why, everything used *vacuum tubes*! A bandwidth of 20,000 hertz was considered fantastic, and we were just beginning to work with primitive TV circuits, stretching technology to get the required 4 megahertz bandwidth needed. It used to take a room full of equipment and 20 tons of air conditioning to keep everything cool; today, you can hold the equipment in one hand.

(An aside: Even the equipment necessary for a remote single-channel—no stereo; that was yet to come—required two men and a boy to carry it. There was a saying in the old AM radio business: "If it has a handle on it, it's portable." It didn't make any difference whether or not it was light enough to pick up with that handle.)

Today, the only vacuum tube you're likely to find in any electronic equipment is a cathode ray tube working as the picture tube in a TV set, the display screen of an oscilloscope, or the display of a computer terminal. And the CRT itself won't be around ten years from now, either, since within a year or so the CRT will begin to be displaced by one of a number of "flat screens" now under development in the United States and Japan, screens that make use of liquid crystal displays, among other things.

And these days, if any signal can be detected, identified, and recorded, it can then be analyzed and synthesized by other electronic equipment. The early Hammond electric organ of fifty years ago did this and produced a unique sound that resembled an actual Wurlitzer pipe organ but couldn't reproduce that pipe organ sound exactly. It sounded like what it was: a Hammond electric organ. Today, a Hammond or Lowry electronic organ, for example, can and does produce pipe organ sounds as well as most sounds of most other musical instruments, thanks to the same integrated circuit technology used by computers.

All this means that once the sensory and emotional neural signals from a human brain can be mapped and identified, equipment already exists for doing things to these signals. And for artificially creating those signals as well.

Here's an example: The early photographs of Mars, Jupiter, and Saturn sent back to Earth by such space craft as Mariner, Pioneer, Viking, and Voyager were digitized before they were transmitted by radio from the space craft. Once received on Earth by the Jet Propulsion Laboratory, they were recorded as received. Then the computer experts got to work on these signals using the big general-purpose high-speed mainframe computers at JPL. The first Mariner photos of Mars looked like a picture of a white cat lying on a white rug in a snow storm. They didn't have any contrast whatsoever because there was a heavy dust storm raging across the entire surface of the planet Mars at that time.

But the computers began to enhance the photos by increasing contrasts, eliminating random noise, amplifying the sudden change in brightness that is known as "edge effect," and generally enhancing any small changes in the picture elements (pixels).

The results were striking and allowed us to see through the Martian dust storm to look at surface features below. The same techniques of computer enhancement were used on other planetary probes. The photographs show views that could never be seen with the human eye even if an astronaut had been along for the ride because the human eye isn't that sensitive. Nor does it have the wide range that can be achieved with simple TV cameras and computer enhancement of images.

Furthermore, as far as we know right now, the human eye-brain system can't accurately record and store visual data. (But research in MEG mapping of neural processes may yet indicate that humans do indeed possess such capabilities and could be trained for perfect visual recall. And computers could record digitized visual inputs from MEGs.) We already know that the human eye-brain system can and does introduce systematic distortion into what it sees. That's a result of cultural bias, education, and often, if done deliberately, a conscious effort to manipulate the emotions of other humans that's known as "art."

A painter can and does introduce distortion into what is drawn or painted. The extent to which this distortion produces fear or wonder in other humans determines the current cultural value of the distortion as "art." Some art is timeless within a culture, and some art transcends culture, bringing the same emotions and meanings to people regardless of their cultural heritage.

Physically, each of us sees the world in the same way. The organic mechanisms of our eyes—cornea, iris, lens—lay down on our retinas an undistorted image of the light patterns reflected from or generated by external objects.

If you and I both look at the capital letter E, the same image will fall on our individual retinas, assuming that we both have healthy eyes capable of focusing on the letter E. When the retina and the optic nerve transmit the neural signal of that image to the visual cortex of the brain, the neural activity associated with that image is also identical in thee and me, assuming that we are not blind and both possess reasonably normal brains in which the visual cortex is working as it should.

There the identity of the visual perception ends because our individual brains will interpret that image differently, and we will each "see" something different.

If you don't know what the letter E is, it will be meaningless as a letter of the alphabet. However, the marking will be full of all sorts of information as a simple symbol.

My father was an opthalmolgist and had a technique for checking the eyesight of persons who couldn't read. He didn't use the usual eye chart with letters of various sizes arranged in sequences that don't form meaningful words to us (but may to people from other cultures; remember the joke about the Pole who was embarrassed at the oculist's eye chart because of all the dirty words on it?). He had a special eye chart with only the letter E on it, but in various sizes and in different orientations—the open end pointing up, down, left, or normally right. He'd ask the patient to use three fingers to indicate the direction the E was pointing. This worked beautifully and was devoid of cultural context.

Although any human being may therefore see the symbol E more or less the same, regardless of cultural background, visual perception of more complex scenes and of other symbols can vary widely from person to person even within a culture, to say nothing of the variation possible between people from widely different cultures. For example, if I type the series of symbols s**t or f**k, you can and do fill in the symbols represented by the asteriks to complete the scatological or sexual taboo word—and they're both still generally taboo in the North American culture in spite of the recent romantic "let it all hang out" movement. However, if I type m***e or s*******k, they don't mean a thing because they're scatological words in other languages.

The simple fact is that each of us does see things differently, even within the same culture. When cross-connecting between cultures, other, more fascinating differences occur.

I bask in the memory of being one of the few people who ever managed to stop in his tracks the great neurolophysiologist/philosoper, the late Dr. Warren S. McCulloch of M.I.T., an imposing and overwhelming Moses-like personage who was one of the first people to undertake neural mapping. He was imposing not only because of the enormous importance of his early work, but also because of his unique personality. He actually believed he was God, and indeed he proclaimed it. During the week he assumed the role of an academic researcher and professor; on the weekends, however, he retired to the isolation of Cape Cod, where he assumed his deity personality. Moral: A person may be perceived as being crazy in our time and cultural milieu, but that doesn't mean he's stupid.

Back in the early 1960s, non-intrusive neural mapping techniques and equipment such as the MEG weren't yet available, so McCulloch had to use electronic pickup probes inserted directly into the brain. As a result, his neural mapping work was done on animals such as frogs and cats. Dr. McCulloch told me proudly that he'd mapped a cat's visual cortex and could tell me exactly what a cat saw. I suggested that while he'd managed to map the neural responses of a cat, he still had no idea of what a cat really perceived. I pulled out a book, "The Story of Man" by the late Dr. Carleton S. Coon, and reiterated Coon's experience in this field as an anthropologist.

In 1947, Coon was leaving Tangiers after an anthropological dig in Morocco. An aged mountaineer tried to sell Coon a ship model he'd just finished carving. The Moroccan declared proudly that the model was an exact replica of the U. S. Navy's battleship U.S.S. *Missouri,* which had been anchored in the harbor for several days a short time before. Unless you'd been told this, you wouldn't know. The hull of the model was copied from that of an ordinary freighter. On either side of the bow, two imitation diamonds glared ahead to ward off evil; eyes are still painted on the bows of most native Mediterranean boats for this ancient purpose. In place of the bridge stood a Moroccan minaret. The ship's guns, stacks, and decorations were subtly distorted, and the model was painted in the colors and decorative patterns deeply associated with the Arabic-Muslim culture that became established in that region during the expansion of Islam in the ninth century. *This is what the man really thought he saw!* And he saw it in the comfortable and well-known terms of his own cultural background.

The image of the U.S.S. *Missouri* that fell on his retina and was transmitted by his optic nerve to his brain was the same image that would fall on your retina and be transmitted to your brain. But the way this Moroccan mountaineer actually perceived what he saw was depicted in the model he'd made.

Coon bought the model, and it is now on display next to an outline of the real shape of the U.S.S. *Missouri* (as we in North America would visualize it) in the University of Pennsylvania Museum in Philadelphia.

This brings forth an interesting dichotomy that the sensing computer is likely to help us solve: all available data seem to indicate that the "real world" that we sense is the same to everyone, but that everyone perceives or interprets it differently. This perception of the real world is distorted by genetic inheritance, cultural factors, education and training, and individual personal experience. Some of the early work on this dichotomy was performed by the gestalt psychologists, but without the benefit of the data we now possess concerning the differences between what is sensed and what is perceived.

By means of the MEG, neuro-mapping, and computer analysis and data storage, researchers are going to be able to make some far-reaching progress in the psychology of perception.

Because once the sensory data plus the resulting neurological pattern is in the computer and stored for future playback, there is no reason why the visual data cannot be displayed on a CRT or the auditory data played back through a sound system.

In the case of auditory data, this will turn out to be one of the greatest diagnostic and theraputic tools ever to fall into the hands of the audio therapist and researcher. It will be possible to determine exactly what a partially-deaf person actually hears. Auditory testing today is largely subjective; the test subject is asked to react to hearing pure tones of various frequencies. Utilizing the auditory sensing computer with its normal audio sensors as well as MEG neural pattern pickups, it will be possible for the audio therapist to determine precisely what the subject is actually hearing and how it is being heard—i.e., what distortions are being introduced into the signal by the subject's nervous system and brain. Hearing technologists can then proceed to design proper hearing aids which, in a very short time, will also become computer-centered, as we'll see shortly.

There are some persons suffering from hearing disabilities who possess otherwise normal ears and auditory nerves; their loss of hearing is termed "hysterical" or psychotic. The auditory signals are transmitted to their brains which in turn sense and decipher these signals normally. But other, higher functions of their brains distort or block the perception or recognition of the auditory information. An auditory sensing and analysis computer would be a positive means of identifying such conditions.

Although auditory sensing, reception, responses, and perceptions will probably be the first of the senses to be subjected to this sort of sensing computer analysis, it won't be long before similar techniques are applied to the visual senses. Once the neural patterns for various visual stimuli are determined through MEG research, it should become possible to determine exactly what is being sensed in the visual cortex of the brain. This MEG data will be as amenable as any other to computer analysis, and thus will be capable of being displayed in a CRT to show what the neural activity of the brain is actually "seeing." Again, this will be an enormously important neurological tool. It will also open up whole new vistas in the study of perception, just the sort of thing that Dr. Coon ran into with his Moroccan and the model of the battleship. Is the visual distortion taking place in the visual cortex? Or is it the result of distortions introduced in the actual perception locale of the brain? And where is that location? If it is taking place in the visual cortex as a result of over-riding distortion-producing signals coming in from other parts of the brain, what is the neural pattern of these distorting signals and where do they come from?

Doing the same sorts of things for other sensory inputs such as taste, smell, touch, and kinesthetic muscle sense—knowing what position your arm is in even when you've got your eyes closed and cannot see where you arm is—appear to be formidable projects at this time, although computer technology has already managed to bypass blocked nerve trunks to permit paraplegics to walk again. Neurophysiologists don't know enough about these other senses yet. How do we identify a salty taste? The smell of roses? The touch of velvet (according to the whiskey ad)? How does the gymnast on the trampoline keep track of the position of his arms and legs?

On the basis of the magnetoencephalograph and electroencephalograph research into the neural response of the brain to fairly simple sensory inputs, we should assume that it will shortly be possible—if it isn't already possible—for computers to recognize, analyze, and store data produced by visual and auditory stimuli of the human nervous system. The technology for doing the same things for other senses will soon follow.

Not only will we then possess a neurological research tool and a medical diagnostic machine of enormous and heretofore unparalleled power, but we will be well on our way toward the use of the human-computer interface to create the most powerful intellectual tool yet developed: the intelligence amplifier.

CHAPTER TWELVE

THE FIRST INTELLIGENCE AMPLIFIERS

When the computer can detect, analyze, and store neural activity, and when the computer can communicate directly back to the neural circuitry that generated that activity we will have created an intellectual tool without parallel in human history.

We will have developed the computer as a literal extension of our nervous systems and, we hope, to our minds as well, assuming that "mind" resides in the nervous system itself (and it if doesn't, this development may well succeed in revealing that, too).

In short, we will have created a device which, for want of a better term, is the "intelligence amplifier."

Remember: hardware to jellyware. This is a voluntary, non-intrusive linkage. The computer is in contact with the user only when desired by the user.

When the computer isn't linked to a human it remains a piece of soul-less hardware; it operates only when being fed electricity, and it can be "killed" at any time by pulling its plug. But, unlike us, the hardware can be turned back on and then remember everything it's been told to remember and behave exactly as if it had never been turned off. When it isn't linked voluntarily to the hardware, the jellyware can go about being jellyware with all of the traits and pecadillos it enjoys in that unencumbered form.

An aside: If you think the problem of computer privacy is a tough one now, wait until your computer is intimately linked with your own nervous system! Naturally, you will want to control the permanent memory files so that others can't get into your head, but that's a problem that we'll discuss in detail when we talk about some of the consequences of the direct-linked human-computer system.

Hardware and software sophisticated enough to perform in a duplex direct link mode with the human nervous system amount to an "intelligence amplifier" and that's the term we'll use henceforth.

But what's an intelligence amplifier supplied person going to be able to do better than a human being alone? What are the advantages that would drive its development in the first place? And what are some of the consequences, good and bad, that can be foreseen this early in the game?

Good questions, and the rest of this book will try to answer them or at least try to get a handle on possible answers.

We won't get all the answers, however, because the intelligence amplifier isn't a reality yet. When it does become one, which it will within the next few years, the exact form that it takes and its exact capabilities will permit us to narrow the range of answers to these questions. It will also permit us to give a more realistic consideration to the questions which, in turn will result in better answers.

What we cannot do at this point is stop, declare the whole thing to be the work of the Devil, and decide that we aren't going to permit any work that will lead to its development. It's too late. The horse is already out of the barn and down the road. If we don't follow up on these definite technical possibilities,—or perhaps I should say "inevitabilities"—others will. And we may not like what they come up with.

Outlawing war has not prevented war. Outlawing a specific area of scientific research has not prevented the same research from being conducted either in a clandestine fashion or where the rules and regulations are more lenient . . . or perhaps where the central government actually subsidizes the research because of certain potentials for the use of the results by the government. Outlawing any technological device hasn't prevented either its continual development or its use because there are always "special circumstances" that any powerful centralized government can invoke, laws or no laws. Example: If you and your potential enemy somehow manage to outlaw war as you know it, you'll soon be faced with war as you never conceived it could be.

One of the biggest hazards inherent in the development and use of intelligence amplification is the consequences of its use by totalitarian central governments, military and police organizations, unscrupulous groups of modern-day goons, or religious and semi-religious priesthoods who are far more interested in power over people than anything else, including—especially including—throwing back the cloak of the unknown. Keep these thoughts in mind as we work through the discussion of the power and potential of the intelligence amplifier in the future scheme of things.

The basic operational motivation driving the development of the intelligence amplifier is to improve and expand the utility of the electronic crystalline-based computer by linking it intimately on a non-intrusive basis with the electrical colloidal-based computer-like nervous system of a human being.

Or to approach it from the opposite and better direction, to expand the capabilities of the colloidal nervous system of a human being by providing it with a hardware/software extension of itself.

We don't know how to build a colloidal computer and link it with another colloidal computer *directly* . . . but the intelligence amplifier offers an interesting approach to that one, too.

The purpose of the system is to extend the intellectual capabilities of the human being, not the other way around. The human being all alone is capable of doing far more things than any computer yet devised or even contemplated. The idea of making the human being subject to the computer is therefore ridiculous. Of course as the technology continues to develop the non–amplified will be at greater and greater risk of domination by the amplified.

In the human-machine system, the human operator is just that: the entity in control. The hardware portion acts only as an extention of the human mind, brain, and nervous system. . . . at first. On the other hand, the hardware can access and manipulate extremely large quantities of data, and it can do so with virtually perfect accuracy. The hardware also offers the capability of doing all of these things without introducing any distortion in either the data or the manipulation of the data. You and I find it very difficult to keep our hopes and fears out of our projections; not so for the hardware. (Keeping our hopes and fears and misconceptions out of the software is the issue!)

Let us take a simple but very important example of a very rudimentary thing that even an ordinary computer can accomplish.

The *Encyclopedia Britannica* or any other reference work, text book, or data base can easily be stored on disk or tape. Before long your encyclopedia will be purchased already on disk or tape, ready for you and your computers to use, much as a piece of software is purchased today. In the future, such "data bases" may be available not only in computer stores but in book stores (not today's book stores, but the ones that will exist the day after tomorrow).

Put on the soft helmet with the non-intrusive input-output units held in place by its fabric. Or perhaps you've got an advanced model that has a reclining chair with not only a helmet but other input-output units arranged so that they can couple inductively with your central nervous system along and on both sides of your spinal cord. Now insert your new data base.

Let's assume that you want to learn something about lichens, that group of plants which are unique in being a combination of two different plants, such as an algae and a fungus. It may be in response to a school assignment. Or the requirement to know something about lichens has arisen in your business. Or applied botany (gardening) may be your hobby.

You would command the computer to tell you something about lichens. You wouldn't speak a word, although you might sub-vocalize because you're not yet totally proficient in using your new tool.

A small, primitive, low-cost proto-intelligence amplifier might reply to you verbally, and you'd "hear" a computer-synthesized voice in your head reading the contents of the "lichen" subject file from the permanent encyclopedia memory. Or you might even prefer to have the data read out onto a screen in reponse to your mental command. Either way, it would seem to occur almost instantaneously following your request.

The tool you are using is the first crude intelligence amplifier. Except for the feeling of integral connection (and don't underestimate the importance of *that!*) its functions can be duplicated by an advanced personal computer with voice recognition circuitry. But just wait till "next year's model"!

The first true intelligence amplifier might or might not vocalize to you, depending upon the instructions you "thought" into it. However, its primary playback of memory to you would link directly with your own memory. Without any indication that the computer had acted, it would suddenly be as if you had freshly read everything that was in the computer's data bank file about lichens.

Whether or not you personally chose to retain that information in your own memory for use in a school examination, for example, or to simply consider it, evaluate some aspect of it, and then forget it . . . that will be up to you and the extent of your proficiency with your intelligence amplifier.

In an individual human being, an eidetic memory or "total recall" can be either a boon or a curse. In elementary and secondary school, most of us are required to develop as much of an eidetic memory as we can because a great deal of "education" involves rote memory which in turn means total recall, if you can achieve it. As an undergraduate your willingness and ability to memorize is about all that is measured in an examination. One usually isn't taught how to think until graduate school, if then, or until one gets on-the-job training and experience in the school of hard knocks.

Eidetic memory can be an absolute boon to a person who elects to become a scholar. Scholarship mostly involves rote memory and rote recall because its basis rests on how much you know about a given subject. However, total recall can be a curse if what you are doing involves knowing a little bit about a lot of things and not a lot about any one thing. And total recall can be a curse if you don't have the intellectual capacity to compare, analyze, and sift the information to get what you're looking for in the way of an answer.

If a person has access to a data base (call it a library if you want), eidetic memory isn't necessary. Total recall becomes superfluous mental baggage. The important things to remember are where the data is located and how to find it when you need it. In human terminology, its "memnomics." In hardware terminology, it's "file access."

My own computer, Calliope, is programmed to set aside a few tracks and sectors on her diskettes for file names and locations. These file sectors tell her that there's a series of files on that diskette and give her their names. When she's instructed to get a particular file and load it in her working memory, she goes to the track and sector where that file is located. She then loads it into working memory. It's possible to open a file in the directory, load that file with data, and then "erase" the file name. The file data is still stored on the diskette, but Calliope thinks it isn't there at all because the file name has been removed. The complete data in that file can be recalled by re-opening or re-creating that file name in the directory. Calliope then "knows" that there's a file with that name and goes looking for it. She acts like a librarian who's lost the file card which lists the Dewey decimal locator number of the book, and therefore as far as she's concerned, the book simply doesn't exist. Put the card back in the file and she can find the book quicker, assuming she hasn't abentmindedly scribbled all over it in the meantime. (In a computer, it's quite rare to find data that's been mis-filed, unlike a library book that's been mis-placed on the wrong shelf.)

Like a computer, a human being can operate much more efficiently if it's not necessary to remember everything. It's far more important to know (a) that the data is available, (b) where the data is located, and (c) how to get to the data quickly.

Even the simplest intelligence amplifier will be an enormous help in doing this. The simplest—and therefore probably the first—software for an intelligence amplifier and the initial use of an intelligence amplifier will be to speed up the location of data and to get it into the jellyware's working memory as quickly. and as free of distortion as possible.

A lot of problems in this world are caused by distortion of the data in transit, a problem known to computer technologists as "drop out." Get a voltage spike on the electric mains powering the computer, and this may cause a spurious bit of data which changes the data in the machine. Get a bad chip that doesn't faithfully handle all the bits in it and going through it, or that takes out bits or creatively adds bits of its own, and the data's been distorted. You and I do this all the time, and there doesn't seem to be any way to prevent it except that, as when it happens with hardware, it can be corrected if the data is recognized as being garbage.

A digression is in order. My generation of old fuddy-duddies grew up with slide rules, primitive hand-powered analog computers, dangling from our belts. One of the problems with slide rules, in addition to the fact that their calculations were only valid to perhaps three or maybe four significant numbers, was the total lack of floating-point arithmetic programming. As a matter of fact, slide rules had no decimal point indicator at all; the operator had to do that mentally. Therefore, we developed a "feeling" for what was known as "ball park numbers." 123 × 67 would show up on a slide rule as the numbers, as close as you could read them, 835. But where's the decimal point? Is the answer 83.5 or 83500? Of course, it's 8350. Do it on a pocket calculator, of course, and it's 8341. But 8350 is a "ball park number," and we learned to locate the decimal point accordingly. There's only a 1.32% difference between the analog and digital calculation, which usually isn't significant in the real world. A lot of buildings and bridges were built and are still standing . . . and they were designed using old slide rules. Moral: the Universe may not always require the precision of even a pocket calculator, to say nothing of a big general-purpose mainframe computer—and precision aside, it takes a certain amount of familiarity with the data to know whether or not the answer is in the ball park.

Even before the arrival of the intelligence amplifier as such, the impact of the small computer on education itself will be staggering. While it is quite probable that some schools will use these basic precursors to the intelligence amplifier, it is probably going to take other schools some time to wise up to the fact that most of its students are using the things anyway; the students will have up-dated their families' home computers with the necessary add-ons or the parents will do it for their youngsters. It will be a situation similar to that in the 1930s when the encyclopedia publishers decided to expand their markets by selling encyclopedias door-to-door, basing their marketing strategy on the desire of parents to give their youngsters a better education.

Sooner or later, people are going to wise-up to the fact that there's nothing wrong with "cramming" in a world that's up to its armpits in data, where the amount of data is doubling every five years. It's long been impossible to know everything there is to know about everything that's known. Even if you sat down and read the encyclopedia from cover to cover—Dr. Isaac Asimov is said to have done it *twice*—by the time you finished reading it through just once, much of the information you'd read would have become out-dated.

Cramming is what all of us do now all of the time when we need to get "up to speed" or "briefed" on any subject. Cramming is a fact of life in the late twentieth century in the technically oriented cultures of the world, where knowledge isn't storehoused by scholars but is expanding every day.

The basic, primitive intelligence amplifier will help people do this, and do it fast. In fact, the hardware is already assisting the software in this regard by operating through the super-slow current peripherals. You and I still have to read "hard copy" or the computer's output on a VDT. That's slow. As soon as we get beyond the primitive Mark One model, the intelligence amplifier is going to be able to dump that data right into your brain.

But what you do with it is going to be up to you, as it always has been and will be.

CHAPTER THIRTEEN

THE ULTIMATE INTELLIGENCE AMPLIFIERS

The early, primitive, limited-capability intelligence amplifier discussed in the previous chapter is well-described by its adjectives. It is probably the first such device that will be put into use. It is very primitive compared to what can and will follow it. And it has limited capability because it functions primarily as an expansion module for the human memory.

But its potential for expansion in terms of uses can be forecast with some degree of certainty, because the forecast can be based on an extrapolation of what has happened to computers and other similar technologies in the immediate past.

Once technologies and their immediately obvious applications become commonplace, engineers begin to build upon the proven foundations of *what is* in order to get to *what could be.* This is known as "stretching" technology or "progress in the state of the art." The most obvious examples of this take place in aviation where airplanes such as the

MacDonnell-Douglas DC-9 airliner have literally been stretched to accomodate greater payloads in a longer fuselage.

Intelligence amplifiers are going to become even more powerful tools because of technology stretches in two directions.

The first of these is the inevitable improvement that will take place in the actual interfaces themselves. Note that the plural "interfaces," is used. Thus far, only one interface has been discussed: direct and conscious programming and command of the hardware, an expanded "Firefox System." The hardware recognizes the gross electromagnetic effects of neural activity and uses neurophonic playback/feedback techniques.

An aside: if you have difficulty accepting without further verification the full range of capabilities described herein for the neurophone, feel free to replace it with subcutaneous probes and radio transmitters; such as are currently in use in prosthetic medicine. Thanks to neurophonic technology such intrusive devices will not be needed, but they would certainly do the job.

We began with a discussion of such a primitive proto-device because such is completely within the capabilities of today's technology. Even non-military speech recognition techniques are at the multiple hundreds of words level and moving ahead fast. Someone just needs to put all the pieces together. Nothing needs to be invented—developed, yes; invented, no—to achieve the first direct human machine linkages. We know that hardware can be programmed and commanded by neural activity. And we know that hardware can communicate directly to the nervous system, at least in the "audible" sense. These two areas have developed quite independently of one another. They represent developed technology. The only thing that remains to be done is to synthesize them.

Why hasn't the fast-moving, high-technology, innovative computer industry already spotted this and started to work on it?

Answer: Because the fast-moving, high-technology, innovative computer industry is just like every other industrial activity. A brilliantly flashy external image covers a plain-vanilla industrial core. This is the way it is because this is the way that industry has to operate if it is going to be successful—i.e., if it is going to make a profit and thereby provide a return on investment, and it will only make a profit if it produces something of value to others that satisfies or fulfills some desire on the part of customers.

The computer industry appears to be charging madly ahead in the technical development of higher computing speeds, very large integrated circuits, 16-bit and even 32-bit microprocessors, smaller physical sizes, permanent memory storage media with increasing density and decreasing size, new display units utilizing flat screens rather than CRTs, and lower costs. There are several reason why technical developments such as these have the highest priorities. First of all, one must never find one's company in a position which is technically *behind* that of a competitor. And, secondly, technical development seems either to be a selling point or to lead to reduced costs, another sales encouragement.

However, the market saturation point for present personal computer hardware is quickly approaching. It's going to require increasing of committment capital to reduce costs and prices by a decreasingly smaller percentage. But even with a minor reduction in present costs, the market will soon reach the point where everyone who wants a computer can buy one—i.e., market saturation. It's questionable whether the computer industry will be able to institute the "planned obsolescence" or "regular up-grading" (pick the term you like best, depending on which side of the fence you happen to be on) of annual "model changes." This can take place when a technology is rapidly changing, but becomes a disadvantage once the technology base has reached a plateau. The general aviation industry tried to adopt the annual model change of the automotive industry and was only marginally successful. Thus far, the computer industry hasn't, and, probably will not.

But there will be a continuing market for upgrading, especially in the field of computer peripherals where devices such as the present-day typewriter-based printers will be displaced by simpler, non-mechanical printers capable of equal or better output.

With the approach of market saturation, as evidenced by the flattening of sales curves, computer companies may opt to emphasize improved software, and this is already becoming evident. However, hardware companies may not be the ones who succeed in the software business. Even as this is being written, many new, small firms that have specialized in software for existing hardware are actually leading the computer industry in terms of gross sales.

But the human use of computers is something else. Nobody is even rumored to be working on direct linkage, even though this is likely to be the really big and important activity in the field by the end of the 1990s and certainly by the millennium. Very few companies (if any) have yet realized this.

Why? Because they're running in the usual highly competitive, industrial Red Queen's race, trying to keep their hardware current with or ahead of that of their competitors. At the time of this writing, the computer industrial and marketing picture looks like this:

Some firms are deliberately under-designing their home computer equipment, using the King Gillette philosophy: practically give the razor away, but make money selling razor blades. These companies are looking a few years down the road at a series of model up-grades.

Other firms that have not been in the mainframe computer business, but have sold office and pocket calculators, are trying, with varying degrees of success, to adapt and up-grade their calculator technology to produce competitive computers which are *slightly* different from other "main line" micros in terms of compatible hardware and software.

Others opted several years ago to bring forth early-day home computers with operating systems that were inexpensive then but which are now basically incompatible with any other systems except through special interface modules.

And in trying to expand the marketplace into the home and other heretofore non-computer areas, many firms have put an enormous amount of effort into "user friendly" software. Some of it is novel and works well; and some of it appears to be worked-over versions of existing software packages that is superficially user-friendly, but at the same time is slow, unwieldy, and operationally complex.

Basically, the name of the game right now is "Grab-Market-Share." This game is played for keeps and usually means survival in the short-term. Get your hardware into as many homes as possible, more on the basis of price and "user-friendliness" than upon technical performance. Once people have your hardware, you've created a market for your software. You've also created product loyalty, so that when the time comes to introduce the technically improved Model Two, the people who bought Model One will tend to buy it out of brand loyalty and familiarity.

The computer companies that don't play this game are going to end up like Ranier, Elmore, Randolph, Oakland, and Durant; all of these names once graced the hoods of automobiles whose makers didn't or couldn't play the "Grab-Market-Share" game with Alfred P. Sloan of General Motors, Walter P. Chrysler, and Henry Ford.

There are some companies that don't behave this way, but they are the exceptions. They'll be around fifty years from now, the General Electrics of their industries. (General Electric was the first modern high-technology company, founded a hundred years ago by Thomas Alva Edison himself. By virtue of excellent marketing, it has remained one of the top companies in the world even though it pioneered in but then opted out of such modern high-tech fields as rocketry and computers.)

Thus as its core the computer industry is just like any other industry although it happens to be the new kid on the block, and a ninety-day wonder at that. An analysis of how the present computer industry grew and how its family tree branched from Bell Labs, IBM, and other early-day organizations shows a strikingly similar splintering to that which took place in other industries. And the computer industry's reaction to its rapid growth phase is also familiar because other industries have gone through the same thing.

There is a less than fifty-fifty chance that one of the existing computer companies will develop and market the first true intelligence amplifiers.

But there is an equally good chance that intelligence amplifier will come about in classic American fashion: A group of disgrunted former computer company employees who couldn't get their employer to back their idea will form their own company in a basement or garage funded by their life savings and mortgages on everything they own. 90% of such spin-off companies go belly-up, but the 10% that make the grade are responsible for most of the technological progress in any given field of endeavor.

The success of the first direct-linkage devices will then provide the impetus and the motivation to proceed with the difficult development of the true, ultimate intelligence amplifier.

This will be a system that amounts to a true extension of the human mind. Its inputs will come from

MEG, EEG, galvanic skin resistance (GSR), inductive nerve coupling (INC), and other signals originating in non-intrusive sensors on the external skin of a human being. The hardware will be programmed to recognize, discriminate among, analyze, and decipher these signals, then to respond to them.

The hardware will be programmed to operate as an extension of the human mind. It will carry out one or a number of intellect-boosting operations based on inputs from the nervous system, abetted by information already stored in its own memory and inputs from other sources. It will probably seem to know everything known and have extremely high-speed recall plus a means for correlating massive amounts of data at a high rate.

This will require a very high-level operating language that amounts to the ultimate in "friendly" and "user-compatible" software.

The hardware will be able to channel its output into any one of the senses—vision, hearing, touch, smell, taste, kinestheics—or directly into the brain itself.

Furthermore, the system will probably be programmed to operate as a fully-circular cybernetic feedback device "dedicated" as an intellectual extension of the human being. At least, when I put on that helmet and boot my amplifier, I'll demand a negative feedback system in the loop so that I could be absolutely certain of maintaining total control of the whole schmear! After all, computers do go into what is known as a "looping" mode where they keep right on doing the same thing over and over again because something happened and the software instruction to STOP didn't register, was somehow bypassed, or got hung out on the limb of the program while the program keeps busy merrily chasing its tail through the hardware.

Yes, there will have to be ample "fail safe" modes built in—something perhaps no more complex that the old "dead man's switch" of the railway locomotive. If the engineer releases the throttle, the locomotive will automatically stop. I'd want a fail-safe switch in both hands so I could stop the party by releasing either or both of them. And I'd want a time limit fail safe, too—an independant device that would periodically query me, and if I didn't respond would power-down the whole affair.

Okay, what's it going to feel like to use an intelligence amplifier?

It's extremely difficult now to know exactly how it will work and what a human being will experience while using it. Nothing like it has ever existed before. We have extended our physical bodies with tools and powered machinery. But we have never created an intellectual tool like this.

It is possible to describe to an Andaman Islander what a bulldozer looks like, but this primitive group of hunters is one of the few left in the world that doesn't know how to use fire. How do you describe to them what it's like to operate that bulldozer and thus easily move a rock that a hundred men cannot budge? They can't possibly understand it. They have no referent in their world.

But you can teach them how to operate it, although they may not have the foggiest notion of how it does what it does. Then and only then will they know what it's like to command the strength of a hundred men.

Closer to home, none of us can describe to ourselves, much less to someone else, many of the intellectual feats we've learned in the course of growing up.

Do you recall what it was like to look into a book before you learned how to read? Do you recall how meaningless and apparently unimportant those strange markings and symbols were that marched across the page? The beautiful pictures were far more interesting and meaningful, weren't they? Could anyone describe to you what it was like to extend your intellectual horizons and capabilities once you'd learned how to read? Would you have understood what they were telling you anyway? But once you had learned this immense intellectual trick, you probably took it for granted and forgot what it felt like to look at a book you couldn't read.

It's not the same if you pick up a book written in the Russian Cyrillic script, or if you try to fathom one printed in Japanese. You *know* that those symbols mean sounds which mean words which in turn stand for ideas and concepts. You know it has meaning, and you know how it must convey that meaning through its symbols. Before you learned how to read your native language in the first place, this very concept was alien to you.

As an aside—but perhaps it isn't because it relates to how we think and therefore to how an intelligence-amplifier will be used—do you realize that you think in words? That you may be sub-vocalizing or sounding out in your mind these very words as you read them? On the other hand, you may not be sub-vocalizing because you've learned how to read for concept rather than for content. But how do you do it? And what do you do when you're doing it? Describe it to someone else.

As a writer, I'm frequently asked how I do what I do. Well, I can string a lot of verbiage together about how I *think* I do what I do, but I'm not so sure I can really describe what happens when I sit down in front of Calliope's keyboard. It comes out of my mind through my fingers into the machine, and I'm not really conscious of what's going on. I'm "talking" to you, dear reader, through my fingers, if you really want to know. When I write fiction, I "hear" the various characters talking to me, and I just write down what they say. Usually, my fictional characters are composites of real individuals whom I've met or known; at least, the ones that seem to be real are that way. When I'm writing non-fiction such as this—and no jokes, please, about the whole subject being pure science-fiction in the first place, because it isn't—I'm trying to explain something in a logical, entertaining fashion. It's a lot easier than carrying on a conversation or even lecturing because I don't get interrupted as I usually do in conversation and occasionally do while engaged in public speaking.

However, I don't speak the same language that I write. I give an occasional lecture and always record what I've said. When I play back those tapes, I discover that it doesn't sound anything like what I write down in words. And when I write my speech ahead of time, it always sounds strange and stilted when I try to deliver it orally the way I wrote it.

My written and spoken communication have two different structures. So do yours.

This brings up an allied point: Each of us has structured our thinking processes on the foundation of our native or "milk" language. Since we think in words, we therefore think according to the structure of that language. Anyone who has learned a foreign language discovers that French requires a different way of thinking. So does German or Spanish. But, since these European languages stem from the same basic Indo-European language roots, the thought processes and structure they impose are pretty much the same. This isn't so with Oriental languages. They are based on different linguistic roots, and the structure of thought they impose is quite different from that of the Indo-European language group.

The extent to which this language-imposed thought structure dominates our lives was brought forcefully home to me when I undertook historical research into the work of Dr. Henri Marie Coanda. I set about tape recording his description of the first attempt at jet-propelled aircraft flight, a feat that took place back on December 10, 1910. Coanda, who was born in Rumania and lived most of his life in France, spoke at least eleven languages fluently. However, when I made the recording in 1965, he remarked, "I will speak in French because I think in French." The recording remains the definitive oral history recording of this occurence. (The stereo reel-to-reel tape recording on mylar is in the archives of the National Air and Space Museum of the Smithsonian Institution.)

I chose German to meet my undergraduate language requirement, and it became easier once I caught on to the grammatical and therefore the thought structure of the language—"See the old man come the street down," or "My old mother a green Volkswagen with a dent upon its front-going end has." Some of the Platt-Deutsch (Pennsylvania Dutch, my own ancestral roots) still speak English this way around Lancaster, Pennsylvania, although the pervasiveness of the telephone, radio, and television is tending to level-out these interesting localized language differences.

I can teach you how to read and write if you don't know how. But I cannot teach you how to write creatively. Nobody can. Although I got a lot of help in the form of tips and techniques from some fine authors, none of them could teach me how to be an author, because they couldn't describe it to me. And no scholastic course in "creative writing" can teach you how to do it, either. "Writers' workshops" are nothing more than an excuse for authors not to work at what they should be doing: putting words together for others to read. "Writers' workshops" are also a grand excuse for authors to get together, tell lies to one another, and discuss the stories they're going to write; having told these stories, there's no need to write them down, which is a boring job anyway. No, the act of creation is and must be a lonely one that is extremely difficult, if not impossible, to teach someone else to do.

In the face of this overwhelming difficulty in basic communication—and it bothers me that I can't communicate to you what I *think* it might be like to use an intelligence amplifier, because I'm supposed to be a communicator who makes his living doing such things—the best description of what it's going to be like is simply this:

It's going to help you think better.

Whatever you do of an intellectual nature (manipulating ideas, concepts, and emotions) vis-a-vis physical nature (manipulating physical things), you'll be able to do it better, faster, easier, and more completely.

This is probably the most human use of computers that's possible.

And in helping us do what humans do best—think—the computer-based intelligence amplifier is going to help us learn how we do what we do best.

The intelligence amplifier is a boot-strap device with enormous and fantastic potential for making us more human.

CHAPTER FOURTEEN

GETTING INSIDE THE JELLYWARE

With hardware that's directly linked to us and operating with software that enables the hardware to read an input originating in the central nervous system, perform according to instructions from that input, and then output directly to the central nervous system circuits, we've got a whole new approach to the human mind.

We may be able to utilize the intelligence amplifier to help us answer the most basic questions of epistemology. Epistemology is that part of the field of philosophy that concerns itself with the nature, foundations, limits, and validity of human knowledge. It is the study of cognition: what we know, how we know, and how we know that we know.

It is very difficult to get inside an human head to find out what's really going on there. Ask any psychologist or psychiatrist.

We're not referring here to something as mundane as neurological mapping using MEG techniques, but of the step beyond that. We alluded to the problem in the discussion of vision and Dr. Carleton Coon's story of the Moroccan model of the U.S.S. *Missouri.*

The basic neural patterns of vision, hearing, and even of cognition itself may be the same among a large population of individuals. The statistical similarity that we already know exists in the way people react to stimuli and therefore must think is the factor that will make the intelligence amplifier work in the first place. The intelligence amplifier software will permit the hardware to recognize certain neural signals as data concerning what's going on inside the jellyware.

It's what the individual human being *does* with those neural operations, how those patterns are intrepreted, and how these are integrated by each individual that determine what "intelligence" really is.

Each human being is likely to be different.

Or perhaps not.

The intelligence amplifier may be able to tell us.

The intelligence amplifier may give us the first tool we've ever had for real, solid, repeatable investigation of the human mind. Thus far we've had to depend upon the jellyware's own output peripherals to get the data, and we already know that such data is usually biased and distorted by the jellyware itself. Almost 99% of psychiatry involves trying to determine what the patient *really* means. And more than 90% of all interpersonal interactions are involved with trying to compensate for distortion in communication. "What did they really mean by *that*? Well, to cover our anatomies just in case we read them wrong, we'd better do it this way . . ."

This occurs even between people who have been intimately acquainted by marriage for more than a quarter of a century. The practice of swearing an oath of truthfulness arises from general recognition that people are untruthful. As a matter of fact, if people were truthful and trustworthy (and possessed eidetic memories) written agreements and contracts would be unnecessary. "Let's get this all down in black and white just so everybody agrees about who's going to do what for whom and for how much . . ."

The intelligence amplifier will probably be the best lie detector ever developed.

Many other futurists and science writers have discussed machines they've called "intelligent." However, by and large, these have been only very large computers, mainframe hardware with rather sophisticated and in some cases conjectural software, that the authors called "intelligent" while begging the question, "What do you mean by 'intelligent?' " These "intelligent machines" were treated anthropomorphically—i.e., the futurists or authors simply considered them as humanistic electronic individuals, the logical extension of the colloidal computer's evolution of intelligence into a crystalline computer. As we've discussed, this may not be the path to the "intelligent" machine after all. There may be no intelligent machine. On the other hand, it is fairly certain that we will be able to use the crystalline computer to extend our colloidal computer and therefore as an intellectual tool.

Since we cannot agree and frankly do not know the answer to the basic question of epistemology—

What does "intelligence" consist of?—it is very unlikely that we will be able to build computers that show traits that we would even begin to call "intelligent." Dr. Marvin Minsky, Dr. John MacCarthy, and other experts in this field haven't been able to do it yet. Although I have great respect for them and for the work they've done, I suggest that they're looking down the blind alley discussed in the preceeding paragraph.

On the other hand, we may be able to use the computer to find out more about ourselves. If we're looking for the definition of something we possess, perhaps we should look within ourselves, using new tools to get the data. Rather than try to build an intelligent machine, perhaps we should investigate the use of machines for extending human intelligence and, in the process, unravel some of the knotty questions of epistemology that now pose formidable barriers in the development of "intelligent machines."

To some extent, this has already taken place. In order to design and program the modern electronic computer, we've had to conceive of a basic system that will accept data through an input, process it, and produce an output. Although fifty years ago we possessed the Boolean algebra upon which most of the internal logic of a computer is based, we didn't then have most of our present-day concepts of information theory.

Now that we have a working hardware-software system that is successfully tackling an increasing number of tasks in the real world which formerly required acres of accountants, clerks, and engineering technicians, and now that it appears we have the potential for directly linking this hardware-software system with our own mind, we can get inside our heads without disrupting what's already going on there or, at worst, causing minimum change, disruption, and "Heisenberg Effect" changes—i.e., the presence of the observer always affects the performance of the system and therefore the results of an experiment. We won't have to use various chemicals and drugs whose basic effects on both gross and individual neuronal activities aren't throughly known yet. We won't have to use intrusive, surgical methods; the MEG-driven computer can be used instead. As the MEG neural maps are completed, and as software grows more sophisticated, we'll be able to record neural activity in real time (as it's taking place). We can then study this data again and again.

We will have a device that is just as important to scientific studies as the motion picture camera, the video recorder, the various audio recorders, and the plethora of data recorders such as oscillographs, chart recorders, etc. These devices permit investigators to replay the data; stretch the data out in time or compress it; manipulate the data by noise-elimination techniques; eliminate unwanted parts of signals by filtering and equalization; massage the data by integration, smoothing, differentiation, and a host of other mathematical tricks; study a given time-period of data, and compare various portions of the record against other portions and against data from other investigations.

Being able to do this for neurological activity and thought patterns is completely new.

And it's going to accelerate the entire field of mind research beyond our wildest imaginings today.

However, since neurological investigation with intelligence amplifiers will involve human beings, it's going to have to be carried out in careful, step-by-step phases. This is always the way one approaches the unknown when there may be hazards present (whether these hazards actually exist or not). Some risks must always be taken; there is no future without risk. But the design of experiments and the conduct of investigations requires both humanitarian and financial parsimony. The old saw about "experience gained is directly proportional to the amount of equipment ruined" can't be allowed to apply to these computer-human linked investigations into epistemology.

The first phase of the epistemological investigation will be nothing more or less than data collection —how various human individuals perceive and think through some basic, simple problems. This is known as "baseline data." There will be differences between individuals, but there will also be similarities.

Once we have baseline data—and the "adequate" amount of baseline data will always be in question because there are some investigators who would spend their entire lives collecting "wall to wall data"—the next phase is to get data from human individuals with known variances, perhaps initially only in the sensory areas. Example: How does a deaf person really perceive those high-energy sounds which resonate with various body cavities? You don't really "hear" the boom of the kettledrum or bass drum so much as you feel it in your body.

You don't "hear" the thunder of a jet airplane taking off so much as you feel it. What is the difference in the way these phenomena are actually perceived by sensory-deficient or sensory-deprived individuals?

This is something more than the sort of neurological research now going on involving "evoked potentials." That field of study is the precursor to what we're discussing here because it involves recording EEG or MEG outputs from various individuals and noting the differences and changes in the signals as a result of the application of known and repeatable stimuli. We can feel certain that the intelligence amplifier will yield basic epistemological data that is, within limits, similar for a three-sigma probability distribution of the population, because this has been the case in "evoked potentials" research. We all exhibit the same basic overt neurological response to the same sort of stimulus.

It's what we do individually, after the evoked potential is generated, that makes the difference. That's what this device is going to help us get a very firm handle on.

This third phase of this epistemological investigation must be run in several parallel lines. Part of the important data from this phase will come from "normal" individuals solving various problems or confronted with various situations. Although there is wide variation in mental abilities and skills, we can indeed define what we mean by a "normal" person based upon statistical analysis of an enormous amount of baseline data now in hand. Just as anthropometricists have determined the size and shape of the "normal" human body and can design a piece of furniture or a car that will be comfortable for 95% of the population ("for the ninety-fifth percentile person"), so psychometricists can and have established norms for performance and behavior. The old bit, "Everyone's crazy but me!" doesn't work any more. Within various cultural mileus, standard norms and standard deviations have been established—or can be established with a little effort. Thus, we will be able to get good intelligence-amplifier baseline data from "normal" people with a high degree of confidence that it will represent "normal" data.

The other important part of this phase of the investigation will come from individuals with known psychotic or neurotic conditions.

This should be very exciting to psychologists and psychiatrists. For the first time, they will be able to up-grade their field to the level of a predictive science ... provided they are willing to remove taboos that prevent them from being objective in their evaluation of data. There are several of these, many based on humanitarian egalitarianism that their own statistical data tells them is incorrect.

The important elements in all this data are, of course, the *differences* in the way the various human subjects respond, as detected, analyzed, and recorded by the intelligence amplifier equipment, so the data isn't distorted by the observer or investigator and certainly not by the hardware itself.

This, then, brings forth a critical question:

If the jellyware's internal programming can be detected and determined using these techniques, will it then be possible to utilize the intelligence amplifier's own feedback circuitry to *alter the jellyware programs?*

Yes, but probably not in the ways one might immediately think possible or as thoroughly as some might like, although all of this remains highly conjectural and subject to up-dating as the inevitable human-computer interface research proceeds during the next quarter of a century.

We must always keep in mind that the intelligence amplifier is only an external intellectual tool. It is quite unlikely that it's going to be able to get in there and "scramble the neurons".

However, feedback technology can be applied here in the same manner as well-established feedback techniques are used in other areas.

For example, any system can be built to eliminate internal "noise" (unwanted signals) or "distortion" (system-induced changes in the signals). The noisy or distorted system output is compared against the system's input *or the desired system output.* The input is subtracted from the output, and the noise or distortion then becomes a signal in itself. This distortion/noise signal is re-introduced into the system in such as way that it subtracts or nullifies itself within the system. The resulting output is "clean."

If the distortion/noise characteristics of a system are known, feedback isn't required at all. The signal is "corrected" at the receiving end. For example, a telephone line may "roll off" the high frequencies of an audio signal by a known number of decibels per octave per mile of cable. At the receiving end, equalizer circuits boost those high frequencies back to normal levels on the basis of the known transmission line characertistics.

Here we have the possibilities for an interesting situation. Baseline data from intelligence amplifier investigations will indicate the nature of the "normal" thought-process signals from a three-sigma sample of the human population. These can be compared against output signals from mentally disturbed or deficient persons. The intelligence amplifier can then use its "talkback" functions to introduce corrected signals into the jellyware, just as a feedback circuit corrects the inevitable distortions in a stereo amplifier.

Will this effect a psychopath, for example?

What will be the individual response?

We have all experienced distorted sensory inputs. The most common occur during illness accompanied by high fever. As we grow older and our minds accumulate a greater store of sensory memories, we tend to "filter out" or "equalize" these feverish inputs, automatically correcting them.

With the intelligence amplifier we could determine exactly how distorted sensory inputs are created in the brain and where the distortion occurs.

What *are* the mental processes involved in schizophernia? How do schizophrenic thought processes differ from those of a normal person? Are the various neuroses and psychoses structural, operational, or chemical in nature, and how do the mental processes exhibited by each differ from other abnormal psychological states and from normal?

We've almost got the intellectual tool to answer these questions, and we've also got some other tools that can be effectively used with the intelligence amplifier in this most important of future scientific investigations.

Extremely important accessories in this third phase investigation will be, strangely enough, the hallucinogenic psychochemicals.

The overarching value of the hallucinogens in mind research has been almost destroyed by the news-media importance tendered to the widespread "recreational" use of LSD and others, as well as the fear, born of ignorance, that these reports have produced. This has affected both law enforcement officials as well as legislators, who seem to think they are dealing with a new phenomenon. They're not. Hallucinogens have been in widespread use in other cultures—primarily the Oriental cultures—for centuries while the primary hallucinogen in Occidental cultures has been ethanol. (Ethanol may be considered a hallucinogen—if consumed in sufficient quantities over a sufficiently long period of time. Many people seem to have forgotten the stories of "pink elephants" and other hallucinations.)

Many people in the sophisticated western cultures don't realize that most if not all of the effects of psychodrugs can be achieved voluntarily by some individuals without chemical assistance. The feats performed almost at will by yogis, shamans, and other "holy men" are unquestionably real, having been observed and recorded with far more objectivity than many physical or chemical phenomena that are the subject of secondary school science lab experiments. Furthermore, many of these shamans are quite capable of producing a "hallucination" in other people.

How do the hallucinogenic psychodrugs really work?

By what neural processes do yogis and shamans perform their feats?

Are the mental processes that are created, enhanced, unlocked, or otherwise activated by psychochemicals the same or similar to those that occur naturally in our nightmares and fever dreams?

What relationships do these mental processes have to those used, apparently naturally (albeit with a great deal of training), by yogis and shamans?

We're going to be able to find out using this new intellectual tool, the intelligence amplifier.

Once we know, is the data going to be able to tell us how to do it ourselves if we want to?

There are a large number of Oriental mental tricks that are indeed enormously helpful to people in the fast-paced, fast-changing Occidental cultures. Yogis often have to spend years studying under a mentor to master the basic physiological techniques that permit the attainment of suitable psychological states. This apprenticeship is a highly effective method of teaching, but it is enormously awkward, lying in the general realm of mysticism. A mystic teaches by saying, "Do as I do because I can't tell you why it works." A teacher in the Occidental sense has figured out what he's doing, understands how he's able to do it, and is therefore capable of instructing someone else who is *remote in time and space.* The instructor teaches by saying, "Do as I tell you, and here's why it works." The instruction may be by written word and picture in a book . . . or via TV, satellites, and all the other aspects of modern technology.

An educator, on the other hand, teaches by *asking,* "Why did that happen when you did it that way? What will happen if you try to do it another way?" An educator makes you figure it out yourself. You tend to remember it better and also to understand some of the consequences. But education takes longer than training.

Forecast: The most advanced techniques of yoga and other mental and even spiritual disciplines will be recorded and analyzed using intelligence amplifiers, and software will be available that will permit you to achieve whatever level of meditative condition you wish. Want satori? Open the file. Want a Kundalini release? Open the file. Remember, you're going to have an *intellectual* tool in your computer-based intelligence amplifier.

Forecast: Psychologists and psychiatrists are going to crack the mental diseases wide open and will be able to "cure"—perhaps only temporarily at first—most mental illness, returning the insane to a relatively "normal" mental condition within, say, the 95th percentile of the population.

And these are only a few of the ways our brand new intellectual tool is going to be used.

CHAPTER FIFTEEN

THE WORLDWIDE MIND

As we've seen again and again thus far, there are an enormous number of unforseen and unsuspected consequences, as well as fantastic potential, created by a process known as "synergy." This is another fancy word that basically means sometimes two plus two doesn't equal four, but seven or nine . . . or zero. The future unravels through synergy, which is why nearly all forecasts of the future turn out to be overly conservative and why some of the most fantastic forecasts come closer to the mark. Synergy is a combination of two or more elements which has capabilities that none of its elements could achieve alone. Perhaps the most common form of synergy involves the human male and the human female. Individually, each can pretty much do the same things the other can, but together they can do something neither can accomplish alone: make a new human being.

The principle of synergy is the reason the intelligence amplifier is a serious forecast. And the synthesis of the device with other areas of technology results in an enormous range and variety of new things.

One such synergy is in results from computer networking.

At this moment, it is possible for me to plug Calliope, my present intellectual tool, into a device called a "modem" that costs about $150. The modem is then plugged into the telephone jack next to my desk. This jack is hooked into the telephone wires that connect my office/home with the rest of the world's telecommunications network. Using this communications system as a data transfer network—a super-long cable, as it were—Calliope can talk to any other computer in the world if the other computer is also linked to the network. She can talk to any number of computers that happen to be on the network.

"Networking" computers right now is useful for (a) transfering data from one computer's memory to another's, and (b) linking computers together for increased operational capability, increased memory size, or increased data handling capabilities.

Networking is going to expand the local capabilities of your home computer in many ways during the next five years. Not the least of these capabilities will include an interconnection with your bank's computer so that both of you won't have to mail so much paper back and forth.

Using network principles, and if our computers were compatible, I could get Calliope to talk with editor Jim Baen's computer so that the text of this book wouldn't have to be printed out on paper by my Rube Goldberg printer, physically transported to New York City by the U. S. Postal Dis-service, then transferred back into another computer by Jim Baen or by a typesetter so that the book could be published.

Arthur C. Clarke lives and works in Sri Lanka with his computer and satellite ground station. If Arthur and I wanted to write a book together, we could transfer data back and forth between our two computers half a world apart and, without ever seeing or talking to one another, produce a joint work. Authors Jerry Pournelle and Larry Niven already do this, but they live only a few miles apart in California.

However, a whole new realm of possibilities open up when a human being can connect his intelligence amplifier to a data transmission network.

First off, it's going to make easy work out of one of the most difficult of modern tasks: the removal of the human operator from machines and devices that operate in hazardous or deadly environments or, conversely, upgrading performance to the human-on-board level.

An example of this is the target drone aircraft used by military forces for gunnery or missile firing practice in order to simulate closely actual operational conditions. Another use for such a remotely operated aircraft is reconaissance over a battlefield where there are lots of small arms ground fire, SAMs, and other phenomena that are hazardous to the continued existence of the craft. These are either old, worn-out airplanes or specially designed craft fitted with radio control equipment, which is known as the "up link," and a "down link" the drone uses to transmit back to the human operator the condition of the craft, its position, its attitude, and its performance.

The problem involved with removing the human operator from the machine itself isn't necessarily the delay in the up-link and down-link, although delay indeed becomes important when the machine is on another planet and there may be several hours' delay between receiving the down-link signal and sending an appropriate up-link command. It involves mostly the lack of adequate sensory input to the human operator and the elimination of the "feel" of being there. It wouldn't make any difference whether the remotely-operated device, or "teleoperator", was a coal-mining machine far underground in a gas-laden tunnel or a milling machine working on a chunk of radioactive material behind a ten-foot lead-and-concrete wall.

What's needed is more than a TV camera looking at the instruments and the surroundings.

What's needed is visual, auditory, tactile, position, acceleration, and other sensors in and on the remote device that the intelligence amplifier software would translate into human sensory data. The intelligence amplifier processes them to produce an output that is almost a 100% analog of what a human operator would sense. For all intents and purposes, the human operator would feel as if he were actually in the machine or operating the machine.

The remote human operator then would use that machine input to "think" the operation of the machine. He doesn't have to operate through a distortion-inducing set of remote controls with no feel or feedback to them. He operates the machine by "thinking" the operation into the system. This is perhaps only a remote version of the basic Firefox System, but it can't work without the total feedback loop being in place.

It isn't going to be the same as actually being there, but it will be the closest thing to it and a step beyond today's simulators in terms of reality. And, if you've ever operated one of the current crop of airplane simulators, for example, you know you can sweat just as hard as you would flying the real thing, because it seems as if you are.

However, this is a very crude and quite obvious application. Suppose we combine the human being using existing sensory technology, computer technology, direct-linking technology such as the neurophone, existing computer networking technology, and another human being with an intelligence amplifier hooked into the network. What have we got then?

Answer: Real, honest, no-foolin' computer-aided telepathy!

The link wouldn't take place mind-to-mind the way classical telepathy apparently occurs according to Dr. J. B. Rhine, who conducted decades of experimentation on telepathy at Duke University. It takes place in a system that's mind-to-computer-to-network-to-computer-to-mind. Furthermore that capability will be shared between any two (or more!) persons anywhere in the world as long as they both have intelligence amplifiers.

Most computer communications based on the existing telephone system operate at 300 or 1200 baud, which is extremely slow for hardware. Intelligence amplifier networking could probably be done at a 1200 baud transfer rate, but better data transfer rates are already becoming available.

A few weeks ago, a group of workmen buried a fat black cable along the street in front of my house. Phoenix was being wired with a network of co-axial cables for "hard-wire" distribution of cable TV signals. "Pay TV," using a specially scrambled UHF radio signal, a de-scrambler UHF converter atop the TV set, and a special antenna, is already in use, is cheaper, but suffers from a limited number of TV channels per carrier frequency that can be transmitted. The frequency spectrum is so jammed now that it's difficult to get a frequency assignment for additional channels. In addition, the radio-link pay TV signal is easily pirated by any amateur capable of putting together the UHF receiver and de-scrambler from ordinary electronic parts. In fact, it's possible to buy kits for doing this and, in places where the courts in their widsom have decreed that a broadcast signal using the public spectrum is nonetheless private property, circuit diagrams and parts lists for doing the same thing can be found if you know the right people, especially those who happen to work in local electronics industries.

I left off writing this book to go out and look at the cable. Any excuse to keep from working. "You gonna get hooked up?" the foreman asked. I replied, "Yeah, when you guys can give me a four megabaud data transfer channel." He didn't understand what I was talking about, but I have the opportunity to explain it to you here.

Television signals generated according to USA standards require that the transmission system be able to handle a signal with a bandwidth of four megahertz; it requires that much spectrum space to transmit the information that generates thirty frames of 525-line television raster, plus the FM audio signal on the "back porch." Calliope runs at two megahertz and, with up-grading, could run at four megahertz. That cable buried in my front yard is capable of transmitting a four-megahertz signal. It will handle the full-speed output of Calliope.

If that cable is connected to a larger system, I could have a four megabaud link to any other computer.

Whether such a wide-band link goes through miles of co-ax cable, microwave relay links, or a comsat up in geosynchronous orbit, the way the other end of that co-ax cable is connected to my end is immaterial. It can be done. Not only is the technology available, but the equipment to accomplish it is also on-line and waiting . . . if I want to pay for it; at the moment wide-band links happen to be expensive. Assuming that you can squeeze a thousand telephone circuits into that four-megahertz channel (it's actually possible to do much better than that) at the current Ma Bell long distance rates of roughly a dollar a minute transcontinental, such a broad-band circuit is going to nick you for a thousand dollars per minute . . . unless you can get the "fleet rate" or find a cheaper net, which you can.

Nevertheless, the capability is there if you want to pay for it. This is an excellent example of Stine's General Forecast: You can do anything you want to do providing you are willing to pay for it and to live with the consequences.

But the availability of broad-band circuits is going to improve. There are going to be more and more of them available because they're useful for a lot of things, especially in the field of computer networking. If they're useful, they're valuable, and if they're valuable someone will risk the capital to make more of them available in order to sell the service and satisfy a market desire. The technology is also there to squeeze several four-megahertz channels into a single co-axial cable, but the problem lies elsewhere. There's limited space remaining in the electromagnetic spectrum up to 3,000 gigahertz (3×10^{12} hertz) which happens to be the top end of the radio spectrum that can now be handled and just about the bottom of the infra red region of the spectrum. Fiber optics technology and laser communications technology, however, use an enormous portion of the electromagnetic spectrum in the infra red, visible, and ultraviolet wavelengths where gobs of broad-band channels can easily be accomodated. If the market desire for broad-band data transfer channels exists, as it does and will continue to expand, fiber optics and lasers can provide the means technically to fill the desire. And the cost will go down as a result because more four-megahertz channels can be accomodated in one fiber optical "light pipe" or on a single laser beam.

The basis for this claim of reduction in costs lies in the historic trend in long-distance telephone rates. In 1920 a transatlantic telephone call from New York to London cost $50 in 1920 dollars for three minutes; in 1983, the same telephone call cost $3 in 1983 dollars (roughly 60 cents in 1920 dollars).

Very well, networking of intelligence amplifiers through broad-band data transmission facilities today is technically feasible, practically possible, and increasingly affordable tomorrow. What are the consequences?

Simple: it will usher in the most important advance in inter-human communication since the invention of writing by the Sumarians about five thousand years ago.

Writing allowed human thoughts to be recorded for transmission to other people at different locations and at any time in the future, provided you knew how to read the writing.

Networked intelligence amplifiers will permit human minds to communicate directly with other human minds.

Gone will be the distortion inherent in all forms of communication used today—voice communication through language, person-to-person communication via telecommunications such as the telephone or television, and written communication.

Do you really want to know what the visual images, subvocalized sounds, and emotions of an author were when a given story was created? The author will be able to use his intelligence amplifier to record what went on in his mind, thereby creating a new art form that could perhaps be called "neuro-novel." There will be authors who create in "real time" on network, a unique form of mental broadcasting. Think of how interesting it would be to know how Homer actually visualized

Helen of Troy. Although she is considered the epitome of female beauty, for whom a major war was fought (it makes a good story even though the Trojan War was fought for economic reasons and not simply over woman-stealing), Homer never described Helen. In fact, Helen of Troy has never been described at all. Yet each of us has a mental image of what she must have looked like.

On the other hand, getting into the mind of a creator or artist may turn out to be a monumentally boring affair. Most creators have incredibly messy minds full of strange and erotic quirks and an enormous amount of garbage. It may take special training to think in such a way that the result will be entertaining to others. Right now, it takes lots of experience and lots of practice to learn how to be entertaining *in print*, and some people never reach a level of accomplishment that makes their creative material entertaining. Right now, we authors can revise and rewrite, and the editors can change it to suit their own likes and dislikes, as well. What you buy today as creative material in the form of books is a far cry from what really went through the minds of the authors during creation. It's been highly filtered both in the writing and in the publication process.

On the other hand, it would be extremely pleasant to to network one's intelligence amplifier with that of a very close friend or loved one. Audio telephone conversations convey only a small part of the information exchange that goes on between people who are extremely close; two-way interactive television communications or video teleconferencing improves the situation right now, but the equipment costs plus the communications channel costs are high. But an intelligence amplifier, being merely an up-rated version of the existing microcomputer with perhaps greater memory and sophisticated programming, is already an affordable item for millions of people. At first this will require that the machines be connected either by wires or waves, but telephonic mind links will come. And even a 1200-baud network channel might prove to be adequate for low level mind networking, at least at first.

Again, what would it be like to be direct-linked to your intelligence amplifier which, in turn, is networked to the intelligence amplifier of a friend or colleague, someone with whom you'd feel comfortable sharing your thoughts, concepts, mental images, etc.?

I do not know and I cannot tell you because I am a blind man attempting to describe a sunset.

This is a totally new form of inter-personal communication.

Save for those rare, isolated, and transitory incidents of telepathy that have been reported in the field or investigated in the laboratory, we don't know what it will be like.

I think I may have achieved a telepathic-like communication from time to time with my wife of thirty-plus years. There are times when I seem to *know* what a close friend is thinking, even when that friend is long gone and far away. But it is impossible to describe what it's like. And I'm not sure that I could achieve an empathy that would permit me to pass the back-scratching test—i.e., if you can always scratch your spouse's or friend's back *exactly* where it itches, it's probably because of telepathy. (At least, the back scratching test is as good as any until a better one gets worked out.)

Our language does not yet have the concepts or terms to describe what it's going to be like.

But we'll certainly develop them, because all of the technology to make the intelligence amplifier possible already exists, and the technology that will allow intelligence amplifiers to be networked also exists.

Ask me again in twenty years. Of course in twenty years you won't need to ask.

In the meantime, I've just going to have to cop out on you or end up writing a science fiction story. And, since the direct linkage of the human colloidal computer system with the electronic crystalline computer system is such a startling concept in itself, the whole idea may well seem to be science fiction to most people anyway. Believe me, it isn't. Fact is usually stranger than fiction.

But there are other highly useful aspects to this concept of networked amplified intelligences, besides the obvious and most controversial ones with which the discussion was started. It's not necessary to bare your entire thinking process, thus baring your entire soul.

Remember: each of us thinks in the words of our "milk language," the one we learned from our parents by listening, by example, and with their encouragement. We may communicate with other people later in other languages that we've learned since, but our thought structure is always determined by the linguistic structure and basic thought concepts of our milk language.

I have a friend who grew up in Czechoslovakia and came to the United States in 1968. He has almost forgotten how to speak Czech, but I know from the way he talks, the way he acts, and the way he writes that deep within his mind the structure of his thought processes is still ruled by the structure of the Slavic languages.

Even with a 100% networking between individuals, it is extremely unlikely that there will be 100% perfect communication. Distortion will be inevitable. (This may not be true of the generation of children who grow up with intelligence amplifiers, but it is most likely to be true for those who didn't. Remember the analogy we discussed earlier about those who grew up with a given technology and those who didn't.)

And each of us is still in control of his or her individual intelligence amplifier. We control the software. We control the elements in the feedback loops, and therefore the nature of the error signals.

The software can be modified to instruct the intelligence amplifier to output to the network only what the jellyware operator wants.

Thus, an intelligence amplifier in networking mode can be programmed to transmit the truth and nothing but the truth, but not the whole truth. It may be possible for the other amplifier to determine whether yours is lying (or perhaps not), but there is no generally reliable way to determine whether or not the whole story is being told.

This, then, does make mind-linking useful for political, diplomatic and business negotiations and communication. While it's possible to conceive of a world that operates truthfully, we'd probably be at one another's throats if everyone knew the whole truth!

On the other hand doubtless some organizations will offer the rental of certified unrestricted full-bore devices for guaranteed full and frank discussions. The mind boggles.

It's going to take the human race some time to get used to having what amounts to telepathy available, even though the phenomenon takes place through the medium of our new intellectual tool, the non-living crystalline computer. Computer-based telepathy is, however, a valid and achieveable concept that is within the capabilities and synergies of existing technology.

If "getting inside someone else's head" via an intelligence amplifier, whether it be for theraputic reasons or political reasons, is a real possibility—and it seems to be very real—we have the possibility of doing a great deal of good, of improving the condition of the human race, and of greatly changing the nature of interpersonal relationships.

We also have a tiger by the tail.

CHAPTER SIXTEEN

RIDE THAT TIGER

We are slowly learning that the organized body of knowledge called "science" and the organized body of working know-how called "technology" are intrinsically neither good nor bad. We have learned that the uses to which knowledge and know-how are put can be either, and that this is determined by people.

We have also learned the hard way that science and technology cannot be stifled, banned by human rules, or forgotten. Once Pandora's box is open, whatever is inside must be dealt with.

When you have a tiger by the tail, the only action possible is to swarm aboard and ride that tiger. Only then is it possible to have some control over where the tiger goes, and it's difficult for the tiger to eat you when you're riding on its back.

The electronic crystalline computer is with us today. It is the subject of continual development.

Bioelectronics, biocybernetics, neuroelectronics, and the other synergistic combinations of the physical sciences and the life sciences discussed herein are real, are with us today, and will continue to develop and progress in both knowledge and know-how.

The synthesis between the electronic crystalline computer and the human colloidal computer is inevitable. It may not happen precisely as it has been forecast herein, but it will happen. Whether the intelligence amplifier comes about and takes the general form we've talked about here is immaterial. The fact that some of us realize that the synthesis can be made amounts to a self-fulfilling prophecy. (However, I do not pretend to make prophecy herein because that is an extremely dangerous venture. Author L. Sprague DeCamp: "It does not pay a prophet to be too specific.")

The intelligence amplifier holds forth enormous promise for improving the general condition of the human race.

It also contains the seeds of unimaginable evil: the actual control of human minds by other humans. Not brain-washing. Not propaganda. Not any of the ancient and well-proven means of mentally or physically imposing one person's will upon another by police action or torture. But the actual control of the human mind.

We began with the stipulation that the biological part of the system would continue to control the system and would have to be inordinately stupid to develop something that it couldn't control or something that it couldn't stop if it got out of control. But that doesn't mean that it cannot somehow, in some way, be used for evil purposes. It probably can.

The history of technology shows that both good and evil uses of technology are inevitable. There is also a finite chance that an unforseen hazard will make itself known.

However, frightening as the evil or hazardous uses of the intelligence amplifier may be, I am reasonably confident that human beings will develop the necessary social institutions to control this technology. We have done so in the past. We are very successful in doing this sort of thing.

I know we're successful at the business of developing social institutions to control science and technology because our ancestors did so with our very first high-energy technology: fire. We're still doing it with fire, developing new institutions to handle the new aspects of fire in the technologies of combustion and energy conversion that we've invented over the centuries.

Unbeknownst to most people, although the information is included in most of the biographies about me that are widely available, I am currently the chairman of the Committee on Pyrotechnics (literally, the art or skill of fire) of the National Fire Protection Association (NFPA). The NFPA is a "voluntary standards organization." It is a group of people with expertise who have come together to develop and publish rules and regulations, based upon the reality of science and technology, for the control of the ancient technology of fire, an energy conversion technology. In the United States and Canada, we live every day with the rules, model laws, codes, and standards developed by the NFPA. One of these is the National Electrical Code.

NFPA is a social institution, one of many that have been organized and are at work today controlling the use of science and technology. The fact that non-government voluntary standards organizations such as the NFPA exist and function well is why I am not overly concerned about the mis-use of the intelligence amplifier and its associated technology.

We will develop the necessary institutions to insure the proper use of the intelligence amplifier because, contrary to much popular and academic thinking, people in general are not stupid.

Individual and social wants and desires—not "needs"—drive technical development. (Curiosity concerning why certain aspects of technology work or why the universe appears to behave the way it does are the drivers of scientific endeavor.) The existence of technology then drives the development of social institutions which act to control the use of technology. The invention of the elements in this chain of events are among the most important developments of the human race and are, to the best of our knowledge, unique to humans as a species on this planet. If we had not accomplished this and perfected it down the centuries, we would never have mastered the basic use of raw, natural fire. Fire would have killed us all.

The intelligence amplifier is very much like fire. It will turn out to be so enormously useful that the good far outweighs the evil. The risks involved in using it will probably turn out to be far less than the risks of not doing so. It cannot be ignored, hidden, or made unlawful.

We've learned our lessons concerning the prohibition of creative work and socially wanted activities. I've developed a hypothesis that says if you really want to push hard on the development of a technology, prohibit work in that technological area. Soon you'll discover that somebody else has done some things with it that you hadn't anticipated, that are beyond your control because you've denied yourself the know-how, that are possibly hazardous to your continued existence as an individual or social group, or that are absolutely necessary to your continued existence albeit at an exorbitant price, usually all that the traffic will bear.

The future human use of computers—and in fact the use of computers in all of their potential future applications—cannot be stopped, prohibited, or outlawed. Outlaw it in this country or in the western culture, and it will develop in other places where the environment is more benign, attracting those scientists and engineers who are personally driven to work on it and rewarding those who are successful.

This is not likely to happen in the United States or the western community of nations (including Japan). Some manner of social institution will develop in response to the requirement to control the technology of the intelligence amplifier and, in fact, of the entire scope of computer technology.

But what do we mean by "social institution?" This term conjures up all sort of different meanings, depending upon a person's background. Actually, we need only use the word "institution." Adding the word "social" to it only serves to make it more firm by redundancy.

An institution is not ideas, practices, customs, laws, rules, regulations, artifacts, or the bricks-and-mortar of edifices. An institution is a group of people. It is organized for some mutally agreed-upon purpose. It establishes and follows its own rules of operation. It develops its own structure or organization. It works out its own protocol for inter-action with other individuals and institutions. In its simplest form, it is a leader and a few followers. In its most complicated form, it is an international organization with worldwide purposes that includes people from a wide variety of cultural backgrounds.

Each of us is a member of several institutions—a local civic club, a church, a charitable organization, a union, a local trade group or chamber of commerce, a national society of a professional, commercial, or fraternal nature, and several political organizations ranging from a lobbying group to a political party to a national citizenry.

At this time, there is no overall international, worldwide institution of people, a "federation of the human race," so to speak, because nobody has yet been able to organize one for the entire human race that would have some mutually agreed-upon purpose. We can't agree on our general, overall, long-range purpose. We don't really know whether we have a purpose. And it often seems that we cannot even follow our own rules for getting along with one another.

The intelligence amplifier may, by the way, help us eventually rectify that situation.

But what sort of institution can we foresee that will develop the controls over this new technology?

Will an existing one work? Can the control of the human/computer system be assumed by some institution already in existence?

I submit not. This is a new development. It would be like putting the control of aviation under an organization devoted to the regulation of railroads. It won't work, and the example *didn't* work. Non-military commercial aviation was regulated by the Interstate Commerce Commission until the Air Commerce Act of 1926 put it under the control of its own institution, then known as the Aeronautics Branch of the Department of Commerce. Although this action was only one of several factors, some of them technical, that contributed to the growth of commercial aviation in the United States, there was no commercial aviation to speak of in the United States before this social institution was started, whereas European commercial aviation was prospering and pioneering because various European governments had developed some manner of institution to control aeronautics following World War I.

New technological developments require new social institutions.

What sort of new social institution can we envision for the intelligence amplifier? Who will operate it?

The obvious cop-out is both too pat and too dangerous: Let the government do it.

Really?

Do you want to put the intelligence amplifier with all of its potential mis-uses under the control of politicians whose one goal in life is power over people?

Do you want to put the basic information center or data bank under governmental control where the strong possibility of "editing" ("censorship" is a stronger word) exists?

Do you really want to give total control of your mind and thought processes to the sort of people who are running things in Washington, regardless of your own political ideologies and regardless of which party currently controls either the administration or Congress?

Do you want to give control of this technology to bureaucrats?

Or haven't you tangled with the bureaucracy lately?

As Herman Kahn pointed out to me while I was writing this book, one of the basic problems of the United States government is that it is so large that it's becoming impossible to control it. The delay between putting in the correction and the correction taking effect is too great. By the time the correcting measure starts working, the system is doing something else. Basically, if you haven't already noticed, nobody is really in charge of anything any more. The only thing that appears to be under control is the ability of the government to clobber somebody it wants to clobber.

This is no institution with which to entrust the control of intelligence amplification.

There is nothing basically wrong with politics and politicians. Politics is a great social invention. It keeps most of us from killing most of the rest of us most of the time. However, political institutions are by and large composed of, led by, and made up mainly of lawyers. Lawyers are members of an absolutely necessary profession; they are experts in the resolution of human conflict.

The basic problem with opting for a governmental solution is that we'd be turning the whole thing over to a system which, in spite of all the high-sounding words and stirring documents, has no feedback.

It is run by people who make the rules, interpret the rules, and enforce compliance to the rules.

We've been beguiled by the false statement that "absolute power corrupts absolutely." We've tended to establish most of our political institutions on that basis, denying absolute power to individuals by dividing the power among many persons and institutions. We've called this a system of "checks and balances." It really doesn't work that well—although it works better than any other political institution we've developed thus far—because its basic premise isn't correct.

Absolute power doesn't corrupt absolutely.

Absolute immunity does.

Individual people—not just leaders—must be held responsible for their actions, be rewarded when their actions result in the betterment of the community, and be punished when their actions are contrary to the mutually agreed-upon rules of the community. Some people call it personal responsibility. Others call it social discipline. And those who don't care to be held responsible call it oppression or sometimes the violation of human rights, *their* rights to do as they please, regardless of the consequences.

This may appear to be a harsh assessment of social actions. Some readers may believe that it's inhuman. However, given the power and potential for mis-use of the forthcoming human/computer technology, it is extremely difficult for me to understand how we can establish the necessary control institution for this technology without using this philosophy as a foundation. The institution we develop for this purpose must allow maximum personal freedom of use and choice while at the same time preventing the use of the technology for physical or mental coercion of others.

Intelligence amplifier technology and its supporting and auxiliary technologies may well permit, as we've discussed, the internal re-programming of human neural processes. This can be of enormous benefit for the mentally ill. It could become the ultimate tool for total rehabilitation of those social mis-fits we call criminals or felons. It could also be used for real brainwashing to eliminate completely any political opposition.

But where is the dividing line? Where is the limit on the actual alteration of the human nervous system to which we should permit ourselves morally to go?

The answers to these questions can be determined both morally, logically, and with scientific basis. This is one of the major tasks of the institution we develop for this technology.

We can determine what's "normal," and we can determine the upper and lower limits of "normality." (By all means, we must not and probably cannot reduce everyone to a single standard; the universe itself operates with a statistical spread.) There is no question about this; we're already doing it in other fields. The insurance industry depends heavily upon its actuarial tables, which are based on a statistical analysis of the real world; an actuary can tell you with great precision about the "normal" population. Any reliable polling firm such as Harris or Roper has precise numbers concerning the normal population; they remain in business only because they can forecast its response with a high degree of reliability and confidence. They *have to* know what the normal population is. Any of the educational testing firms knows with great accuracy what "normality" is because they have an enormous library of data which provides them with a highly reliable data base; they couldn't stay in business if their standards of normality were wrong.

The data is there, and what is considered "normal" in this culture at this time can be determined with surprising accuracy, reliability, and confidence. People and institutions get into trouble using this data when they don't believe it or deliberately reject it on philosophical, ideological, or emotional grounds.

The social institution that develops to establish the standards of use and mis-use of human/computer technology will deal with this from the start, but there is indeed a point of departure for doing so.

With regard to the moral right of the social group to alter human neural processes, we have to start by looking carefully and dispassionately at how we're already doing so, then carefully evaluating what we mean by the moral right to do it.

First of all, some of the things we're doing today with few if any compunctions would have been considered "playing God" a hundred years ago. Our standards have changed. To what extent the change of these standards has been brought about by a better understanding acquired through scientific research and technological development is another matter for another book.

The City of Berkeley, California, has outlawed the use of electroshock therapy for the treatment of mental disease. Electroshock is normally a "treatment of last resort" anyway and is used only when a person fails to respond to psychotherapy and chemotherapy. Electroshock therapy doesn't cure anything; it probably eliminates the cause of aberrant behavior by simply electrically short-circuiting and scrambling the neuron network. A manic-depressive or other menally ill person can be returned to a reasonably normal life in society with a good degree of confidence that the aberrant behavior won't re-occur. True, the individual isn't exactly the same; there are personality changes. Question: where does the line between morality and immorality lie here?

Suppose that proper reshaping of the "error signals" derived from an intelligence amplifier would produce the same result. To my thinking, it is far more humane to *selectively* re-program a human brain than to cure the problem by hitting the whole system with a massive over-voltage spike. If the intelligence amplifier could replace electroshock therapy, that in itself would be worth it. But: It is moral to do it?

The general level of treatment of the mentally ill today is far better than it was when Dr. Phillipe Pinal unlocked the shackles of the insane inmates of La Saltpetrier Asylum in Paris during the French Revolution and began treating them in a humane fashion instead of as inhuman spirit-controlled pieces of meat. But it is still far below the general level of treatment available to the physically ill. A great deal of the treatment or lack of treatment is simply caused by ignorance: It's impossible to get inside the head of some of the seriously ill mental patients or those unfortunate individuals with retarded mental abilities.

Modern medical technology in general faces this question daily. Its practitioners can, if they wish, play at being God. But, by and large, they don't (with lurid exceptions). Why? Is there a clue here that can give us a leg up on forecasting the sort of social institution needed to control the tiger we've got to ride?

CHAPTER SEVENTEEN

CONTROLLING THE TIGER AND ITS IMPLICATIONS

To a large extent, there is an existing social institution that can give us some idea of how to develop the institution to control intelligence amplifier technology as well as computer technology in general.

We should look carefully at the field of medical ethics and the sort of institutions that exist to control medical technology.

Yes, Virginia, there are medical ethics. It's unfortunate that a few modern physicians either don't know of them (and are therefore an-ethical, although it is difficult to understand *how* they could be ignorant of them) or know of them and choose to ignore them (and are therefore un-ethical). Fortunately, in a free society, there are few of the latter. They tend to exist mostly in the government medical centers where there are few if any "peer controls" upon them, only the dictates of bureaucratic regulations which, by their very nature, protect the bureaucrats rather than the patients.

A doctor's purpose is to treat the ill, to cure if possible, or to allieviate pain and suffering if that's all that can be done. The basic tenets of medical ethics are bound up in the Hippocratic Oath. But no medical doctor ever stands, raises his hand, and takes the Hippocratic Oath. The Oath is merely a guideline to practice. It is left to the doctor's own conscience to abide by its general principles.

The Judicial Council of the American Medical Association has published and regularly up-dates a document entitled "Principles of Medical Ethics." It is now some thirty-three pages long. It isn't a set of rules, but a code that the AMA strongly recommends all doctors try to follow. Its preamble states, in part, "The medical professional has long subscribed to a body of ethical statements developed primarily for the benefit of the patient. As a member of this profession, a physician must recognize responsibility not only to patients, but also to society, to other health professionals, and to self." One doesn't have to be a physician or an AMA member to get a copy of this document. It can be obtained by contacting the AMA at 535 N. Dearborn Street, Chicago IL 60610.

"Principles of Medical Ethics" has expanded its scope enormously in the past thirty years. Today, its provisions embrace fetal research, genetic engineering, organ transplantation, terminal illness, advertising and publicity, health maintenance organizations, computer confidentiality (for medical records), informed consent, and a host of other matters that weren't even thought of in 1950, much less included in the old AMA pamphlet on medical ethics that I still retain from my father's library.

The AMA is not a disciplinary organization, although it can and has expelled members for various reasons, some of which involved medical ethics. The disciplinary and control measures of the field of medicine are handled at a much lower and more personal level by the city, county, or state medical societies (usually the county society).

All states currently license medical doctors for practice. The licensing procedures are controlled by committees of doctors authorized by law to handle such procedures. Licenses for medical practice can be granted, denied, suspended, or revoked by the state board of medical examiners. In many cases, the state boards will act upon or investigate complaints of the various local medical societies or medical patients.

If there are insufficient grounds for consideration of action by the state board of medical examiners, the local medical societies still have an enormous degree of power through discretionary actions. The organization can deny or revoke the privileges of society membership to a physician who engages in unethical acts. Member physicians can withold patient referrals to the errant physician. Although medical ethics as well as civil law prohibit doctors from slandering or libeling other doctors, it is completely within their rights to deny the unethical physician professional courtesies and professional interaction. This can effectively cut off a physician from the mainstream of medical professionalism in the community.

Such drastic actions are rarely taken. If the situation becomes serious enough, the unethical physician will usually end up in a court of law on the short end of a medical malpractice suit.

Few non-professionals know of or can thoroughly appreciate the unvoiced but highly effective control of a professional society. This is indeed elitism, but it is not Brahmanism. It must be elitist because of the length and intensity of the education and training required, factors which in turn demand a high degree of dedication to the healing arts. But it not a priesthood because it will admit anyone of any class or background who has obtained the rigorous training and education and who shows, by examination, the ability to measure up to extremely high standards of know-how and performance.

Here is a social institution of the sort that may serve as a precursor or a basis for the one that controls human/computer technology. The voluntary, non-governmental medical society made up of all or nearly all practitioners in a given area tries hard to be a self-policing institution. By and large, it has been successful and, by its ability to accomodate changes in both the state of the art and social demands, will remain successful in the future. Many will accuse such an institution, and profession, of being a closed operation that can become unresponsive to personal and social factors. Such accusations produce pressure which can be the external feedback necessary to keep such an institution from running in the "open loop" mode, out of control.

Skepticism is therefore justified while at the same time, in its radical forms, mostly unnecessary. The institution has shown that it can *effectively* respond to individual and social desires while remaining a self-policing organization. It works because decades of effort have gone into developing and evolving the internal checks and balances, the controls that keep it viable. The extensive changes in the principles of medical ethics that have taken place since 1950 show that the profession is indeed sensitive to social desires as well as to the wants and needs of physicians themselves. As a self-policing organization which has a great deal of potential for good and evil utility, the modern medical society has been a highly successful institution.

Naturally, because the intelligence amplifier and all its attendant potential uses are both new and different, this institutional form cannot and must not be adopted outright to prevent the mis-use of the general technology and, most important, medical and mental therapy, if it becomes feasible. But it can be used as a model, providing a reasonable indication that we do not need tightly restrictive legal protection under the aegis of the court system, nor centralized big-government control through a bureaucracy.

In a world of technologically created economic abundance—the world into which we are slowly moving, a world in which all human beings will be, by present-day standards, rich and, by any standards, in control of the forces of nature—and in a world that the intelligence amplifier in connection with the communications/information network makes possible, tight and restrictive control of technology by a centralized government may actually work to reverse the intended purpose of control. One of the implications of such a world of abundance may well be that large, centralized governments, now approaching loss of control, may totally cease to be effective.

There is one important caveat in what has been said about government control of the data base: One of the most important and complete data bases now in existence is a government institution which, because of its basic purposes, cannot possibly be "edited" or "censored."

That institution is the Library of Congress.

And it may well be that the Library of Congress will indeed evolve to become the major (but perhaps not the only) data base because of the ancilliary function that keeps it from being censored.

The Library of Congress—more specifically, the Librarian of Congress—is responsible for registering copyrights. In order to secure a copyright, which amounts to a registry of property rights to a creative work and a government-backed guarantee of exclusive rights thereto, one must deposit in the Library of Congress two copies of the work for which copyright protection is requested. The requirement for deposition thus creates the nation's largest data base. It also prevents censoring the data base.

Under the Copyright Act of 1978, computer programs can be copyrighted. Thus, the Library of Congrees has already become a software source, although you couldn't use the software without permission of the copyright holder.

If it also becomes a computer network data base (if its enormous contents are digitized by means of character reading devices), it will have to assume some additional functions, primarily that of keeping track of use and user charges for the copyright-able material in the data base. TANSTAAFL (There Ain't No Such Thing As A Free Lunch). If this book eventually goes into the computerized data base of the Library of Congress, I will certainly want to have my efforts in creating it recompensed in the same manner as you recompensed me by buying the original paper-based book.

Or the Library of Congress will become a score-keeping organization. Publishers may, under the original contract with the author, hold or control all or part of such computer data base rights and actually collect the fees and then distribute the author's royalties.

In this regard, the intelligence amplifier is also going to change the publishing industry to a far greater extent than will the microcomputer itself.

The Library of Congress may be the keeper of the score, but this will not prevent the establishment of other, private data bases that are accessible by computer network. Nor would we want to prohibit such privately operated data bases. Some material cannot be copyrighted because of its content, the manner in which it was created—say, for a government contract—or because it is already in the public domain. And privately operated data bases—the evolved public library, so to speak—are insurance against any possible editing or censorship by centralized government.

Yes, the data bank will know who is accessing the bank and for what material. So it knows that you like pornography, for example. So what? There are already many ways to discover covertly that you're buying it.

To a large extent, technology has already greatly eroded personal privacy. Your bank accounts are open to scrutiny by a large number of people and organizations; any bank employee with access to the bank computer can learn about your accounts. Every time you use your credit card, its number is revealed and could be used by others. Anyone knowing your Social Security number—and that's an extremely large number of people and organizations; how many times are you asked for it?—can gain access to an extremely large dossier of information about you.

Will this new technology permit others to gain access against your will to your inner thoughts, to your mind itself?

Possibly. Probably.

This is why the proper control institution must be and will be established: certainly for the next century or so, as we become more used to a world of super intellectual tools and an economy of abundance, we'll treasure our private pecadillos.

And yet it may also turn out that nobody, not even a centralized, totalitarian government, really gives a damn what you are thinking because, even now, technology itself is on the verge of destroying an already crumbling edifice called large, centralized government.

The ubiquity of the microcomputer alone, to say nothing of the enormous number of vastly improved computers and the intelligence amplifier that we can already detect coming down the road, will serve to reduce the size, impact, power, and influence of large national governments upon our lives.

Regardless of the political, ideological, or governmental system that happens to be running things at any given time at any given place, there are and always have been a small number of bright, intelligent people who have been able to out-think and out-maneuver the system. In essence, they either operate outside the system or manipulate the system to their advantage. They've been called pirates, corsairs, moguls, and entrepreneurs, among the more printable epithets. In overly repressive systems, they've eventually either saved the system, built a better system in its place or, as a last resort, took the good parts of the system somewhere else to start again. But there have never been enough of these people. A lot of them were caught and never had the chance to breed progeny to carry on. It has been only in the last two hundred years that they've managed to slowly increase their numbers.

Computers have increased the number of these people enormously. Computers have given them the ability to circumvent or manipulate the system. Even if the system itself is heavy with mainframe computers, it finds itself stacked up not against just people, but people plus their personal computers who, together, are capable of just as much number-crunching, just as much logorrhea, and just as much obfuscation as a bureacucracy. People and their micros at last can fight back against large centralized governments and *their* computers.

A humorous example serves to explain this. It is rumored that the government uses computers exclusively to write laws, rules, regulations, and letters. These computers use what is known as the GCPG (Government Communications Phrase Generator) Program. The program operates with a random number generator picking three words at random from the list shown in Table 17-1—one word from Column A, one from Column B, and one from Column C. This generates a three-word bureaucratic phrase. The program then inserts a random selection of bridging phrases to produce the final document. In response to a letter of complaint or inquiry from a taxpayer, the program might generate the following four phrases:

Implemented Integrated Procedures
Contextual Start-up Processing
Desired Energy-oriented Environment
Synergistic Automated Objectives

The letter is then assembled as follows:

"Dear sir: Thank you for your inquiry. Please be advised that implemented integrated procedures to achieve contextual start-up processing in the desired energy-oriented environment are in progress. You will be informed of the synergistic automated objectives. If we may be of further help, please do not hesitate to contact us."

TABLE 17-1
MEMORY CONTENTS
GOVERNMENT COMMUNICATIONS PHRASE GENERATOR

Column A	*Column B*	*Column C*
Automated	Energy-oriented	Functions
Controlled	Econometric	Technology
Balanced	Sociological	Objectives
Contextual	Socioeconomic	Values
Profound	Fixed	Systems

Specified	Algorithmic	Capacity
Synergistic	Optimized	Considerations
Sophisticated	Automated	Applications
Computerized	Integrated	Acquisition
Controlling	Processed	Procedures
Desired	Functional	Constraints
Complex	Co-operating	Tasks
Decentralized	Distributive	Environment
Quantified	Qualitative	Programs
Multiple	System-Wide	Processing
Implemented	Software	Feedback
Problematic	Start-up	Performance
Interconnected	Environmental	Installations
Flexible	Hardware	Potential
Reliable	Interacting	Capability
Associated	Multilevel	Scenario
Overall	Spatial	Interface
Advanced	Control	Excursions
Derived	Fiscal	Disciplines
Viable	Monitored	Data
Constant	Maximum	Innovation

It has been said with some veracity that the business of government in the United States for the past fifty years has basically been the business of money. Money is something that the government either gives to you or takes away from you. An enormous number of people keep track of it all and assign money values to products and services. Now that computers are on the government payroll, it can be done faster for more citizens.

It's no joke: citizens now have as much if not more computer power than the government. They can keep track of just as much data and can massage and manipulate it. They can generate just as many statistics and projections. They can handle the number values assigned to money just as well, if not better. And because the number of personal computers is increasing, more and more power is trickling back into the hands of people. With computer assistance, many people can now do for themselves what was easiest to let the government to do for them twenty-five years ago.

The capabilities of the microcomputer and its wide distribution mean that many of the functions of a large centralized government can be assumed or re-assumed by smaller state and local governments. A quiet revolution is in progress in this regard. What could not be accomplished by the individual states in 1860 and therefore had to be given up to the federal government by default can now be handled by smaller government entities, thanks to computers. And because large centralized governments now move much slower than individual citizens with their micros the size of government has to be reduced in order to cope with this phenomenon.

For example, there is no longer any reason for local tax money to be sent to Washington, where it filters through a bureaucracy and what's left is then returned to the local scene to fix the roads or even provide economic assistance. What's left usually arrives too late to do what was needed; in the delay, the local situation has changed.

If the real purpose of a large, centralized government is to scrutinize activities, enforce laws, collect and disburse tax moneys, provide for the common defense, and carry out other activities which are beyond the capabilities of smaller, localized governments, the number and kind of these purposes begin to be drastically whittled down as more and more computer power becomes available to local governments and individual citizens.

The capability of individuals to handle their own affairs becomes even greater when the intelligence amplifier is brought into the picture.

It's therefore highly unlikely that the federal government will evolve a control institution for this new technology. It might have if personal computers hadn't already become so widespread.

I may not have completely or accurately forecast the uses and mis-uses of intelligence amplifier technology herein. I would be greatly surprised if I had. This is because there are two basic elements to fear of the mis-use of technology: fear born of ignorance of the technology, and fear born of ignorance of people.

We naturally have some fear based upon ignorance of the technology itself because I've only just forecast the technology. Although the various technical and scientific elements necessary for intelligence amplification already exist, the total synthesis of technologies that represent the actual device is still conjectural, albeit feasible to forecast. Some of what we've discussed as mis-use may not occur, because the elements to permit it may not exist in the actual technology when it's developed. And we just don't know whether it will be technology whose hazards become apparent after it's been put into use. Although I feel certain that the basic intelligence amplifier can be achieved more or less as described in this book, I cannot accurately forecast either the short-term effects or the long-term effects of it upon a human operator. If it's done right, there will be no short-term effects; we won't know what the long-term effects will be until we have the technology in hand and have amassed some experience with it. But this is no reason to either refuse to proceed with it—the Ostrich Syndrome—hoping it will go away, which it won't, or to try to second-guess it and place unrealistic restraints on it beforehand. Technology is slippery stuff; just when you think you've got all its elements under your thumb, it squirts out between your fingers in some unforeseen direction.

It's rather like testing a parachute: you can, of course, drop it with a dummy load, but sooner or later you have to dive out of the airplane door with the canopy packed on your back and the D-ring in hand.

As for the fear based on ignorance of people, this is prompted by the fact that, by and large, most people interested in technology and therefore most likely to read this book are generally not as well acquainted with or interested in people. They tend to fear people and what the Great Unwashed will do with their beloved technological dreams and creations.

I must simply say: Hey, not to worry.

Basically, the general run of people are not stupid when it comes to technology. They have a long history of having made excellent short-range and long-range choices and decisions with regard to technology. Sometimes they can be fooled by bad data or distorted data fed to them by demagogues, but people have a disturbing penchant for feretting out the real data and analyzing it rationally.

By and large, people are going to survive in spite of everything.

And they're going to make choices that will, in both the short-term and long run, improve their individual and collective conditions.

CHAPTER EIGHTEEN

THE SILICON GODS

There are a number of great hazards faced by any individual who tries to forecast the future of any given technological area, to say nothing of forecasting the developments possible in an area created by the synthesis of two formerly disconnected areas.

One of these is the siren call to play it cool and make a "safe" forecast. Such a "safe" forecast will undoubtedly turn out to be wrong, short of the mark, and terribly conservative.

To prevent this, one then attempts to go in the other direction and makes what appears to be an outlandish forecast. Again, based on historical evidence, the more preposterous a forecast sounds with it is made, the more likely it is to come to pass. The hazard here lies in the forecaster gaining the reputation of being a far-out crazy nut. This sort of thing is hard to live with even if the forecaster turns out to be absolutely right twenty-five or fifty years later.

An additional hazard is to succumb to the "Gloom and Doom Syndrome," which considers only the negative or "downside" factors of a possible future. To some people, this isn't hazardous but a way to make a living—writing sensationalist books and magazine articles about the future that stress the dangers and the evil uses of technology. These seem to sell well, and the word rates and royalties undoubtedly help pay the rent. If the futuristic sensationalist is wrong, nobody will remember his forecast anyway. If he just happens to be right, which is seldom, his early forecast is usually lost in the uproar when everything hits the impeller. Or he's treated like Cassandra, who should have gotten it worse than she did. But playing the gloom-and-doom game and putting out lots of downside scenarios is a popular and easy way to be a "futurologist." But why is there so much of this type of "futurism" around, especially in newspapers? There must be a reason. "Bad news sells," Herman Kahn points out. Good news doesn't. People enjoy hearing about death and destruction because these reports and stories make their own little problems appear to be trivial.

But by far the most hazardous and frightening aspect of forecasting, from the personal viewpoint of the forecaster, is the utter loneliness that accompanies most forecasting work, such as the writing of this book. There are constant, nagging questions that run through the lone forecaster's mind: "Am I really out in left field on this? Have I gone over the edge? Have I slipped my trolley and am I now ready to be towed to the trolley barn?"

Therefore, one of the nicest things that can happen to a forecaster is to learn that somebody else thinks more or less the same way or has made a similar forecast.

In this last regard, I feel on solid ground because of a guest editorial that appeared in the March 1983 issue of ANALOG magazine written by Charles Sheffield. Here's a man with his feet solidly planted in reality. He runs a successful company dealing with earth resources satellite data. His recent Macmillan book, "Earthwatch," is a magnificent volume devoted to earth resources satellite photography. Fifty years ago, of course, his job, his book, and his company all would have been considered a fantastic "Buck Rogers" science fiction having no relationship with reality. But the fact that Charles Sheffield must interface with the real world on a constant basis to sell a service and meet a payroll gives him a great deal of believeability when it comes to forecasting.

In running down of possible developments in technology, Sheffield writes, "The next item on the list sits on the vague border between science and technology, but it is so important that the classification is irrelevant. It is the interface between electronic equipment and the human mind and body. We do not need to look for the 'cyborgs' of conventional science fiction, but we can certainly expect modes of man/machine coupling that go far beyond our present clumsy methods of fingers and keyboards."

Although it's encouraging to me to know that somebody else has also thought of the direct-linkage possibility upon which the technology of the intelligence amplifier rests, I'm also well aware that agreement between two or even more people doesn't necessarily produce truth or reality. Democratic agreement doesn't offer any assurance that the agreed-upon item is right, truthful, correct, or even rational. After all, the medieval bishops of Europe spent an enormous amount of time in seminars discussing how many angels could dance on the head of a pin. They never considered the critical question at the base of their principle assumption.

Here's a critical question with regard to the intelligence amplifier:

Do we really need it?

Probably. Anything that will serve as an intellectual tool is probably needed at this point because one of our growing problems is the conservation of brainpower. Our brains and the way we use them are perhaps the most important differences between ourselves and every other entity that we know of. If we don't use our brains, we're at a severe disadvantage on this planet. In fact, the human race would probably become die out if we didn't use our brains. We certainly cannot compete with other species when it comes to speed, strength of muscle, or sharpness of claw.

Therefore, let's re-phrase the question:

Do we want it?

I can't answer that. You will. The marketplace will determine the answer as it usually determines the answer to many other questions concerning technology.

Stine's Generalized Forecast as stated in "The Hopeful Future," (Macmillan, 1983) goes as follows:

"We can do anything we want to do, but we must be willing and able to pay for it and to live with all the consequences."

As Herman Kahn pointed out in a seminar about the technological future held on January 15, 1983, at Arizona State University, whether or not we are willing and able to pay for a technological product, service, or progress is now far more important than whether or not we are able to develop the technology in the first place. In other words, we are putting our own brakes on our own technological development through the marketplace, which demands a serious consideration of capital requirements, costs, and prices.

In an era of moderate interest rates and low inflation, capital is more readily available and flows more easily into capital-intensive long-term activities; we build lot of power plants, install lots of new equipment in factories, pump lots of money and effort into research and development, and can afford to do big things in a big way.

In an era of high interest rates and high inflation when there isn't much confidence in the monetary system or the government, we can do only short-term things with low capital requirements, little things that we could also do in the previous situation but which are usually buried beneath the overwhelming size and fervor of the big things.

What we are talking about here is, fortunately, a field that currently involves only moderate capital resources of a short-term nature and what appears to be a reasonably rapid payback schedule, exploiting existing technologies in a synthesis. It amounts to a moderate low-cost research and development program to work out the details of the initial intelligence amplifier and a moderate risk of failure for the initial Phase One Int-Amp. If successful, it can boot-strap itself, because nothing attracts risk capital like market success. Even if it isn't successful, the R&D effort will produce serendipitous findings that may be worth far more than the original research goal itself.

We can pay for the intelligence amplifier, and therefore we will.

How about our willingness to live with the consequences?

I wish the answers were as pat on that question!

We don't know what all the consequences will be, and we cannot know them until we actually have intelligence amps and begin working with them. There appear to be moderate physiological and psychological risks involved. It also appears that the benefits outweigh the disadvantages on the basis of current knowledge and forecasts. There is no existing institution that can exercise adequate control over its uses and mis-uses, which is another favorable sign. It means that an institution to do the job will evolve out of actual needs based on actual data rather than from second-guessing technology-yet-to-be, which usually results in an ineffective and overly restrictive institution.

There is always the problem of the hidden risks, the thalidomide problem. We face this no matter what area of technology and technology development we consider. Often we do not know and cannot determine in advance what may turn out to be the most hazardous consequences. Furthermore, we cannot determine in advance whether or not the situation is reversible—i.e., can we pull the plug and shut it off before it pulls the house down around us, so to speak? The only answer is to proceed with caution, but without excessive caution, setting up the system so that there is always a shut-off means; being constantly on guard for the hazard, identifying it, and determining whether to shut down or re-direct the activity involved.

Thalidomide was used as the exemplary technological hidden risk here, and its serves the purpose well. Thalidomide is still one of the most effective tranquilizers and sleeping aids yet developed, with the fewest harmful side effects to the large majority of people. However, thousands of malformed children were born after their pregnant mothers took this innocuous sleeping aid. This hit us all in a crucial emotional spot: the well-being of children. (This isn't necessarily a bad reaction, by the way, because a viable and successful culture must always operate on the basis of women and children first; any that do not are in trouble and cannot possibly survive the technological, political, or other futures.) There was therefore an over-reaction to thalidomide, which is still one of the most effective tranquilizers and sleeping aids with the fewest side effects *provided* it isn't used by pregnant women!

On the other hand, there is the THC problem. Tetrahydrocannabinol such as is found in the smoke of the burning flower of the marijuana plant appears to be a harmless drug. However, the data on its hazards is in, is solid, and has been totally ignored. THC causes sterility, loss of libido, and gonadal genetic damage. Before you condemn me as being a hide-bound conservative or lackey of the Establishment, see the various annals of the New York Academy of Sciences that cover this subject. And as for the use of other drug-like commodities of our Euro-American culture: Yes, I used to smoke tobacco until the solid data on lung cancer and cardiac disease persuaded me to quit. I certainly imbibed as much ethanol in various forms as the next person while in college, but not enough to require a liver transplant and, since I enjoy operating complex machinery, I do little elbow-bending today.

If hazard-data is available and is ignored, that's a social, personal, and probably an emotional problem that *no* control institution has yet been able to cope with. Nor should it. Every person should be allowed to choose his own form of poison, provided that in the act of taking poison he doesn't poison others in the process. The future should be built on a basis for both personal choice and personal responsibility for the consequences of the choices made. Otherwise, we're in deep trouble with or without the intelligence amplifier because the same problems will crop up in some other area of personal-use technology.

Note the caveat that it must be a personal choice. In its handling of the hidden hazards of technology use, things that are about to go over the edge and become disasters, centralized government certainly leaves much to be desired. Individual citizens quite rightly suspect that the government organizations involved might be trying to cover their anatomies, even if the organizations would lose credibility in the process. For example, the Agent Orange data may or may not be solid, but it's certainly questionable because the investigation was carried out by organizations that could be held liable for any mis-use. Whether the data be right or wrong, individual citizens are certainly right to question the government results in the Utah *radioactive fallout matter*. But in both cases, which are charged with high emotions, it behooves everyone concerned to seek unbiased data from disinterested investigating institutions.

These examples offer another reason to work hard to keep intelligence amplifier technology out from under government control. "Fool me once, shame on you; fool me twice, shame on me." People are not stupid, which is why a reasonable voluntary institution will probably be established for this technology.

We will either be willing to live with the consequences of future computer technology or believe that we can control unforseen ones in time to keep them from becoming deadly. The benefits will be continually measured against the disadvantages, and we will try to control the disadvantages, convert them into advantages, or design the disadvantages out of the system by technological development. This has been the historical trend of handling hazards and disadvantages in other technologies.

Naturally, we can't begin to consider, much less imagine, all the consequences of an intellectual tool with as much power and potential as the intelligence amplifier promises to give us. There will be as many profound changes in ourselves, our social systems, and our culture that come from the intelligence amplifier—as there have been from the computer, the telephone, television, the automobile, medicine, and even writing.

We would not want to go back to living in a world without any of those things; indeed, we probably could not. Regressing to the "simple life without modern technology" would mean that nine-tenths of the present population couldn't survive the first five years. Question: Who choses who survives?

In fifty years or less, the intelligence amplifier will evoke similar thoughts, and we'll wonder how we ever managed to get along without it. And, because of the intellectual and social growth of our culture it will probably have caused, the answer will be as it is now for those other technological wonders:

We can't get along without them, not without destroying what we have built as a result of having them, which is certainly preferable to what we had before we developed them in spite of all the problems they've created.

Gene Roddenberry, the creator of *Star Trek*, originated a phrase that has passed into contemporary language ". . . To boldly go where no man has gone before." And that's just what we're doing and will continue to do.

Roddenberry has also pointed out that any journey outward is always accompanied by a journey inward. In the twentieth century, we appear to have been obsessed with a journey outward into the universe around us.

But we have also been on an inward journey.

Nothing exemplifies the basic correctness of Roddenberry's statement better than the intelligence amplifier. Born of our own brains and minds as the computing machine and created as a result of a striving to know more about the external universe in terms of physics and chemistry, it promises to become the critical tool on an inward journey that has just begun.

There are numerous religious consequences to all of thus, as well there should be. We are delving deeply into epistemology. Inevitably, the question will be asked: Are we going to find God with the help of the intelligence amplifier?

We may.

We may also discover that He's been there all along.

As you recall, early in this book I pointed out that silicon-based integrated-circuit computers were not well-understood by most people, including many of those who designed, built, and programmed them. One could be led to believe that deep down in the computer the Deity may lurk. God may indeed be in the Z-80 or 8086 CPU chip.

We may either have put Him there or given Him a place to exist outside ourselves in a location where we could reach Him.

There is a convention that derives from classical Greek theater, the *deus ex machina,* the god in the machine. It was actually a human actor playing the part of a god who was lowered in a machine (a bucket on a rope) from the proscenium. By his arbitrary actions, the god solved a dramatic problem that somehow kept the play from proceeding in the general direction the author desired. It was a great dramatic ploy and is still used by lazy authors, which accurately describes most of us.

We may have a real *deus ex machina* in the form of the intelligence amplifier. Maybe we've got a god in a machine that will keep our human drama proceeding in the direction we'd like it to go.

And that's probably the real silicon god.

ABOUT THE AUTHOR

G. Harry Stine graduated from Colorado College in Colorado Springs, Colorado (his home town) with a B.A. in physics in 1952. Before deciding on a degree in physics because of counselling from Robert A. Heinlein, who coached him in writing, he studied psychology and pre-medicine at the University of Colorado. He spent the early 1950's at White Sands missile range in New Mexico, working with high altitude rockets and rocket motor testing. He founded the international hobby/sport of model rocketry in 1957. During the 1960's he was the manager of an industrial research laboratory in New England. He has been the marketing manager for a high-technology electronics instrument firm. Today, he devotes his time to writing and to consulting on high technology.

He has written widely about the future and is the author of more than 30 books, numerous scientific and technical papers, and hundreds of magazine articles since 1951. He writes a regular column called "The Alternate View" in ANALOG magazine. He's a Senior Editor and regular contributor to "Aviation/Space" magazine of the American Society for Aerospace Education. His science fiction has been written under the psuedonym "Lee Correy." He does all his writing on a computer word processor.

He's a member of the New York Academy of Sciences, a Fellow of the Explorers Club and the British Interplanetary Society, and an Associate Fellow of the American Institute of Aeronautics and Astronautics.

He lives in Phoenix, Arizona "in the midst of high technology" with his wife, three golden retrievers and two cats.

He's listed in "Who's Who In America," 1982 Edition, as well as the current edition of "Jane's Who's Who In Aerospace."

WE ARE

The Silicon Gods

Think computers are taking over the world? Only temporarily. Technology is in the works that will give all of us the ability to "hook into" computers and use them as easily as we use our eyes, ears, and mouth.

Here science writer/computer consultant G. Harry Stine presents the concept of "jellyware"—the human brain...and what it will be capable of once it's linked up with hardware—the computer itself—and software, the programs which every computer uses. The result will be an exciting new definition of human intelligence.

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