# 21. [Introduction] From *Computer Lib / Dream Machines*

◊08 93
◊09 109
◊11 133
◊16 231



*Computer Lib / Dream Machines* is the most important book in the history of new media.

Nelson's volume is often called the first personal computer book, probably because it arrived shortly before the first personal computer kit (the Altair) and was later recognized to have predicted the effects of its coming. This, however, was only one of the many visions, prescient and influential, offered in the volume.

*Computer Lib / Dream Machines* is a Janus-like codex that joins two books back to back; in the middle, the texts of the two bound-together books meet. The "Computer Lib" side, its cover featuring a raised fist with a computer in the background, didn't simply predict that personal computers were coming, but effectively challenged the popular notion of what computers were for, at a fundamental level. As Stewart Brand wrote in his foreword to the 1987 edition, Ted Nelson is "accurately depicted as the Tom Paine of the personal-computer revolution. His 1974 tract, *Computer Lib / Dream Machines,* had the same effect as Paine's *Common Sense*—it captivated readers, informed them, and set them debating and eventually marching, rallying around a common cause many of them hadn't realized was so worthy or even a cause before. . . . The enemy was Central Processing, in all its commercial, philosophical, political, and socio-economic manifestations. Big Nurse." Nelson's book raised the cry, "Down with Cybercrud!" He exhorted his readers to defy the computer priesthood, and its then-leader IBM, and to never accept, "The computer doesn't work that way" as an answer again. "Computer Lib" was in writing what the Altair and Apple II became in engineering: an artifact that destabilized the existing computer order, that brought about a conception of the computer as a personal device.

The volume's other side, "Dream Machines," had even greater significance for new media's development. Nelson wrote in the "Dream Machines" introduction, "Feel free to begin here. The other side is just if you want to know more about computers, which are changeable devices for twiddling symbols. Otherwise, skip it." He wrote this believing his most essential message was not about computers, but about media and design. He believed the importance of computers lay not in their capacity for calculation, but in the fact that they would enable new generations of media. In the pages that followed, Nelson reported on some of the most important work in new media up to that time, such as that of Doug Engelbart (◊08, ◊16) and Ivan Sutherland (◊09), and set forth his own unique twofold vision.

First, he argued that computer experiences were media to be designed, and that this design should be both a creative process and undertaken with the audience (users) in mind. His most stirring essay on the subject ("Fantics") is reprinted here, along with a small selection of Nelson's own designs. These are founding documents for the field now called human-computer interaction. They caused Nelson's book to be passed around, borrowed, stolen, and made a totemic object in early new media businesses. One former Apple Computer designer tells the story of having a copy of *CL/DM* placed in her hand the first day she reported for work.

Second, Nelson proposed that these new, designed media experiences be placed in a radical, open publishing network. A network that supported the reconfiguration, comparison, and interconnection of his 1965 hypertext proposal (◊11), in addition to complex version management and powerful user interface conventions. In pages reprinted here, he envisions the resulting explosion of knowledge radically altering the daily experiences of everyone from students to scientists. This vision and the project to realize it—Xanadu—made Nelson the butt of jokes for 20

*Mitch Kapor, Designer of Lotus 1-2-3, Cofounder of the Electronic Frontier Foundation:*

I spent a lot of the early 1970's prowling around the bookstores and newsstands of Harvard Square. By day, I was a very junior computer programmer and occasional teacher of Transcendental Meditation. I stumbled upon *Computer Lib* on a nocturnal excursion and was instantly bewitched. Here was a man who dreamed my dreams before I did, who gave voice to a radically different concept of computers as other than giant calculating machines. *Computer Lib* inspired me as no other book has before or since and sustained me over the next few years until I bought my first Apple II. It pointed me in the direction of a career in the as-yet then-uninvented field of personal computers. For which I am eternally grateful.

*Dream Machines* (2):

It matters because we live in media, as fish live in water. (Many people are prisoners of the media, many are manipulators, and many want to use them to communicate artistic visions.)

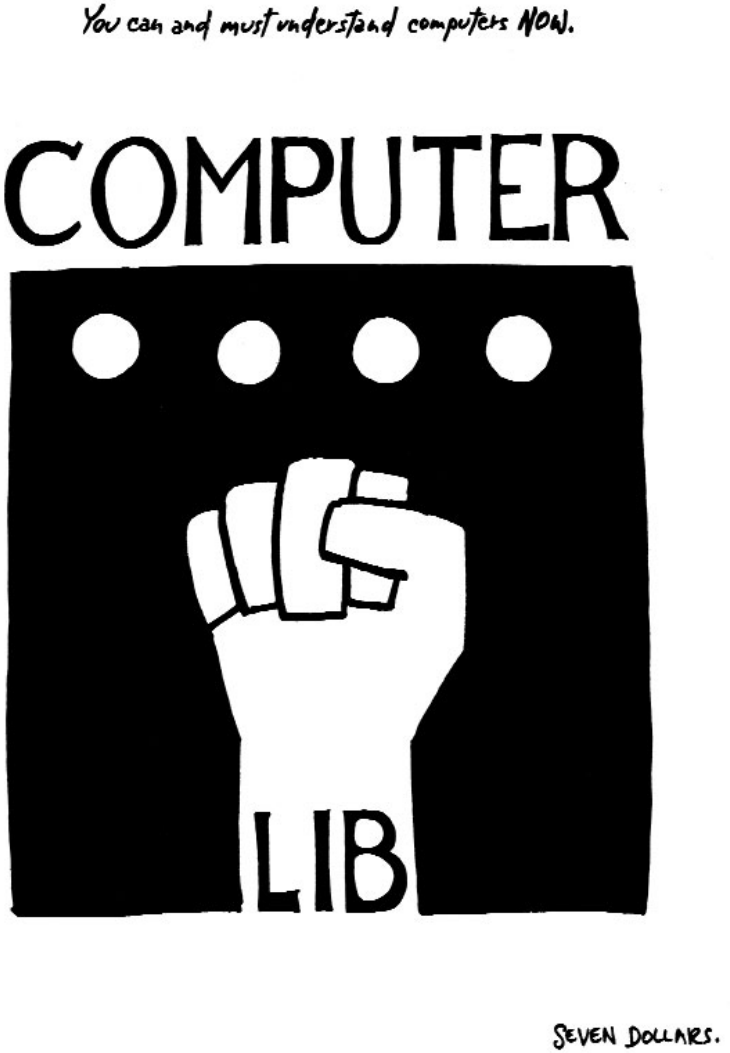
But today, at this moment, we can and must design the media, design the molecules of our new water, and I believe the details of this design matter very deeply. They will be with us for a very long time, perhaps as long as man has left; perhaps if they are as good as they can be, man may buy even more time—or the open-ended future most suppose remains.



years: he was called a crackpot (and worse) for his strong conviction that Xanadu's fundamentals represented the future of media and culture. The general belief was that there simply was not demand for a public, hypertext-enabled publishing network. This belief was resisted, however, by small groups around the world who created and worked with various types of hypertext-enabled networks. Although we have not yet reached Xanadu, when one of these systems, the World Wide Web, began to explode in popularity during the 1990s (◊54), the voices of Nelson naysayers were drowned forever in a flood of international hypertext publishing.
—NWF

Original Publication

Self-published, 1974. 2nd ed., Redmond, Washington: Tempus Books/Microsoft Press, 1987.

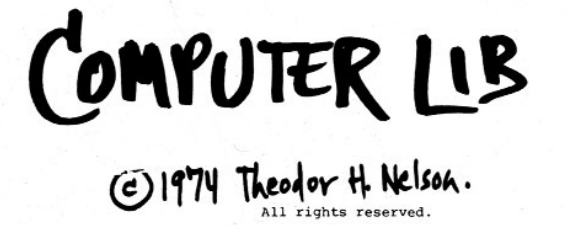



Further Reading

Nelson, Ted. "A Conceptual Framework for Man-Machine Everything." *Proceedings AFIPS National Computer Conference and Exposition* M21-M26, June 4–8, 1973, New York. Montvale, N.J.: AFIPS Press, 1973.

Nelson, Ted. "The Right Way to Think about Software Design." *The Art of Human-Computer Interface Design,* 235–243. Ed. Brenda Laurel. Reading, Mass.: Addison-Wesley. 1990.

Rheingold, Howard. *Tools for Thought: The People and Ideas Behind the Next Computer Revolution*. New York: Simon & Schuster, 1985; Cambridge: MIT Press, 2000.




Any nitwit can understand computers, and many do. Unfortunately, due to ridiculous historical circumstances, computers have been made a mystery to most of the world. And this situation does not seem to be improving. You hear more and more about computers, but to most people it's just one big blur. The people who *know* about computers often seem unwilling to explain things or answer your questions. Stereotyped notions develop about computers operating in fixed ways—and so confusion increases. The chasm between laymen and computer people widens fast and dangerously.

This book is a measure of desperation, so serious and abysmal is the public sense of confusion and ignorance. Anything with buttons or lights can be palmed off on the laymen as a computer. There are so many different things, and their differences are so important; yet to the lay public they are lumped together as "computer stuff," indistinct and beyond understanding or criticism. It's as if people couldn't tell apart camera from exposure meter or tripod, or car from truck or tollbooth. This book is therefore devoted to the premise that

**EVERYBODY SHOULD UNDERSTAND COMPUTERS.**

It is intended to fill a crying need. Lots of everyday people have asked me where they can learn about computers, and I have had to say *nowhere.* Most of what is written about computers for the layman is either unreadable or silly. (Some exceptions are listed nearby [on pp. 6–7 of the first edition, not reprinted here]; you can go to them instead of this if you want.) But virtually nowhere is the big picture simply enough explained. Nowhere can one get a simple, soup-to-nuts overview of what computers are really about, without technical or mathematical mumbo-jumbo, complicated examples, or talking down. This book is an attempt.

(And nowhere have I seen a simple book explaining to the layman the fabulous wonderland of computer graphics which awaits us all, a matter which means a great deal to me personally, as well as a lot to all of us in general. That's discussed on the flip side.)

Computers are simply a necessary and enjoyable part of life, like food and books. Computers are not everything, they are just an *aspect* of everything, and not to know this is computer illiteracy, a silly and dangerous ignorance.

Computers are as easy to understand as cameras. I have tried to make this book like a photography magazine—breezy, forceful and as vivid as possible. This book will explain how to tell apples from oranges and which way is up. If you want to make cider, or help get things right side up, you will have to go on from here.

I am not a skillful programmer, hands-on person or eminent professional; I am just a computer fan, computer fanatic if you will. But if Dr. David Reuben can write about sex I can certainly write about computers. I have written this like a letter to a nephew, chatty and personal. This is perhaps less boring for the reader, and certainly less boring for the writer, who is doing this in a hurry. Like a photography magazine, it throws at you some rudiments in a merry setting. Other things are thrown in so you'll get the sound of them, even if the details are elusive. (We learn most everyday things by beginning with vague impressions, but somehow encouraging these is us not usually felt to be respectable.) What I have chosen for inclusion here has been arbitrary, based on what might amuse and give quick insight. Any bright highschool kid, or anyone else who can stumble through the details of a photography magazine, should be able to understand this book, or get the main ideas. This will not make you a programmer or a computer person, though it may help you talk that talk, and perhaps make you feel more comfortable (or at least able to cope) when new machines encroach on your life. If you can get a chance to learn programming it's an awfully good experience for anybody above fourth grade. But the main idea of this book is to help you tell apples from oranges, and which way is up. I hope you do go on from here, and have made a few suggestions.

I am "publishing" this book myself, in this first draft form, to test its viability, to see how mad the computer people get, and to see if there is as much hunger to understand computers, among all you Folks Out There, as I think. I will be interested to receive corrections and suggestions for subsequent editions, if any. (The computer field is its own exploding universe, so I'll worry about up-to-dateness at that time.)

## Summary of This Book

Man has created the myth of "the computer" in his own image, or one of them: cold, immaculate, sterile, "scientific," oppressive.

Some people flee this image. Others, drawn toward it, have joined the cold-sterile-oppressive cult, and propagate it like a faith. Many are still about this mischief, making people do things rigidly and saying it is the computer's fault.

Still others see computers for what they really are: versatile gizmos which may be turned to any purpose, in any style. And so a wealth of new styles and human purposes are being proposed and tried, each proponent propounding his own dream in his own very personal way.

This book presents a panoply of things and dreams. Perhaps some will appeal to the reader . . .



## The Computer Priesthood

Knowledge is power and so it tends to be hoarded. Experts in any field rarely want people to understand what they do, and generally enjoy putting people down.

Thus if we say that the use of computers is dominated by a priesthood, people who spatter you with unintelligible answers and seem unwilling to give you straight ones, it is not that they are different in this respect from any other profession. Doctors, lawyers and construction engineers are the same way.

But computers are very special, and we have to deal with them everywhere, and this effectively gives the computer priesthood a stranglehold on the operation of all large organizations, of government bureaux, and everything else that they run. Members of Congress are now complaining about control of information by the computer people, that they cannot get the information even though it's on computers. Next to this it seems a small matter that in ordinary companies "untrained" personnel can't get straight questions answered by computer people; but it's the same phenomenon.

It is imperative for many reasons that the appalling gap between public and computer insider be closed. As the saying goes, war is too important to be left to the generals. Guardianship of the computer can no longer be left to a priesthood. I see this as just one example of the creeping evil of Professionalism,* the control of aspects of society by cliques of insiders. There may be some chance, though, that Professionalism can be turned around. Doctors, for example, are being told that they no longer own people's bodies.** And this book may suggest to some computer professionals that their position should not be as sacrosanct as they have thought, either.

This is not to say that computer people are trying to louse everybody up on purpose. Like anyone trying to do a complex job as he sees fit, they don't want to be bothered with idle questions and complaints. Indeed, probably any group of insiders would have hoarded computers just as much. If the computer had evolved from the telegraph (which it just might have), perhaps the librarians would have hoarded it conceptually as much as the math and engineering people have. But things have gone too far. People have legitimate complaints about the way computers are used, and legitimate ideas for ways they should be used, which should no longer be shunted aside.


COMPUTER LIB

In no way do I mean to condemn computer people in general. (Only the ones who don't want you to know what's going on.) The field is full of fine, imaginative people. Indeed, the number of creative and brilliant people known within the field for their clever and creative contributions is considerable. They deserve to be known as widely as, say, good photographers or writers.

*This is a side point. I see Professionalism as a spreading disease of the present-day world, a sort of poly-oligarchy by which various groups (subway conductors, social workers, bricklayers) can bring things to a halt if their particular new increased demands are not met. (Meanwhile, the irrelevance of each profession increases, in proportion to its increasing rigidity.) Such lucky groups demand more in each go-round—but meantime, the number who are permanently unemployed grows and grows.

**Ellen Frankfort, *Vaginal Politics*. Quadrangle Books.
Boston Women's Health Collective, *Our Bodies, Ourselves*. Simon & Schuster.

> "Computers are catching hell from growing multitudes who see them uniformly as the tools of the regulation and suffocation of all things warm, moist, and human. The charges, of course, are not totally unfounded, but in their most sweeping form they are ineffective and therefore actually an acquiescence to the dehumanization which they decry. We clearly need a much more discerning evaluation in order to clarify the ethics of various roles of machines in human affairs."
>
> Ken Knowlton in "Collaborations with Artists—a Programmer's Reflections," in Nake & Rosenfeld, eds., *Graphic Languages* (North-Holland Pub. Co.), p. 399.




This is the flip side of *Computer Lib.*

(Feel free to begin here. The other side is just if you want to know more about computers, which are changeable devices for twiddling symbols. Otherwise skip it.)

(But if you change your mind it might be fun to browse.)

In a sense, the other side has been a come-on for this side. But it's an honest come-on: I figure the more you know, the readier you'll be for what I'm saying here. Not necessarily to agree or to be "sold," but to think about it in the non-simple terms that are going to be necessary.

The material here has been chosen largely for its exhilarating and inspirational character. No matter what your background or technical knowledge, you'll be able to understand some of this, and not be able to understand some of the rest. That's partly from the hasty preparation of this book, and partly from the variety of interests I'm trying to comprise here. I want to present various dreams and their resulting dream machines, all legitimate.

If the computer is a projective system, or Rorschach inkblot, as alleged on the other side, the *real* projective systems—the ones with projectors in them—are all the more so. The things people try to do with movies, TV and the more glamorous uses of the computer, whereby it makes pictures on screens—are strange inversions and foldovers of the rest of the mind and heart. That's the peculiar origami of the self.

Very well. This book—this side, *Dream Machines*—is meant to let you see the choice of dreams. Noting that every company and university seems to insist that *its* system is the wave of the future, I think it is more important than ever to have the alternatives spread out clearly.





But the "experts" are not going to be much help; they are part of the problem. On both sides, the academic and the industrial, they are being painfully pontifical and bombastic in the jarring new jargons. Little clarity is spread by this. Few things are funnier than the pretensions of those who profess to dignity, sobriety and professionalism of their expert predictions—especially when they, too, are pouring out their own personal views under the guise of technicality. Most people don't dream of what's going to hit the fan. And the computer and electronics people are like generals preparing for the last war.

Frankly, I think it's an outrage making it look as if there's any kind of scientific basis to these things; there is an underlevel of technicality, but like the foundations of a cathedral, it serves only to support what rises from it. THE TECHNICALITIES MATTER A LOT, BUT THE UNIFYING VISION MATTERS MORE.

This book has several simultaneous intentions: to orient the beginner in fields more complex and tied together than almost anybody realizes; nevertheless, to partially debunk several realms of expertise which I think deserve slightly less

attention than they get; and to chart the *right* way, which I think uniquely continues the Western traditions of literature, scholarship and freedom. In this respect the book is much more old-fashioned than it may seem at the gee-whiz, very-now level.

The main ideas of this book I present not as my own, but as a curious species of revealed truth. It has all been obvious to me for some time, and I believe it should be obvious as well to anyone who has not been blinded by education. If you understand the problems of creative thinking and organizing ideas, if you have seen the bad things school so often does to people, if you understand the sociology of the intellectual world, and have ever loved a machine, then this book says nothing you do not know already.



For every dream, many details and intricacies have to be whittled and interlocked. Their joint ramifications must be deeply understood by the person who is trying to create whatever-it-is. Each confabulation of possibilities turns out to have the most intricate and exactly detailed results. (This is why I am so irritated by those who think "electronic media" are all alike.)

And each possible combination you choose has different precise structures implicit in it, arrangements and units which flow from these ramified details. *Implicit* in Radio lurk the Time Slot and the Program. But many of these possibilities remain unnoticed or unseen, for a variety of social or economic reasons.

Why does it matter?

It matters because we live in media, as fish live in water. (Many people are prisoners of the media, many are manipulators, and many want to use them to communicate artistic visions.)

But today, at this moment, we can and must design the media, design the molecules of our new water, and I believe the details of this design matter very deeply. They will be with us for a very long time, perhaps as long as man has left; perhaps if they are as good as they can be, man may even buy more time—or the open-ended future most suppose remains.

So in these pages I hope to orient you somewhat to various of the proposed dreams. This is meant also to record the efforts of a few Brewster McClouds, each tinkering toward some new flight of fancy in his own sensoarium.

But bear in mind that hard-edged fantasy is the corner of tomorrow. The great American dream often becomes the great American novelty. After which it's a choice of style, size and financing plan.

The most exciting things here are those that involve computers: notably, because computers will be embraced in every presentational medium and thoughtful medium very soon.

That's why this side is wedded to the other: if you *want* to understand computers, you can take the first step by turning the book over. I figure that the more you know about computers—especially about minicomputers and the way on-line systems can respond to our slightest acts—the better your imagination can flow between the technicalities, can slide the parts together, can discern the shapes of what *you* would have these things do. The computer is not a limitless partner, but it is deeply versatile; to work with it we must understand what it can do, the options and the costs.

My special concern, all too tightly framed here, is the use of computers to help people write, think and show. But I think presentation by computer is a branch of show biz and writing, not of psychology, engineering or pedagogy. This would be idle disputation if it did not have far-reaching consequences for the designs of the systems we are all going to have to live with. At worst, I fear these may lock us in; at best, I hope they can further the individualistic traditions of literature, film and scholarship. But we must create our brave new worlds with art, zest, intelligence, and the highest possible ideals.

I have not mentioned the emotions. Movies and books, music and even architecture have for all of us been part of important emotional moments. The same is going to happen with the new media. To work at a highly responsive computer display screen, for instance, can be deeply exciting, like flying an airplane through a canyon, or talking to somebody brilliant. This is as it should be. ("The reason is, and by rights ought to be, slave to the emotions."—Bertrand Russell.)

In the design of our future media and systems, we should not shrink from this emotional aspect as a legitimate part of our fantic (see p. 317) design. The substratum of technicalities and the mind-bending, gut-slamming effects they produce, are two sides of the same coin; and to understand the one is not necessarily to be alienated from the other.

Thus it is for the Wholiness of the human spirit, that we must design.

### Dreams

Technology is an expression of man's dreams. If man did not indulge his fantasies, his thoughts alone would inhibit the development of technology itself. Ancient visionaries spoke of distant times and places, where men flew around and about, and some could see each other at great distance. The technological realities of today are already obsolete and the future of technology is bound only by the limits of our dreams. Modern communications media and in particular electronic media are outgrowths and extensions of those senses which have become dominant in our social development.

How Wachspress, "Hyper-Reality."
© Auditac Ltd. 1973.




Ladies and gentlemen, the age of prestidigitative presentation and publishing is about to begin. Palpitating presentations, screen-scribbled, will dance to your desire, making manifest the many mysteries of winding wisdom. But if we are to rehumanize an increasingly brutal and disagreeable world, we must step up our efforts. And we must hurry. Hurry. Step right up.

Theodor H. Nelson, "Barnum-Tronics."

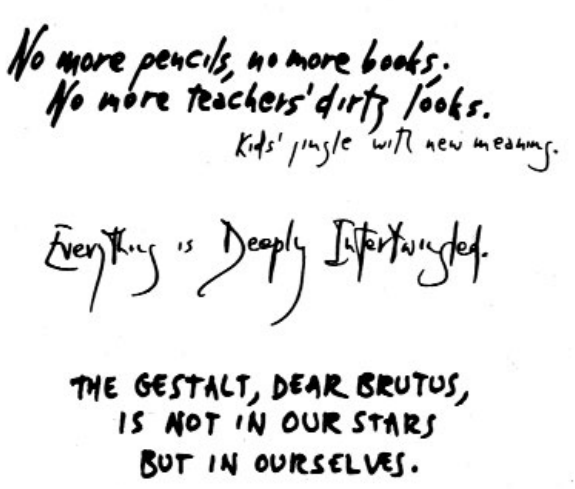
*Swarthmore College Alumni Bulletin,* Dec 1970, 12–15.

"When you're dealing with media you're in show business, you know, whether you like it or not."

"Show business," he said. "Absolutely. We've gotta be in show business. We've gotta put together a team that will get us there."

I made a mental note to use the show business metaphor again, and continued, "IBM's real creative talent probably lies in other areas . . ."

Heywood Gould, *Corporation Freak* (Tower), 23.






(The following article appeared in the September, 1970 issue of *Computer Decisions,* and got an extraordinary amount of attention. I have changed my views somewhat—we all go through changes, after all—but after consideration have decided to re-run it in the original form, without qualifications, mollifications or anything, for its unity. Thanks to *Computer Decisions* for use of the artwork by Gans and for the Superstudent picture on the cover, whose artist unfortunately insists on preserving his anonymity.

An interesting point, incidentally, is that people read this a lot of different ways. One Dean of Education hilariously misread it as an across-the-board plug for CAI. Others read in it various forms of menace or advocacy of generalized mechanization. One letter-writer said *I* was a menace but at least writing articles kept me off the streets. Here is my fundamental point: *computer-assisted instruction, applied thoughtlessly and imitatively, threatens to extend the worst features of education as it is now.*

# NO MORE TEACHERS' DIRTY LOOKS

**by Theodor H. Nelson**
**The Nelson Organization**
**New York**



Some think the educational system is basically all right, and more resources would get it working again. Schools would do things the same way, except more so, and things would get better.

In that case the obvious question would be, how can computers help? How can computers usefully supplement and extend the traditional and accepted forms of teaching? This is the question to which present-day efforts in "computer-assisted instruction" —called CAI—seem to respond.




But such an approach is of no possible interest to the new generation of critics of our school system—people like John Holt (*Why Children Fail*), Jonathan Kozol (*Death at an Early Age*) and James Herndon (*The Way It Spozed to Be*). More and more, such people are severely questioning the general framework and structure of the way we teach.

These writers describe particularly ghastly examples of our schooling conditions. But such horror stories aside, we are coming to recognize that schools as we know them appear designed at every level to sabotage the supposed goals of education. A child arrives at school bright and early in his life. By drabness we deprive him of interests. By fixed curriculum and sequence we rob him of his orientation, initiative and motivation, and by testing and scoring we subvert his natural intelligence.

Schools as we know them all run on the same principles: iron all subjects flat than then proceed, in groups, at a forced march across the flattened plain. Material is dumped on the students and their responses calibrated; their interaction and involvements with the material is not encouraged nor taken into consideration, but their dutifulness of response is carefully monitored.

While an exact arrangement of intended motivations for the student is preset within the system, they do not usually take effect according to the ideal. It is not that students are *un*motivated, but motivated *askew*. Rather than seek to achieve in the way they are supposed to, students turn to churlishness, surliness, or intellectual sheepishness. A general human motivation is god-given at the beginning and warped or destroyed by the educational process as we know it; thus we internalize at last that most fundamental of grownup goals: just to get through another day.

Because of this procedure our very notion of human ability has suffered. Adult mentality is cauterized, and we call it "normal." Most people's minds are mostly turned off most of the time. We know virtually nothing of human abilities except as they have been pickled and boxed in schools; we need to ignore all that and start fresh. To want students to be "normal" is criminal, when we are all so far below our potential. Buckminster Fuller, in *I Seem to Be a Verb,* says we are all born geniuses: Sylvia Ashton-Warner tells us in *Teacher* of her success with this premise, and of the brilliance and creative potential she was able to find in all her schoolchildren.

Curricula themselves destructively arrange the study situation. By walls between artificially segregated "studies" and "separate topics" we forbid the pursuit of interest and kill motivation.

In ordinary schooling, the victim cannot orient himself to the current topic except by understanding the official angle of approach and presentation. Though tie-ins to previous interests and knowledge are usually the best way to get an initial sense of a thing, there is only time to consider the officially presented tie-ins. (Neither is there time to answer questions, except briefly and rarely well—and usually in a way that promotes "order" by discouraging "extraneous" tie-ins from coming up.)

The unnecessary division and walling of subjects, sequencing and kibbling of material lead people to expect simplifications, to feel that naming a thing is understanding it, to fear complex wholes; to believe creativity means

recombination, the parsing of old relations, rather than synthesis.

Like political boundaries, curriculum boundaries arise from noticeable features of a continuum and become progressively more fortified. As behind political borders, social unification occurs within them, so that wholly dissimilar practitioners who share a name come to think they do the same thing. And because they talk mainly to each other, they forget how near is the other side of the border.

Because of the fiction of "subjects," great concern and consideration has always gone into calculating the "correct" teaching sequence for each "subject." In recent years radical new teaching sequences have been introduced for teaching various subjects, including mathematics and physics. But such efforts appear to have been misinformed by the idea of supplanting the "wrong" teaching sequence with the "right" teaching sequence, one which is "validated." Similarly, we have gone from a time when the instructional sequence was a balance between tradition and the lowest common denominator of each subject, to a time when teachers may pick "flexible optimized strategies" from textbooks. And this all ignores a simple fact: all are arbitrary. Instructional sequences aren't needed at all if the people are motivated and the materials are clear and available.




Testing as we know it (integrated with walled curricula and instructional sequences) is a destructive activity, particularly for the orientation which it creates. The concerns of testing are extraneous: learning to figure out low-level twists in questions that lead nowhere, under pressure.

The system of tensions and defenses it creates in the student's personality are unrelated to the subject or the way people might relate to the subject. An exploitive attitude is fostered. Not becoming involved with the subject, the student grabs for rote payoff rather than insight.

All in a condescending circumstance. Condescension is built into the system at all levels, so pervasive it is scarcely noticed. Students are subjected to a grim variety of put-downs and denigrations. While many people evidently believe this to be right, its productivity in building confident and self-respecting minds may be doubted.

The problems of the school are not particularly the teacher's fault. The practice of teaching is principally involved with managing the class, keeping up face, and projecting the image of the subject that conforms to the teacher's own predilections. The educational system is thereby committed to the fussy and prissy, to the enforcement of peculiar standards of righteousness and the elevation of teachers—a huge irrelevant shell around the small kernel of knowledge transmitted.

The usual attacks on computer teaching tend to be sentimental and emotional pleas for the alleged humanism of the existing system. Those who are opposed to the use of computers to teach generally believe the computer to be "cold" and "inhuman." The teacher is considered "warm" and "human." This view is questionable on both sides.



Some premises relevant to teaching

1. The human mind is born free, yet everywhere it is in chains. The educational system serves mainly to destroy for most people, in varying degrees, intelligence, curiosity, enthusiasm, and intellectual initiative and self-confidence. We are born with these. They are gone or severely diminished when we leave school.

2. Everything is interesting, until ruined for us. Nothing in the universe is intrinsically uninteresting. Schooling systematically ruins things for us, wiping out these interests; the last thing to be ruined determines your profession.

3. There are no "subjects." The division of the universe into "subjects" for teaching is a matter of tradition and administrative convenience.

4. There is no natural or necessary order of learning. Teaching sequences are arbitrary, explanatory hierarchies philosophically spurious. "Prerequisites" are a fiction spawned by the division of the world into "subjects;" and maintained by not providing summaries, introductions or orientational materials except to those arriving through a certain door.

5. Anyone retaining his natural mental facilities can learn anything practically on his own, given encouragement and resources.

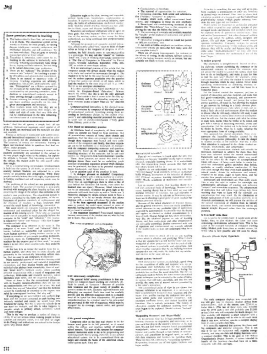
6. Most teachers mean well, but they are so concerned with promoting their images, attitudes and style of order that very little else can be communicated in the time remaining, and almost none of it attractively.

The computer is as inhuman as we make it. The computer is no more "cold" and "inhuman" than a toaster, bathtub or automobile (all associated with warm human activities). Living teachers can be as inhuman as members of any people-prodding profession, sometimes more so. Computerists speak of "freeing teachers for the creative part of their work;" in many cases it is not clear what creative tasks they could be freed for.

At the last, it is to *rescue* the student from the inhuman teacher, and allow him to relate directly and personally to the intrinsically interesting subject matter, than we need to use computers in education.

Many successful systems of teacherless learning exist in our society: professional and industrial magazines; conventions and their display booths and brochures; technical sales pitches (most remarkably, those of medical "detail men"); hobbyist circles, which combine personal acquaintance with a round of magazines and gatherings; think-tanks and research institutes, where specialists trade fields; and the respectful briefing.





None of these is like the conventional classroom with its haughty resource-chairman; they are not run on condescension; and they get a lot across. We tend to think they are not "education" and that the methods cannot be transferred or extended to the regions now ruled by conventional teaching. But why not?

If everything we ate were kibbled into uniform dogfood, and the amount consumed at each feeding time tediously watched and tested, we would have little fondness for eating. But this is what the schools do to our food for thought, and this is what happens to people's minds in primary school, secondary school and most colleges.

This is the way to produce a nation of sheep or clerks. If we are serious about wanting people to have creative and energetic minds, it is not what we ought to do. Energy and enthusiasm are natural to the human spirit; why drown them?

Education ought to be clear, inviting and enjoyable, without booby-traps, humiliations, condescension or boredom. It ought to teach and reward initiative, curiosity, the habit of self-motivation, intellectual involvement. Students should develop, through practice, abilities to think, argue and disagree intelligently.

Educators and computer enthusiasts tend to agree on these goals. But what happens? Many of the inhumanities of the existing system, no less wrong for being unintentional, are being continued into computer-assisted teaching.

Although the promoters of computer-assisted instruction, affectionately call "CAI," seem to think of themselves as being at the vanguard of progress in all directions, the field already seems to operate according to a stereotype. We may call this "classic" or "conventional" CAI, a way of thinking depressingly summarized in "The Use of Computers in Education" by Patrick Suppes, *Scientific American,* September, 1966, 206–220, an article of semi-classic stature.

It is an unexamined premise of this article that the computer system will always decide what the student is to study and control his movements through it. The student is to be led by the nose through every subject, and the author expresses perplexity over the question of *how* the system can decide, at all times, *where* to lead the student by the nose (top of col. 3, p. 219). But let us not anticipate alternatives.

It is often asserted (as by Alpert and Bitzer in "Advances in Computer-Based Education," *Science,* March 20, 1970) that this is not the only approach current. The trouble is that it *seems* to be the only approach current, and in the expanding computer universe everyone *seems* to know what CAI "is." And this is it.

Computer-assisted instruction, in this classical sense, is the presentation by computer of bite-sized segments of instructional material, branching among them according to involuntary choices by the student ("answers") and embedding material presented the student in some sort of pseudo-conversation ("Very good. Now, Johnny, point at the . . .")

## CAI: Based on Unnecessary Premises

At whichever level of complexity, all these conventional CAI systems are based on three premises: that all presentations consist of *items,* short chunks and questions; that the items are arranged into *sequences,* though these sequences may branch and vary under control of the computer; and finally, that these sequences are to be embedded in a framework of

*dialogue;* with the computer composing sentences and questions appropriately based on the student's input and the branching structure of the materials. Let us call such systems SIC (Sequenced-Item Conversational) systems.

These three premises are united. For there to be dialogue means there must be underlying graph structure of potential sequences around which dialogue may be generated; for there to be potential sequences means breakpoints, and hence items.

Let us question each of the premises in turn.

**1 Is dialogue pleasant or desirable?**

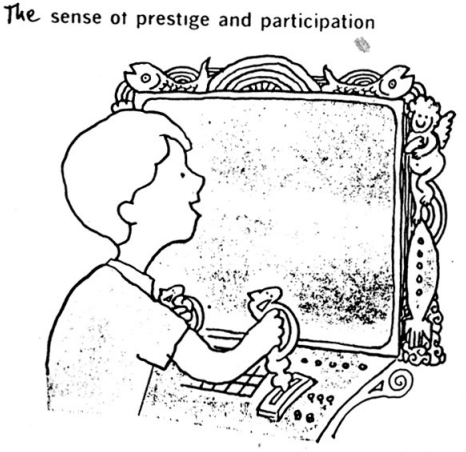
Compulsory interaction, whether with a talking machine or a stereotyped human, is itself a put-down or condescension. (Note that on superhighways there is often a line of cars behind the automatic toll booths, even when the manned ones are open.) Moreover, faked interaction can be an annoyance. (Consider the green light at the automatic toll booth that lights up with a "thank you.") Moreover, dialogue by simple systems tends to have a fake quality. It is by no means obvious that phony dialogue with a machine will please the student.

**2 Is the item approach necessary?**

If the student were in control, he could move around in areas of material, leaving each scene when he got what he wanted, or found in unhelpful.

**3 Are sequences necessary?**

Prearranged sequences become unnecessary if the student can see what he has yet to learn, then pursue it.




## CAI: Unnecessary Complication

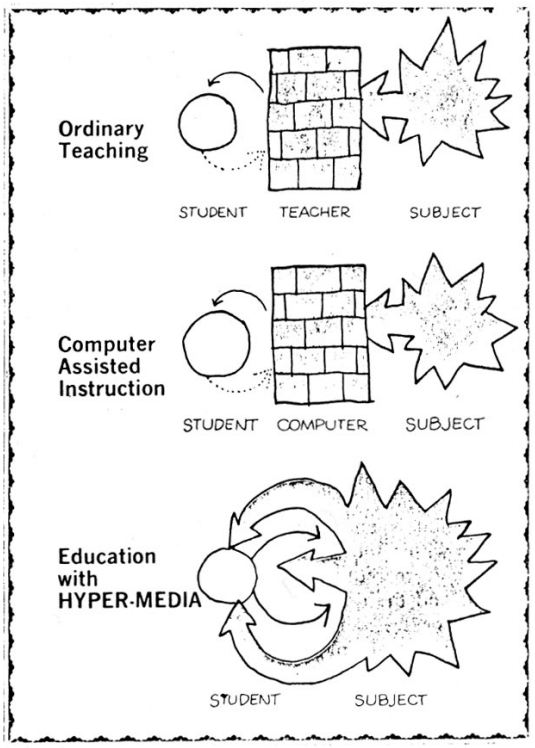
The general belief among practitioners is that materials for computer-based teaching are extremely difficult to create, or "program." Because of possible item weakness and the great variety of possible sequences within the web, extensive experimentation and debugging are required. Each item must be carefully proven; and the different sequences open to a student must all be tested for their effectiveness. All possible misunderstandings by a student need to be anticipated and prevented in this web of sequences, which must be designed for its coverage, correct order, and general effectiveness.

## CAI: General Wrongfulness

Computers offer us the first real chance to let the human mind grow to its full potential, as it cannot within the stifling and insulting setting of existing school systems. Yet most of the systems for computer-assisted instruction seem to me to be perpetuating and endorsing much that is wrong, even evil, in our present educational system. CAI in its conventional form enlarges and extends the faults of the American educational system itself. They are:

- Conduciveness to boredom;
- The removal of opportunities for initiative;
- Gratuitous concerns, both social and administrative ("subject," "progress" in subject);
- Grades, which really reflect commitment level, anxiety, and willingness to focus on core emphasis;
- Stereotyped and condescending treatment of the student (the "Now-Johnny" box in the computer replacing the one that sits before the class);
- The narrowing of curricula and available materials for "results" at the expense of motivation and generalized orientation;
- Destructive testing of a kind we would not permit on delicate machinery; and,
- An overt of hidden emphasis on invidious ratings. (Ungraded schools are nice—but how many units did *you* complete today?)

There are of course improvements, for instance in the effects of testing. In the tell-test, tell-test nattering of CAI, the testing becomes merely an irritant, but one certainly not likely to foster enthusiasm.






## But Isn't CAI 'Scientific?'

Part of CAI's mystique is based upon the idea that teaching can become "scientific" in the light of modern research, especially learning theory. It is understandable that researchers should promote this view and that others should fall for it.

Laymen do not understand, nor are they told, that "learning theory" is an extremely technical, mathematically oriented, description of the behavior of abstract and idealized organisms learning non-unified things under specific conditions of motivation and non-distraction.

Let us assume, politely, that learning theory is a full and consistent body of knowledge. Because of its name, learning theory has at least what we may call nominal relevance to teaching; but real relevance is another matter. It may be relevant as Newtonian equations are to shooting a good game of pool: implicit but without practical bearing.

Because of the actual character of learning theory, and its general remoteness from non-sterile conditions, actual relevance to any particular type of application must still be demonstrated. To postulate that the theory still applies in diluted or shifted circumstances is a leap of faith. Human beings are not, taken all together, very like the idealized pigeons or rats of learning theory, and their motivations and other circumstances are not easily controlled. Studies concerned with rate of repetition and reinforcement are scarcely relevant if the student hates or does not understand what he is doing.

I do not mean to attack all CAI, or any teaching system which is effective and gratifying. What I doubt is that SIC systems for CAI will become more and more wonderful as effort progresses, or that the goal of talking tutorial systems is reachable and appropriate. And what I further suspect is that we are building boredom systems that not only make life duller but sap intellectual interest in the same old way.

## Should Systems 'Instruct?'

Drill-and-practice systems are definitely a good thing for the acquisition of skills and response sets, an improvement over workbooks and the like, furnishing both corrections and adjustment. They are boring, but probably less so than the usual materials. But the CAI enthusiasts seem to believe the same conversationalized chunk techniques can be extended to the realm of ideas, to systems that will tutor and chide, and that this will provide the same sort of natural interest provided by a live tutor's instruction.

The conventional point of view in CAI claims that because validation is so important, it is necessary to have a standardized format of item, sequence and dialogue. This justifies turning the endeavor into picky-work within items and sequence complexes, with attendant curricular freeze, and student inanition and boredom. This is entirely premature. The variety of alternative systems for computer teaching have not even begun to be explored. Should systems "instruct" at all?

## 'Responding Resources' and 'Hyper-Media'

At no previous time has it been possible to create learning resources so responsive and interesting, or to give such free play to the student's initiative as we may now. We can now build computer-based presentational wonderlands, where a student (or other user) may browse and ramble through a vast variety of writings, pictures and apparitions in magical space, as well as rich data structures and facilities for twiddling them. These we may call, collectively, "responding

resources." Responding resources are of two types: facilities and hyper-media.

A *facility* is something the user may call up to perform routinely a computation or other act, behaving in desired ways on demand. Thus JOSS (a clever desk calculator available at a terminal) and the Culler-Freed graph-plotting system (which graphs arbitrary functions the user types in) are facilities.

*Hyper-media* are branching or performing presentations which respond to user actions, systems of prearranged words and pictures (for example) which may be explored freely or queried in stylized ways. They will not be "programmed," but rather *designed, written, drawn* and *edited,* by authors, artists, designers and editors. (To call them "programmed" would suggest spurious technicality. Computer systems to present them will be "programmed.") Like ordinary prose and pictures, they will be *media;* and because they are in some sense "multi-dimensional," we may call them *hyper-media,* following mathematical use of the term "hyper-."

## A Modest Proposal

The alternative is straightforward. Instead of devising elaborate systems permitting the computer or its instructional contents to control the situation, why not permit the student to control the system, show him how to do so intelligently, and make it easy for him to find his own way? Discard the sequences, items and conversation, and allow the student to move freely through materials which he may control. Never mind optimizing reinforcement or validating teaching sequences. Motivate the user and let him loose in a wonderful place.

Let the student control the sequence, put him in control of interesting and clear material, and make him feel good—comfortable, interested, and autonomous. Teach him to orient himself: not having the system answer questions, all typed in, but allowing the student to get answers by looking in a fairly obvious place. (Dialogue is unnecessary even when it does not intrude.) Such ultra-rich environments allow the student to choose what he will study, when he will study it and how he will study it, and to what criteria of accomplishment he will aim. Let the student pick what he wishes to study next, decide when he wishes to be tested, and give him a variety of interesting materials, events and opportunities. Let the student ask to be tested on what he thinks he knows, when he is ready, selecting the most appropriate form of testing available.

This approach has several advantages. First, it circumvents the incredible obstacles created by the dialogue-item-sequence philosophy. It ends the danger to students of bugs in the material. And last, it does what education is supposed to do—foster student enthusiasm, involvement, and self-reliance.

Under such circumstances students will actually be interested, motivated to achieve far more than they have ever achieved within the normal instructional framework; and any lopsidedness which may result will be far offset by the degree of accomplishment which will occur—it being much better to create lopsided but enthusiastic genius specialists than listless, apathetic, or cruelly rebellious mediocrities. If they start soon enough they may even reach adulthood with natural minds: driven by enthusiasm and interest, crippled in no areas, eager to learn more, and far smarter than people ordinarily end up being.

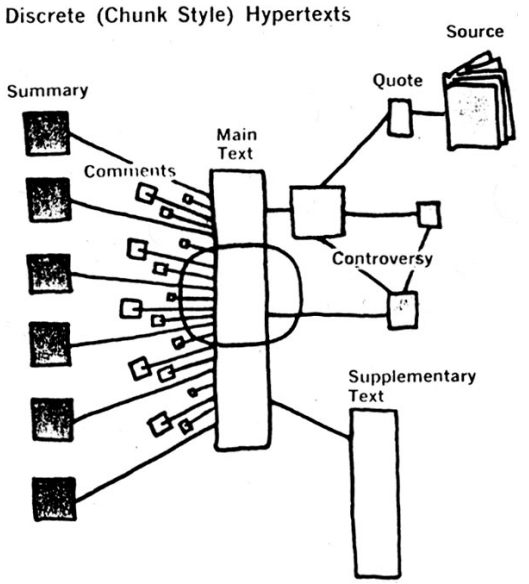


Enthusiasm and involvement are what really count. This is why the right to explore far outweighs any administrative advantages of creating and enforcing "subjects" and curriculum sequences. The enhancement of motivation that will follow from letting kids learn anything they want to learn will far outweigh any specialization that may result. By the elimination or benign replacement of both curriculum and tests in an ultra-rich environment, we will prevent the attrition of the natural motivation of children from its initially enormous levels, and mental development will be the natural straight diagonal rather than the customary parabola.

## Is It So Hard? Some Ideas

CAI is said to be terribly hard. It would seem all the harder, then, to give students the richer and more stimulating environments advocated here. This is because of the cramped horizons of computer teaching today. Modest goals have given us modest visions, far below what is now possible and will soon be cheap.

The static computer displays now associated with CAI will give way to dynamic displays driven from minicomputers, such as the IDIIOM, IBM 2250/4 or Imlac PDS–1. (The last of these costs only $10,000 *now;* by 1975 such a unit will probably cost $1,000 or less.) Not only will computers be






much cheaper, but their usability will improve: a small computer with a fair amount of memory will be able to do much more than it can now, including operate a complex display from its own complex data base.

It is generally supposed that systems like these need big computers and immense memories. This is not true if we use the equipment well, organize storage cleverly, and integrate data and display functions under a compact monitor. This is the goal of The Nelson Organization's Project Xanadu, a system intended to handle all the functions described here on a mini-computer with disk and tape.

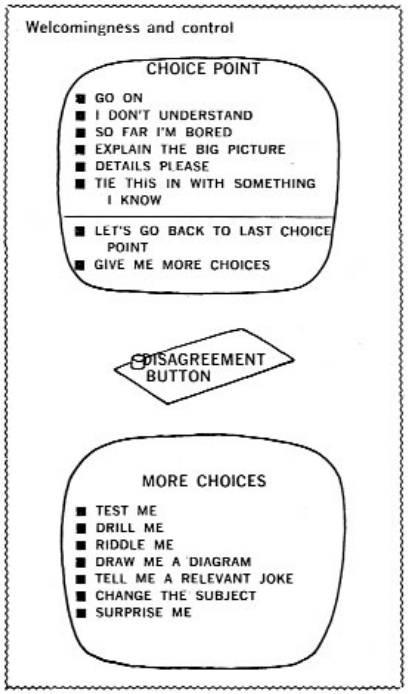
## Discrete Hypertexts

"Hypertext" means forms of writing which branch or perform on request; they are best presented on computer display screens.

In ordinary writing the author may break sequence for footnotes or insets, but the use of print on paper makes some basic sequence essential. The computer display screen, however, permits footnotes on footnotes on footnotes, and pathways of any structure the author wants to create.

Discrete, or chunk style, hypertexts consist of separate pieces of text connected by links.

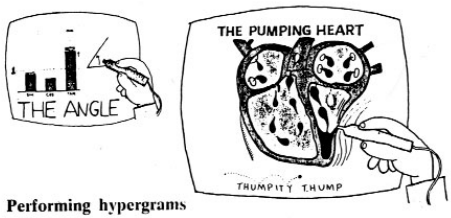
Ordinary prose appears on the screen and may be moved forward and back by throttle. An asterisk or other key in the text means, not an ordinary footnote, but a *jump*—to an




entirely new presentation on the screen. Such jumpable interconnections become part of the writing, entering into the prose medium itself as a new way to provide explanations and details to the seeker. These links may be artfully arranged according to meanings or relations in the subject, and possible tangents in the reader's mind.

## Performing Hypergrams

A hypergram is a performing or branching picture: for instance, this angle, with the bar-graph of its related trigonometric functions. The student may turn the angle upon the screen, seizing it with the light-pen, and watch the related trigonometric functions, displayed as bar charts, change correspondingly.




**Performing hypergrams**

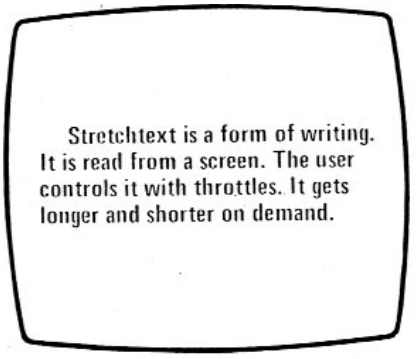
Hypergrams may also be programmed to show the consequences of a user's prod—what follows or accompanies some motion of the picture that he makes with a pointing tool, like the heartbeat sequence.

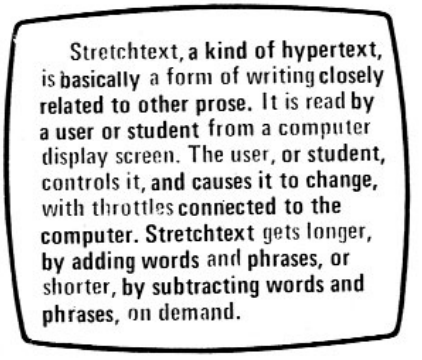
## Stretchtext™ Fills in the Details

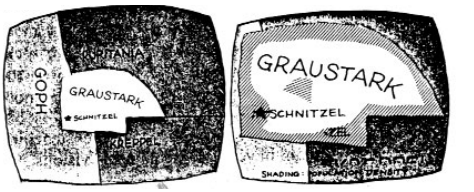
This form of hypertext is easy to use without getting lost. As a form of writing, it has special advantages for discursive and loosely structured materials—for instance historical narratives.

There are a screen and two throttles. The first throttle moves the text forward and backward, up and down on the screen. The second throttle causes changes in the writing itself: throttling toward you causes the text to become *longer* by minute degrees. Gaps appear between phrases; new words and phrases pop into the gaps, an item at a time. Push back on the throttle and the writing becomes shorter and less detailed.

The stretchtext is stored as a text stream with extras, coded to pop in and pop out at the desired altitudes:



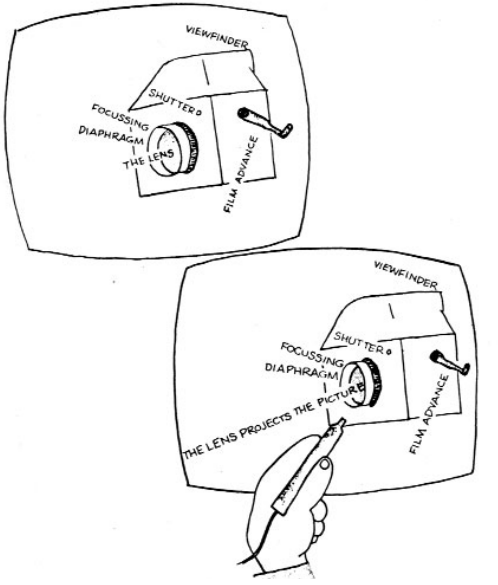



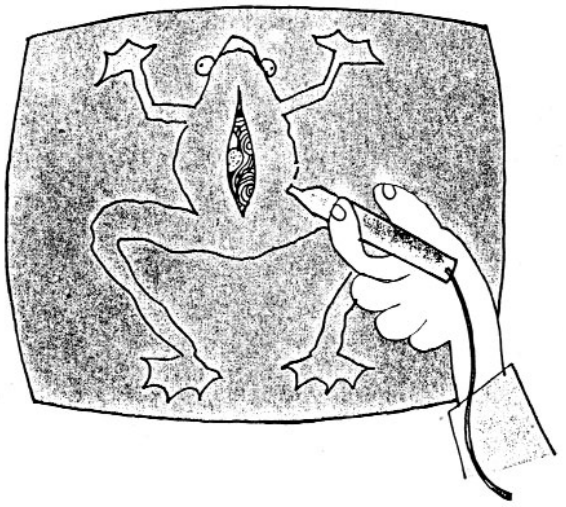

## Hypermap Zips Up or Down

The screen is a map. A steering device permits the user to move the map around the world's surface: a throttle zooms it in. Not by discrete jumps, but animated in small changes, the map grows and grows in scale. More details appear as the magnification increases. The user may request additional display modes or "overlays," such as population, climate, and industry. Such additional features may pop into view on request

## Queriable Illustrations: a Form of Hypergram

A "hypergram" is a picture that can branch or perform on request. In this particular example, we see on the screen a line-drawing with protruding labels. When the student points at a label, it becomes a sliding descriptive ribbon, explaining the thing labeled. Or asterisks in an illustration may signal jumps to detailed diagrams and explanations, as in discrete hypertexts.

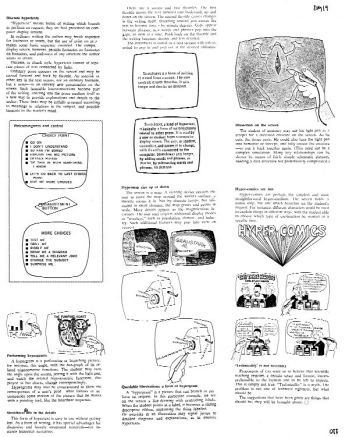






## Dissection on the Screen

The student of anatomy may use his light-pen as a scalpel for a deceased creature on the screen. As he cuts, the tissue parts. He could also turn the light-pen into hemostat or forceps, and fully dissect the creature—or put it back together again. (This need not be a complex simulation. Many key relationships can be shown by means of fairly simple schematic pictures, needing a data structure not prohibitively complicated.)






## Hyper-comics are Fun

Hyper-comics are perhaps the simplest and most straightforward hyper-medium. The screen holds a comic strip, but one which branches on the student's request. For instance, different characters could be used to explain things in different ways, with the student able to choose which type of explanation he wanted at a specific time.

## 'Technicality' Is Not Necessary

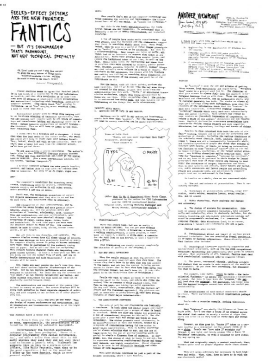
Proponents of CAI want us to believe that scientific teaching requires a certain setup and format, incomprehensible to the layman and to be left to experts. This is simply not true. "Technicality" is a myth. The problem is not one of technical rightness, but what *should* be.

The suggestions that have been given are things that should be; they will be brought about.

FEELED-EFFECT SYSTEMS
ARE THE NEW FRONTIER
FANTICS
— BUT IT'S SHOWMANSHIP
THAT'S PARAMOUNT,
NOT ANY TECHNICAL SPECIALTY

Ah, Love! could you and I with Him conspire
To grasp this sorry Scheme of Things entire,
Would not we shatter it to bits—and then
Re-mould it nearer to the Heart's Desire!

Edward Fitzgerald.


FEELED-EFFECT SYSTEMS
ARE THE NEW FRONTIER
FANTICS

Almost everyone seems to agree that Mankind (who?) is on the brink of a revolution in the way information is handled, and that this revolution is to come from some sort of merging of electronic screen presentation and audio-visual technology with branching, interactive computer systems. (The naïve think "the" merging is inevitable, as if "the" merging meant anything clear. I used to think that too.)

Professional people seem to think this merging will be an intricate mingling of technical specialties, that our new systems will require work by all kinds of committees and consultants (adding and adjusting) until the Results—either specific productions or overall Systems—are finished. Then we will have to Learn to Use Them. More consulting fees.

I think this is a delusion and a con-game. I think that when the *real* media of the future arrive, the smallest child will know it right away (and perhaps first). That, indeed, should and will be the criterion. When you can't tear a teeny kid away from the computer screen, we'll have gotten there.

We are approaching a screen apocalypse. The author's basic view is that RESPONSIVE COMPUTER DISPLAY SYSTEMS CAN, SHOULD AND WILL RESTRUCTURE AND LIGHT UP THE MENTAL LIFE OF MANKIND. (For a more conventional outlook, see box nearby, "Another Viewpoint.")

I believe computer screens can make people happier, smarter, and better able to cope with the copious problems of tomorrow. But only if we do right, right now.

## Why?

The computer's capability for branching among events, controlling exterior devices, controlling outside events, and mediating in all other events, makes possible a new era of media.

Until now, the mechanical properties of external objects determined what they were to us and how we used them. But henceforth this is arbitrary.

The recognition of that arbitrariness, and reconsideration among broader and more general alternatives, awaits us. All the previous units and mechanisms of learning, scholarship, arts, transaction and confirmation, and even self-reminder, were based in various ways upon physical objects—the properties of paper, carbon paper, files, books and bookshelves. To read from paper you must move the physical object in front of you. Its contents cannot be made to slide, fold, shrink, become transparent, or get larger.



But all this is now changing, and suddenly. The computer display screen does all these things if desired, to the same markings we have previously handled on paper. The computer display screen is going to become universal very fast; this is guaranteed by the suddenly rising cost of paper. And we will use them for everything. This already happens wherever there are responding computer screen systems. (I have a friend with two CRTs on his desk; one for the normal flow of work, and one to handle interruptions and side excursions.) A lot of forests will be saved.

Now, there are many people who don't like this idea, and huff about various apparent disadvantages of the screen. But we can improve performance until almost everyone is satisfied. For those who say the screens are "too small," we can improve reliability and backup, and offer screens everywhere (so that material need not be physically carried between them).

The exhilaration and excitement of the coming time is hard to convey on paper. Our screen displays will be alive with animation in their separate segments of activity, and will respond to our actions as if alive physically too.

The question is, then: HOW WILL WE USE THEM? Thus the design of screen performances and environments, and of transaction and transmission systems, is of the highest priority.

## The French Have a Word for It

In French they use the term *l'Informatique* to mean, approximately, the presentation of information to people by automatic equipment.

Unfortunately the English equivalent, *informatics,* has been preempted. There is a computer programming firm called Informatics, Inc., and when I wrote them about this in the early sixties they said they did *not* want their name to become a generic term. Trademark law supports them in this to a certain extent. (Others, like Wally Feurzeig, want that to be the word regardless.) But in the meantime I offer up the term *fantics,* which is more general anyhow.

## Media

What people don't see is how computer technology now makes possible the revision and improvement—the transformation—of all our media. It "sounds too technical."



But this is the basic misunderstanding: the fundamental issues are NOT TECHNICAL. To understand this is basically a matter of MEDIA CONSCIOUSNESS, not technical knowledge.

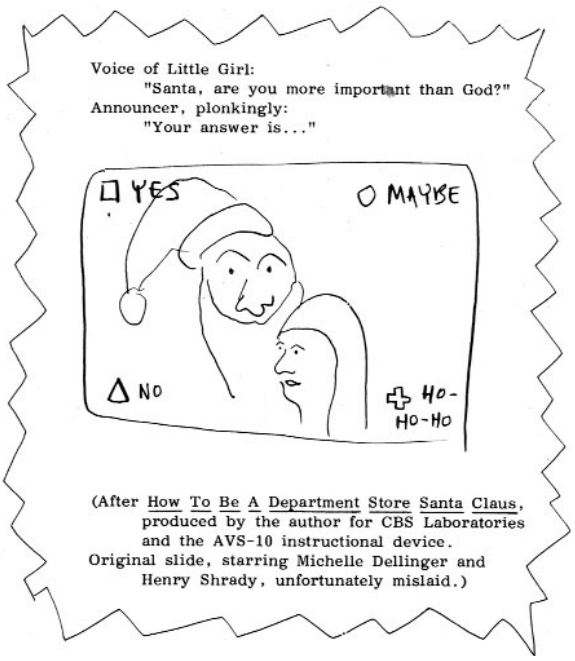
A lot of people have acute media consciousness. But some people, like Pat Buchanan and the communards, suggest that there is something shabby about this. Many think, indeed, that we live in a world of false images promulgated by "media," a situation to be corrected. But this is a misunderstanding. Many images are false or puffy, all right, but it is incorrect to suppose that there is any alternative. Media have evolved from simpler forms, and convey the background ideas of our time, as well as the fads. Media today focus the impressions and ideas that in previous eras were conveyed by rituals, public gatherings, decrees, parades, behavior in public, mummer' troupes . . . but actually every culture is a world of images. The chieftain in his palanquin, the shaman with his feathers and rattle, are telling us something about themselves and about the continuity of the society and position of the individuals in it.

Now the media, with all their quirks, perform the same function. And if we do not like the way some things are treated by the media, in part this stems from not understanding how they work. "Media," or structured transmission mechanisms, cannot help being personalized by those who run them. (Like everything else.) The problem is to understand how media *work,* and thus balance our understanding of the things that media misrepresent.

## Thoughts about Media:

### 1 Anything Can Be Said in Any Medium

Anything can be said in any medium, and Inspiration counts much more than 'science.' But the techniques which are used to convey something can be quite unpredictable.




### 2 Transposability

There has always been, but now is newly, a UNITY OF MEDIA OPTIONS. You can get your message across in a play, a tract, a broadside, a textbook, a walking sandwich-board, a radio program, a comic book or fumetti, a movie, a slide-show, a cassette for the Audi-Scan or the AVS–10, or even a hypertext.

(But transposing can rarely preserve completely the character or quality of the original.)

### 3 Big and Small Approaches

What few people realize is that big pictures can be conveyed in more powerful ways than they know. The reason they don't know it is that they see the *content* in the media, and not *how* the content is being gotten across to them—that in fact they have been given very big pictures indeed, but don't know it. (I take this point to be the Nickel-Iron Core of McLuhanism.)

People who want to teach in terms of building up from the small to the large, and others who (like the author) like to present a whole picture *first,* then fill in the gaps, are taking two valid approaches. (We may call these, respectively, the Big Picture approach and the Piecemeal approach.) Big pictures are just as memorable as picky-pieces *if* they have strong insights at their major intersections.

**4 The Word-Picture Continuum**

The arts of writing and diagramming are basically a continuum. In both cases the mental images and cognitive structures produced are a merger of what is heard or received. Words are slow and tricky for presenting a lot of connections; diagrams do this well. But diagrams give a poor feel for things and words do this splendidly. The writer presents exact statements, in an accord-structure of buts and indeeds, molded in a structure of connotations having (if the writer is good) *exact impreciseness*. This is hardly startling: you're always selecting what to say, and the use of vague words (or the use of precise-sounding words vaguely) is simply a flagrant form of omission. In diagrams, too, the choice of what to leave in and out, how to represent overweening conditions and forces and exemplary details, are highly connotative. (Great diagrams are to be seen in the *Scientific American* and older issues of *Time* magazine.)

This word-picture continuum is just a part of the broader continuum, which I call Fantics.

ANOTHER VIEWPOINT
[from handout, 1974 Natl. Joint Comp. Conf.]

John B. Macdonald
Research Leader, Computer Applications: Graphics, Western Electric Company, Engineering Research Center

***Problems, Perils, and Promises of Computer Graphics***

I would begin with some definitions which may be obvious but bear repeating.

1. Engineering is the application of science for ($) profit,
2. Computer graphics does not make possible anything that was previously impossible; it can only improve the throughput of an existing process,
3. A successful application of computer graphics is when over a period of five years the cost savings from improved process throughput exceed the costs of hardware, software, maintenance and integration into an existing process flow.

## Fantics

By "fantics" I mean the art and science of getting ideas across, both emotionally and cognitively. "Presentation" could be a general word for it. The character of what gets across is always dual; both the explicit structures, and feelings that go with them. These two aspects, exactness and connotation, are an inseparable whole; what is conveyed generally has both. The reader or viewer always gets feelings along with information, even when the creators of the information think that its "content" is much more restricted. A beautiful example: ponderous "technical" manuals which carry much more connotatively than the author realizes. Such volumes may convey to some readers an (intended) impression of competence, to others a sense of the authors' obtuseness and non-imagination. Explicit declarative structures nevertheless have connotative fields; people receive not only cognitive structures, but impressions, feelings and senses of things.



Fantics is thus concerned with both the arts of effect—writing, theater and so on—and the structures and mechanisms of thought, including the various traditions of the scholarly event (article, book, lecture, debate and class). These are all a fundamentally inseparable whole, and technically-oriented people who think that systems to interact with people, or teach, or bring up information, can function on some "technical" basis—with no tie-ins to human feelings, psychology, or the larger social structure—are kidding themselves and/or everyone else. Systems for "teaching by computer," "information retrieval," and so on, have to be governed in their design by larger principles than most of these people are willing to deal with: the conveyance of images, impressions and ideas. This is what writers and editors, movie-makers and lecturers, radio announcers and layout people and advertising people are concerned with; and unfortunately computer people tend not to understand it for beans.

In fantics as a whole, then we are concerned with:

> 1. The art and science of presentation. Thus it naturally includes
>
> 2. Techniques of presentation: writing, stage direction, movie making, magazine layout, sound overlay, etc. and of course
>
> 3. Media themselves, their analysis and design; and ultimately
>
> 4. The design of systems for presentation. This will of course involve computers hereafter, both conceptually and technically; since it obviously includes, for the future, branching and intricately interactive systems enacted by programmable mechanisms, i.e. computers. Thus computer display, data structures (and, to an extent, programming languages and techniques) are all a part.



Fantics must also include

> 5. Psychological effect and impact of various presentational techniques—but not particular formal aesthetics, as of haiku or musical composition. Where directly relevant fantics also includes
>
> 6. Sociological tie-ins—especially supportive and dysfunctional structures, such as tie-ins with occupational structure; sponsorship and commercials; what works in schools and why. Most profoundly of all, however, fantics must deal with psychological constructs used to organize things:
>
> 7. The parts, conceptual threads, unifying concepts and whatnot that we create to make aspects of the world understandable. We put them into everything, but standardize them in media.

For example, take radio. *Given* in radio—the technological fundament—is merely the continuous transmission of sound. *Put into it* have been the "program," the *serial* (and thus the *episode*), the *announcer,* the *theme song* and the *musical bridge*—conventions which are useful presentationally.

The arbitrariness of such mental constructs should be clear. Their usefulness in mental organization perhaps is not.

Let's take a surprise example, nothing electronic about it.

Many "highways" are wholly fictitious—at least to begin with. Let's say that a Route 37 is created across the state: that number is merely a series of signs that users can refer to as they look at their maps and travel along.

However, as time goes by, "Route 37" takes on a certain reality as a conceptual entity: people think of it as a *thing.* People say "just take 37 straight out" (though it may twist and turn); groups like a Route 37 Merchants' Association, or even a Citizens to Save Scenic 37, may spring up.

What was originally simply a nominal construct, then, becomes quite real as people organize their lives around it.

This all seems arbitrary but necessary in both highways and radio. What, then, does it have to do with the new electronic media?

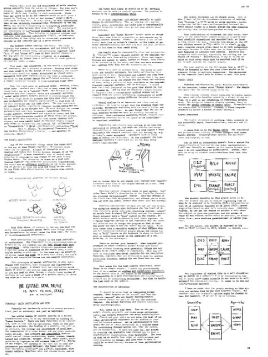
Simply this: till now the structures of media somehow sprang naturally from the nature of things. *Now they don't anymore.* Radio, books and movies have a natural inner dynamic of their own, leading to such constructs. While this may prove to be so for computer media as well (—as I argued in "Getting It Out of Our System"), then again it may not. In other words, WE MUST ACKNOWLEDGE THAT WE ARE *INVENTING* PRESENTATIONAL TECHNIQUES IN THE NEW MEDIA, not merely transporting or transposing particular things into them, because they seem right. *The psychological constructs of man-machine systems may turn out to be largely arbitrary*. Thus bringing to terminal systems conventions like dialogue instruction ("CAI"), or arbitrary restrictions of how things may be connected, presented or written on the computer may be a great mistake.

The highway-number analogy continues. The older highways had numbers for convenience, and our travels became organized around them, and particular highways (like "U.S. 1" and "Route 66") came to have special character. But now with the Interstates, a highway is a *planned, sealed unit,* no longer just a collection of roads gathered together under a name.

This unit, the Interstate, is not merely a psychological construct, but a planned structure. Knowing what works and what doesn't in the design of fast highways, the Interstates were built for speed, structured as closed units. Designing them with limited access has been a conscious decision in the system design for well-based reasons, *not* a chance structure brought in from horse-and-buggy days.

Now, the constructs of previous media—writing, films, other arts—evolved over time, and in many cases may have found their way to a "natural" form. But because of the peculiar way that computer media are currently evolving (—under large grants largely granted to professionals who use very large words to promote the idea that their original

professions are largely applicable—), this sort of natural evolution may not take place. The *new* constructs of computer media, especially computer screen-media, may not have a chance to be thought out. We need designs for screen presentations and their mixture—vignetting, Windows, screen mosaics, transformed and augmented views, and the rapid and comprehensible control of these views and windows. We are still just beginning to find clever viewing techniques, and have hardly begun to discover highly responsive forms of viewability and control (cf. collateration in "Thinkertoys," p. 330), and Knowlton's button-box (oops, omitted). (See T. Nelson, "A Conceptual Framework for Man-Machine Everything," and material on controls, below.)



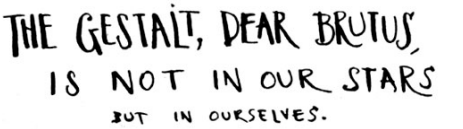
## The Mind's Unification

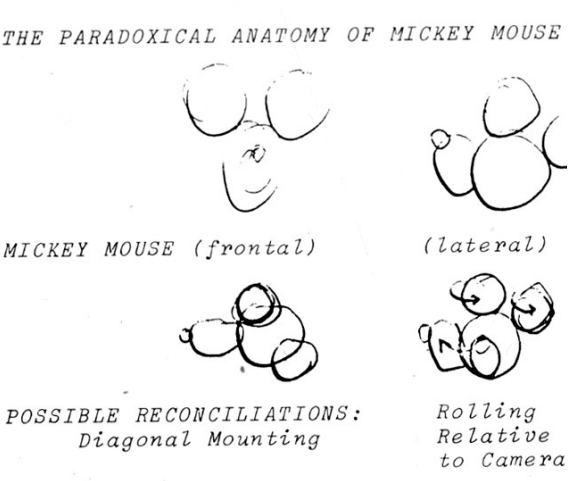
One of the remarkable things about the human mind is the way it ties things together. Perceptual unity comes out of nowhere. A bunch of irregular residential and industrial blocks becomes thought of as "my neighborhood." A most remarkable case of mental unification is afforded by the visage of our good friend Mickey Mouse. The character is drawn in a most paradoxical fashion: two globelike protrusions (representing the ears) are in *different positions on the head,* depending on whether we view him for the front or the side. No one finds this objectionable; few people even notice, it seems.

What this shows, of course, is the way the mind can unify into a consistent mental whole even things which are inconsistent by normal rules (in this case, the rules of three-dimensional structure).

Even perceptions are subject to the same principle of unification. The fingernail is an excrescence with no nerves in it; yet somehow you can *feel things with your fingernails*—tying together disparate sensations into a unified sense of something in the world (say, a coin you're trying to pick up). In the same way, an experienced driver *feels the road;* in a very real sense, the car's wheels and suspension become his own sensory extensions.

This principle of mental unification is what makes things come together, both literally and figuratively, in a fantic field. A viewer sees two consecutive movie shots of streets and unifies them into one street; controls, if you are used to them, become a single fused system of options; we can have a sense of a greater whole, of which one view on a screen is a part.




## Controls: Their Unification and Feel

Controls are intimately related to screen presentation, just as arbitrary, and just as important.

The artful design of control systems is a deeply misunderstood area, in no way deconfused by calling it "human factors." There are many functions to be controlled, such as text editing operations, views of the universe on a screen, the heading of a vehicle, the tilt of an aircraft, the windage and adjustments of artillery, the temperature of a stove burner and any other controllable devices. And nowadays *any conceivable* devices could control them—pushbuttons, knobs, cranks, wheels, levers and joysticks, trigger, dials, magic wands, manipulation by lightpen on CRT screens, flicks of the finger, the *turning of the eyes* (as in some experimental gun-aiming devices), the human voice (but that introduces problems), keyboards, electronic tablets, Engelbart mice and chord writers, and so on.

The human mind being as supple as it is, anything whatever can be used to control systems. The problem is having it be a *comprehensible whole.*

As already remarked, our ability mentally to unify things is extraordinary. That we somehow tie together clutch, gear, accelerator and brake into a comprehensible control structure to make cars go and stop should amaze and instruct.

Engineers and "human factors" people speak as though there were some kind of scientific or determinate way to design control systems. Piffle. We choose a set of controls, much like an artist's Palette, on the basis of general appropriateness; and then try best and most artistically to fit them to what needs doing.

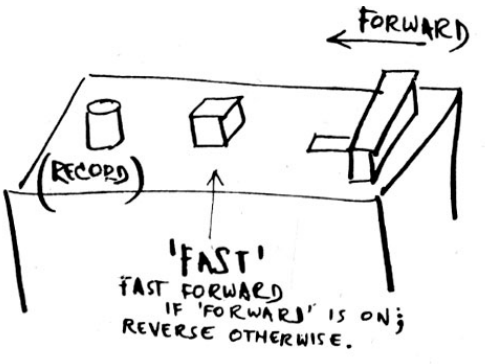
The result must be conceptually clear and retroactively "obvious"—simply because clarity is the simplest way to keep the user from making mistakes. Clear and simple systems are easier to learn, harder to forget, less likely to be screwed up by the user, and thus are more economical—getting more done for the resources put in.



There is a sort of paradox here. The *kinds* of controls are totally arbitrary, but their unification in a good system is not. Smoothness and clarity can come from disparate elements. It is for this reason that I lay particular stress on my JOT system for the input and revision of text, using a palette of keys available on the simplest standard computer terminal, the 33 Teletype. I cannot make the final judgement on how good this system is, but it pleases me. JOT is also an important example because it suggests that a conceptually unified system can be created from the artful non-obvious combination of loose elements originally having different intended purposes.

Mental analogy is an important and clear control technique. We tend to forget that the steering wheel was *invented,* separately replacing both the boat's tiller and the automobile's tiller. We also forget that the use of such steering mechanisms must be actually learned by children. Such continuous analogies, though, require corresponding continuities in the space to be controlled—an important condition.

Simplicity and clarity have nothing to do with the *appearance* of controls, but with the clarity and unique locatability of individual parts. For this reason I find deplorable the arrayed controls that are turning up, e.g., on today's audio equipment. Designers seem to think *rows of things* are desirable. On the contrary: the best designed controls I ever used are on the Sony TC-50 pocket tape recorder




but of course this is now phased out; instead most cassette recorders have *five or six* stupid buttons in a row. (Was it too good to last?)

Spurious control elegance comes in many guises. Consider Bruce McCall's description of the Tap-A-Toe Futuroidic Footless De-Clutching™ system. This was offered on the fictitious 1934 Bulgemobiles, and allowed you to drive the car with one pedal, rather than three (see box p. 328).

Careless and horrible designs are not all fictitious. One egregious example also indicates the low level of design currently going into some responding systems: computer people have designed CRT writing systems for newspapers which actually have a "kill" button on the console, by which authors would accidentally kill their stories. In a recent magazine article it was explained that the eventual solution was to change the program so that to kill the story you had to hit the "kill" button *twice.* To me this seems like a beautiful example of what happens when you let insulated technical people design the system for you: a "kill" button on the keyboard is about as intelligent as installing knives on the dashboard of a car, pointing at the passenger.

There is another poor tendency. When computer programmers or other technical people design particular systems without thinking more generally, things are not likely to be either simple or combinable. What may result are intricate user-level controls for one par*ti*cular function, controls that are differently used for another *particular* function, making the two functions not combinable.

What makes for the best control structures, then? There is no simple answer. I would say provisionally that it is a matter of *unified and conspicuous constructs* in the mental view of the domain to be controlled, corresponding to a well-distinguished and clearly-interrelated set of controlling mechanisms. But that is hardly the last word on the subject.

## The Organization of Wholeness

It should be plain that in responding screen-systems, "what happens on the screen" and "how the controls respond" are not really distinguishable. The screen events are *part* of the way the controls respond. The screen functions and control functions merge psychologically.

Now, there is a trap here. Just as the gas pedal, clutch, gearshift and brake merge psychologically, *any* control structure can merge psychologically. Clutch and gearshift do not have, for most of us, clear psychological relevance to the problem of controlled forward motion. Yet we psychologically integrate the use of these mechanisms as a unified means for controlling forward motion (or, like the author, get an Automatic). In much the same way, any system of controls can gradually come through *use* to have a psychological organization, even spuriously. The trap is that we so easily lose sight of arbitrariness and even stupidity of design, and live with it when it could be so much better, because of this psychological melding.

But useful wholeness can be helped along. Just as what I have called the accordance-structure of writing moves it along smoothly, fantic design that builds from a well-organized internal dynamic should confer on a fantic system the same momentum and clarity that carefully-organized writing has.

This contribution of wholeness can only occur, however, if the under-level complications of a system have been carefully streamlined and smoothed back, at least as they affect the user. Consider the design of the JOT text editing system (p. 332): while it is simple *to the user,* computer people often react to it with indignation and anger because it hides what are *to them* the significant features of computer text editing—explicit preoccupation with storage, especially the calling and revision of "blocks." Nevertheless, I say it is the details at this level which must be smoothed back if we are to make systems for regular people.

The same applies to the Th3 system, which is designed to keep the user clear-minded as he compares things in multiple dimensions. The mechanisms at the computer level must be hidden to make this work.

## Fantic Space

Pudovkin and Eisenstein, great Russian movie-makers of the twenties, talked about "filmic space"—the imaginary space that the action *seems* to be in.

This concept extends itself naturally to *fantic space,* the space and relationships sensed by a viewer of any medium, or a user in any presenting or responding environment. The design of computer display systems, then, is really the *artful crafting of fantic space.* Technicalities are subservient to effects. (Indeed, I think computer graphics is really a branch of movie-making.)

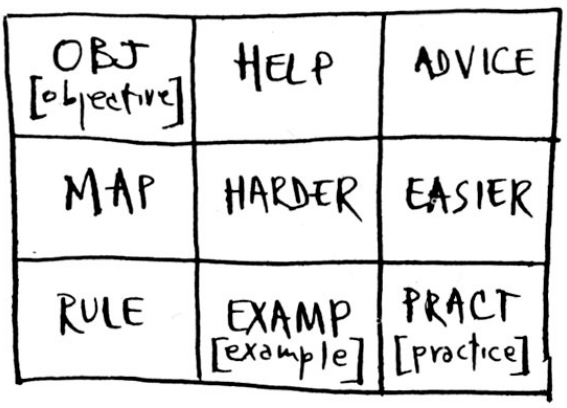


## Fantic Structure

The *fantic structure* of anything, then, consists of its noticeable parts, interconnections, contents and effects.

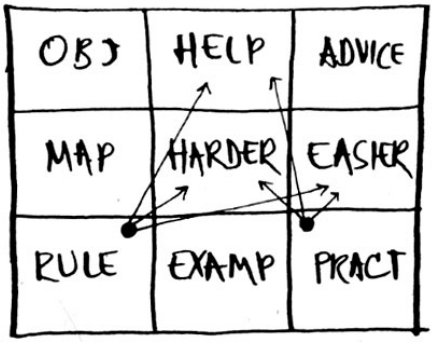
I claim that it is the *fantic unity*—the conceptual and presentational clarity of these things—that makes fantic systems—presentational systems and material—clear and helpful, or not.

Let us take an interesting example from a system for computer-assisted instruction now under implementation. I will not identify or comment on the system because perhaps I do not understand it sufficiently. Anyway, they have an array of student control-buttons that look like this:



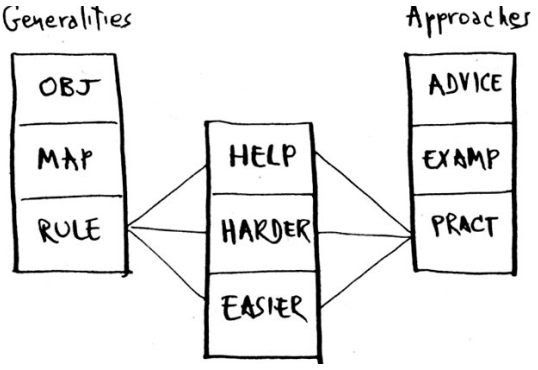
The general thinking in this system seems to be that the student may get an overall organizing view of what he is supposed to be learning (MAP); information on what he is currently supposed to be about (OBJ); canned suggestions based on what he's recently done (ADVICE). Moreover, he can get the system to present a rule about the subject or give him practice; and for either of these he may request easier rules or practice, or harder rules (i.e., more abstruse generalities) or harder practice.

For the latter, the student is supposed to hit RULE or PRACT followed by HELP, HARDER or EASIER, viz.:

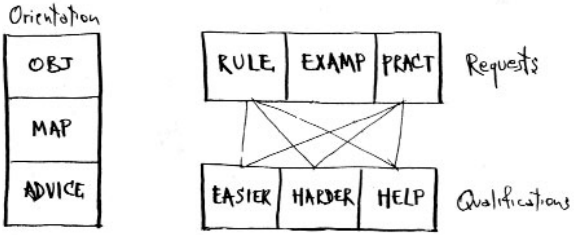



Now regardless of whether this is a well-thought-out way to divide up a subject—I'll be interested to see how it works out—these controls do not seem to be well-arranged for conceptual clarity. It seems to be the old rows-of-buttons approach.

I have no doubt that the people working on this system are certain this is the only possible layout. But consider that the student's options might be clearer to him, for instance, if we set it up as follows:




Or like this:




What I am trying to show here is that merely the *arrangement of buttons* creates different fantic constructs. If you see this, you will recognize that considering all the *other* options we have, designing new media is no small matter. The control structures merge mentally with the presentational structures. The temptation to settle on short-sighted designs having shallow unity is all too great.

## Fantic Design

Fantic design is basically the planning and selection of *effects*. (We could also call these "performance values"—cf. "production values" in movies.)

Some of these intended effects are simply the communication of information or cognitive structure—"information transfer," to use one of the more obtuse phrases current. Other desirable effects include orienting the user and often moving him emotionally, including sometimes overwhelming or entrancing him.

In the design of fantic systems involving automatic response, we have a vast choice among types of presentational techniques, tricks that are just now becoming understood. Not just screen techniques and functions, but also response techniques and functions.

(If "feelie" systems are ever perfected, as in Huxley's *Brave New World*, it's still the same in principle.)

In both general areas, though—*within* media, and *designing* media—it seems to me that the creation of *organizing constructs* is the most profound problem. In particular, the organizing constructs must not distract, or tear up contents. An analogy: in writing, the inventions of the paragraph, chapter and footnote were inventions in writing technique that helped clarify what was being expressed. What we need in computer-based fantic design is inventions which do not artificially chop up, constrain, or interfere with the subject (see box, Procrustes, p. 328).

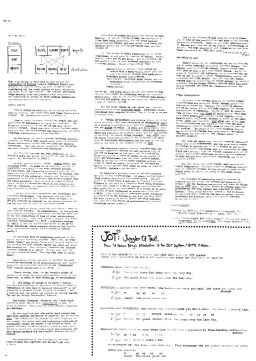
I do not feel these principles are everywhere sufficiently appreciated. For instance, the built-in structures of PLATO disturbs me somewhat in its arbitrariness—and the way its control keys are scattered around.

But there is always something artificial—that is, some form of artifice—in presentation. So the problem is to devise techniques which have elucidating value but do not cut connections or ties or other relationships you want to save. (For this reason I suggest the reader consider "Stretchtext," p. 315) , collateral linkage (p. 330), and the various hypergrams (p. 314-16). These structures, while somewhat arbitrary and artificial, nevertheless can be used to handle a subject gently.)

An important kind of organizing construct is the map or overall orienting diagram. This, too, is often partly "exact" and partly "artifice": certain aspects of the diagram may have unclear import but clear and helpful connotation.

Responding systems now make it possible for such orienting structures to be multidimensional and responding.

Fantic design, then, is the creation either of things to be shown (writing, movie-making, etc.) at the lower end, or media to show things *in,* or environments.



1. The design of things to be shown—whether writing, movie-making, or whatever—is nearly always a combination of some kind of explicit structure—an explanation or planned lesson, or plot of a novel—and a *feeling* that the author can control in varying degrees. The two are deeply intertwined, however.

The author (designer, director, etc.) must think carefully about how to give *organization* to what is being presented. This, too, has both aspects, cognition and feelings.

At the cognitive end, the author must concern himself with detailed exposition or argument, or, in fiction, *plot.* But simply putting appropriate parts together is not enough: the author must use *organizing constructs* to continually orient the reader's (or viewer's) mind. Repeated reference to main concepts, repeated shots (in a movie) of particular locations, serve this function; but each medium presents its own possible devices for this purpose.

The organization of the *feelings* of the work criss-crosses the cognitive; but we can't get into it here.

Selection of points and parts contributes to both aspects. If you are trying to keep the feeling of a thing from being ponderous, you can never include everything you wanted, but must select from among the explicit points and feeling-generators that you have thought of.

2. The design of media themselves, or of media subsystems, is not usually a matter of option. Books, movies, radio and TV are given. But on occasion, as for world's fairs or very personal projects, we have a certain option. Which allows thing like:

- *Smellavision* or whatever they called it: movies with a smell-track, which went out into the theater through odor generators.
- Branching movies.
- "Multi-media" (Multiple audio tracks and simultaneous slide projections on different screens).
- Stereo movies.

And so on. The thing about the ones mentioned is that they are not viable as continuing setups for repeated productions. They do not offer a permanent wide market; they are not stable; they do not catch on. Which is in a way, of course, too bad.

But the great change is just about now. Current technicalities allow *branching media*—especially those associated with computer screens. And it is up to us now to design them.

3. MENTAL ENVIRONMENTS are working places for structured activity. The same principles of showmanship apply to a working environment as to both the *contents* of media and the *design* of media. If media are environments into which packaged materials are brought, structured environments are basically environments where you use *non*-packaged material, or create things yourself. They might also be called "contentless media." The principles of wholeness in structured environments are the same as for the others, and many of our examples refer to *them.*

The branching computer screen, together with the selfsame computer's ability to turn anything *else* on and off as selected by the user, and to fetch up information, yields a realm of option in the design of media and environment that has never existed before. Media we design for screen-based computer systems are going to catch on widely, so we must be far more attentive to the options that exist in order to commit—nationally, perhaps—to the *best*.

In tomorrow's systems, properly unified controls can give us new flexibilities. If deeply well-designed, these promise magnificent new capabilities. For instance, we could allow a musician to "conduct" the performance of his work by a computer-based music synthesis system, perhaps controlling the many qualities of the performance on a screen as he goes, by means of such techniques as dimensional flip. (The tradition of cumulative audio synthesis, as practiced in the fifties by Les Paul and Mary Ford, and more recently by Walter Carlos and Mike Oldfield, will take on a new fillip as multidimensional control techniques become common.)



One of the intents of this book has been to orient you to some of the possibilities and some of the options, considered generally. There is not room, unfortunately, to discuss more than one or two overall possibilities in detail. The most successful such system so far has been PLATO; others could not be listed for lack of space

## New Media to Last

What's worse, we are confronted not merely with the job of using computers to present specific things. The greater task is to design overall computer media that will last us into a more intelligent future. Adrift in a sea of ignorance and confusion, it is nevertheless our duty to try to create a whole transportation system that everybody can climb aboard. For the long run, fantic systems must be treated *not* as custom systems for explicit purposes, but as OVERALL GENERAL DESIGNS WHICH WILL HAVE TO TIE TOGETHER AND CATCH ON, otherwise collapse and perish.

## Final Consequences

It seems to me certain that we are moving toward a generalized and universal Fantic system; people can and should demand it. Perhaps there will be several; but if so, being able to tie them together for smooth transmission is essential. (Think of what it would be like if there were *two kinds of* telephone?) This then is a great search and crusade; to put together truly general media for the future, systems at which we can read, write, learn and visualize, *year after year after year.* The initiatives are not likely to come from the more conventional computer people; some of them are part of the problem. (Be prepared for every possible form of aggressive defensiveness from programmers, especially: "Why would you want that?" The correct answer is BECAUSE, damnit!)

But all this means that interior computer technicalities have to be SUBSERVIENT, and the programmers cannot be allowed to dictate how it is to behave on the basis of the under level structures that are convenient to them. Quite the contrary: from the fullest consideration of the richest upper-level structures we want, *we* the users-to-be must dictate what lower-level structures are to be prepared within.

But this means you, dear reader, must develop the fantic imagination. You must learn to visualize possible uses of computer screens, so you can get on down to the deeper level of how we are going to tie these things together.

The designer of responding computer systems is creating unified setups for viewing and manipulating things—*and* the feelings, impressions and sense of things that go with them. Our goal should be nothing less than REPRESENTING THE TRUE CONTENT AND STRUCTURE OF HUMAN THOUGHT. (Yes, Dream Machines indeed.) But it should be something more: enabling the mind to weigh, pursue, synthesize and evaluate ideas for a better tomorrow. Or for any at all.

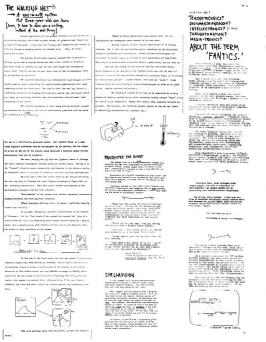
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instead of the real thing.]

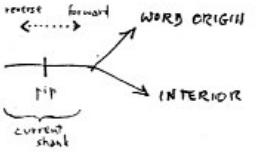
Another application of the present invention is also in the area of pictorial display, but offers a great variety of potential user choices in a simple circumstance. I call this the "walking net" system because control is effected through a changing network of choices which step, or "walk," around the screen.



The problem of intricate computer graphics may be phrased as follows: given that a digital system can hold a wide variety of graphical materials ready to present, how may the user most simply and conveniently choose them? Indeed, how may the user keep track of what is happening, where he is and where he has been?

The external mechanism I have selected for this facility paradoxically combines great versatility for sophisticated presentations with great simplicity before the naïve user. The idea is this: the user may command a continuing succession of changing presentations, making only one simple choice at a time, yet receiving intricate and rich animations with extremely clear continuity on the screen.

The exterior mechanism is this: along with an arbitrary graphic presentation on the screen, the user is continuously presented with the image of a forking set of labeled arrows, e.g.:




The pip is a conventional right-pen cursor. The "current shank" is a line whose implicit gradations control developments in the picture; and the choice of arrows at the end of the current shank determine a discrete choice between alternatives that are to transpire.

The user, seizing the pip with the lightpen, moves it (through the usual lightpen techniques) sideways along the current shank. Moving it in the "forward" direction causes progressive developments in the picture, moving it "backward" causes a reversal of animations and other previous developments.

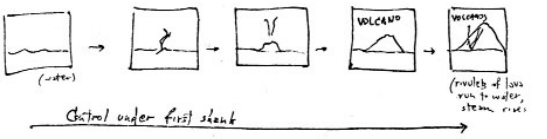
When the pip reaches the choice point in the forward direction, the user may drag it (through the usual lightpen techniques) along either of the beckoning alternatives. This then causes further developments in the presentation consonant with the line selected.

"Developments" of the picture here include expansion, contraction, sliding movements and frame-by-frame animation.

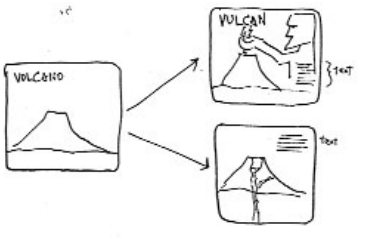
(These materials will have been, of course, explicitly input by authors and artists.)

In a sample employment, consider a presentation on the subject of volcanoes. Let the first shank of the control net control the "rise of a volcano from the sea"—an undulating ocean surface pierced first by a wisp of smoke, then a growing peak, with rivulets of lava seen to run down its sides and darken as they contribute to its growth.

At the end of the first shank, the user may branch to two arrows, labeled respectively WORD ORIGIN and INTERIOR. Either option continues the presentation without a break, retaining much of the picture




on the screen. Selection of WORD ORIGIN causes the word VOLCANO to change to VULCAN, and a picture of the god Vulcan is seen to seize a lightning bolt rising from the crater; text appears to explain this. Alternatively, if the user chooses INTERIOR, the tubes and ducts within the volcano appear, and explanatory text also.



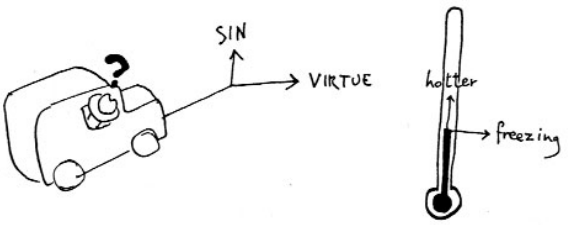
(The path unchosen fades from the screen, as does the previous shank.)

Either of these alternatives may continue with its own developments and animations under the control of its own shank.

Several features of this control application are of special interest. One is that the presentation may be continuous in all directions, aiding in continuous user orientation. Another is that presentations are reversible in various ways, an aid both in user orientation and self-study. (Not only is a demonstration reversible within a given shank, but the user may back the pip through an intersection into the antecedent shank—which reappears at the juncture as the lightpen backs up—and the user may continue to reverse the presentation through that preceding shank, or to re-enter the intersection and make another choice, "the path not taken.") These features allow the user clearly to repeat demonstrations as often as he likes and to explore numerous alternatives.



The displayed control net is thus to be understood as a large network of choices, mostly unseen, whose currently visible portion "walks" around the screen as use progresses. Within this system, then, numerous variants are possible. For instance, the currently visible portion of the net may itself be whimsically incorporated in a picture, viz.:




## PROCRUSTES THE GIANT

The Greeks told of a giant named Procrustes (rhymes with Rusty's) who was very hospitable to passing travelers. He would invite, indeed compel them, to sleep in his bed. Unfortunately, because it was a very odd bed, he had to cut them up first . . .

Procrustes has haunted conversations ever since; and any time we are forced to use categories that don't properly fit a subject, it seems like an invitation to the Procrustean bed.

Hypertext systems at last offer total freedom from arbitrary categorizing and chopping; but in *some* systems for storing and presenting information, I can't help hearing the whisk of Procrustes's knife—

> "Take new Tap-A-Toe Futuroidic Footless De-Clutching. Instead of old-fashioned gas, brake and clutch pedals that kept your feet busier than a dance marathon, Tap-A-Toe Futuroidic Footless De-Clutching offers the convenience of Single Pedal Power Control—combines *all foot functions* in one single pedal!
>
> "Think of it: one tap—you go, moving off faster than a barfly after Repeal.
>
> "Two taps—you change gears, as smooth and automatic as a mortgage foreclosure.
>
> "Three taps—you stop quicker than the U.S. economy.
>
> "And that's all there is to it. Tap-A-Toe Futuroidic Footless De-Clutching with Single Pedal Control is as easy and effortless as the Jap march on Manchuria!"
>
> Bruce McCall,
> "1934 Bulgemobile Brochure,"
> *National Lampoon,* May 74, 76–7.

## STELLAVISION

A nice example of a unified presentational system would allow you a "feelie" glove along with your computer display—the sort of thing Mike Noll has been doing at Bell Labs.

Now, suppose you are playing with a diagram of a star on a computer display screen. It's all very well to see its layers, flowing arrows representing convection currents, promontories and so on—but some things you ought to be able to *feel*. For example, the mechanical resonance-properties of stars. It would be nice to be able to reach and *grasp* the star, to *squeeze* it and feel its pulsations as it regains its shape. This could be done in the glove—at the same time the *image* of the glove grasps the star on the screen, and the star is squished.

Of course, to build such a responding glove, particularly one that gave you subtle feelings back in your fingers, would probably be very expensive. But it's the kind of possibility people should start considering.




First of all, I feel that very few people understand what interactive computer systems are *about*. It's like the story of the blind man and the elephant—each thinks it's a different thing (based, usually, on his own technical specialty).

But I think it's all show business. PENNY ARCADES are the model for interactive computer systems, not classrooms or libraries or imaginary robot playmates. And computer graphics is an intricate branch of movie-making.

Okay, so I wanted a term that would connote, in the most general sense, the showmanship of ideas and feelings—whether or not handled by machine.

I derive "fantics" from the Greek words "phainein" (show) and its derivative "phantastein" (present to the eye or mind).

You will of course recognize its cousins *fantastic, fantasy, phantom.* ("Phantom" means *what is shown;* in medical illustration it refers to an opaque object drawn as transparent; a "phantom limb" is an amputee's temporary feeling that the severed limb has been restored.) And a fantast is a dreamer.

The word "fantics" would thus include the showing of anything (and thus writing and theater), which is more or less what I intended. The term is also intended to cover the tactics of conveying ideas and impressions, especially with showmanship and presentational techniques, organizing constructs, and fundamental structures underlying presentational systems.

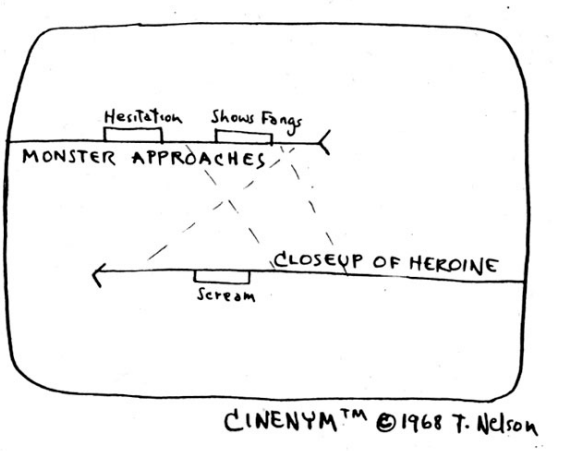
Thus Engelbart's data hierarchy, SKETCHPAD's Constraints, and PLATO's fantic spaces are fantic constructions that need to be understood if we are to understand these systems and their potential usages.

> Livermore Labs, those hydrogen-bomb design people, will have a "Laboratory for Data Analysis," an opulent facility for experimenting with multidimensional visualization.
>
> One of your jolly ironies. I have seen pictures of beautiful multibutton control handles which were designed for project SMASH, would you believe Southeast [Asia] Multisensory Armament System for Helicopters. Aargh.
>
> The best with the worst.
>
> Everything is deeply intertwingled.

Designing screen systems that focus the user's thought on his work, with helpful visualizations and no distractions, is the great task of fantic design.

In a system I designed for CRT motion-picture editing, the user could manipulate written descriptions on the screen (corresponding to the usual yellow-pad notes). To see the consequences of a particular splice, for instance, the editor would only have to draw a line between two annotated lines representing shots. Trim variations could be seen by moving this cut-line (illustrated).






Not long after, CBS and Memorex *did* introduce a system for movie editing by CRT—but I've heard that in their system the user has to actually deal with numbers. If so, this is missing the whole point.

# *THINKERTOYS*

Our greatest problems involve thinking and the visualization of complexity.

By "Thinkertoy" I mean, first of all, a system to help people think. ('Toy' means it should be easy and fun to use.) This is the same general idea for which Engelbart, for instance, uses the term "augmentation of intellect."

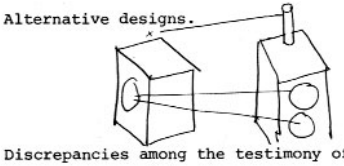
But a Thinkertoy is something quite specific: I define it as a computer display system that *helps you envision complex alternatives.*

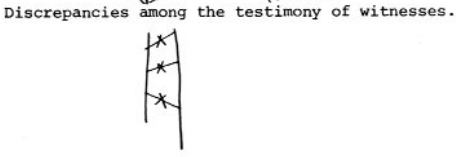
The process of envisioning complex alternatives is by no means the only important form of human thought; but it is essential to making decisions, designing, planning, writing, weighing alternate theories, considering alternate forms of legislation, doing scholarly research, and so on. It is also complicated enough that, in solving it, we may solve simpler problems as well.

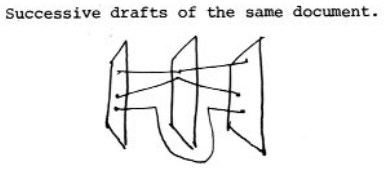


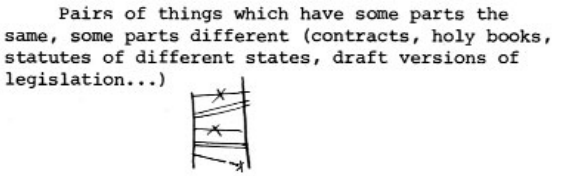
We will stress here some of the uses of these systems for handling *text,* partly because I think these are rather interesting, and partly because the complexity and subtlety of this problem has got to be better understood: the written word is nothing less than the tracks left by the mind, and so we are really talking about screen systems for handling ideas, in all their complexity.

Numerous types of complex things have to be inter-compared, and their relations inter-comprehended. Here are a few of the many types:

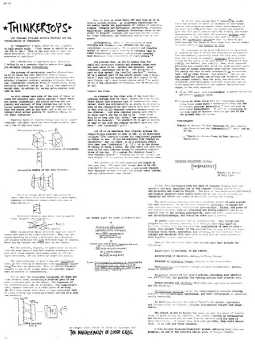


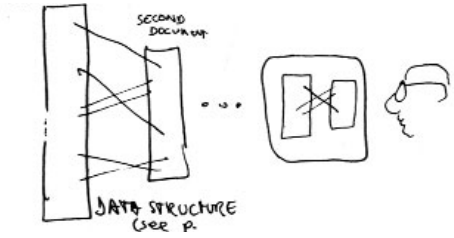

Under examination these different types of inter-comparison seem to be rather different. Now, one approach would be to create a different data structure and viewing technique for *each* different type of complex. There may be reasons for doing that in the future.




For the present, however, it makes sense to try to find the most general possible viewing technique: one that will allow complex intercomparisons of all the types mentioned, and any others we might run across.

One such technique is what I now call *collateration,* or the linking of materials into *collateral structures,** as will be explained. This is fairly straightforward if you think enough about the problem; Engelbart discovered it independently.

Let us call two structures *collateral* if there are links between them, connecting a selected part of one with a selected part of the other. The sequences of the connected parts may be different. For simplicity's sake, suppose each one is a short piece of writing. (We will also assume that there is some convenient form of rapid viewing and following between one end of a link and another.)



Now, it will be noted first off that this is an extremely general method. By collateral structuring we can easily handle the equivalents of: tables of contents; indexes; comments and marginalia; explanations, exegesis, explication; labeling; headings; footnotes; notes by the writer to himself; comments and questions by the reader for later reference; and additional details out of sequence.

*Collateration,* then, is the creation of such multiple and viewable links BETWEEN ANY TWO DATA STRUCTURES, in principle. It is general and powerful enough to handle a great variety of possible uses in human intellectual endeavor, and deserves considerable attention from researchers of every stripe.**

The problem then, is how to handle this for rapid and convenient viewing and whatever other work the user wants to do—writing and splicing, inter-comparing, annotating and so on. Two solutions appear on this spread: The Parallel Textface™, designed as a seminal part of the Xanadu system (see p. 335), which I hope will be marketed with that system in the near future, and a more recent design which I've worked on at the University of Illinois, the 3D Thinkertoy or Th3.

## Clarity and Power

We stressed on the other side of the book that computer systems must be clear, simple and easy to use. Where things like business uses of computers are concerned, which are intrinsically so simple in principle, some of the complications that people have been forced to deal with in ill-designed computer systems verge on the criminal. (But some computer people want others to think that's the way it has to be. "Your first duty is to keep your job, right?" one computer person said to me recently. "It wouldn't do to set up systems so easy to use that the company wouldn't need you anymore.")

But if it is desirable that computer systems for *simple-minded* purposes be easy to use, it is *absolutely necessary* that computer systems for *complicated* purposes be simple to use. If you are wrangling over complex alternatives—say, in chess, or in a political simulation game, or in the throes of trying to write a novel, the last thing you will tolerate is for your computer screen to introduce complications of its own. If a system for thinking doesn't make thinking simpler—allowing you to see farther and more deeply—it is useless, to use only the polite term.

But systems can be both powerful and simple at the same time. The myth that things have to be complicated to do anything for you is pernicious rubbish. Well-designed systems can make our mental tasks lighter and our achievements come faster.

It is for this reason that I commend to the reader these two designs of mine: as examples of user-level control and viewing designs—fantic environments, if you will (see p. 317)—that are pruned and tuned to give the user great control over the viewing and cross-consideration of intricate alternatives, *without* complication. I like to believe that both of these, indeed, are *ten-minute systems*—that is when we get them running, the range of uses shown here can be taught to naive users, in *ten minutes or less.*

It is because of my heartfelt belief in this kind of simplicity that I stress the creation of prefabricated environments, carefully tuned for easy use, rather than the creation of computer *languages* which must be learnt by the user, as do such people as Engelbart and DeFanti.

Now, their approach obviously has considerable merit for sophisticated users who want to tinker repeatedly with variant approaches. For people who want to work incessantly *in* an environment, and *on* other things—say writers—and are absent-minded and clumsy and nervous and forgetful (like the present author), then the safe, prefabricated environment, with thoroughly fail-safe functions and utterly memorable structural and control interrelationships, is the only approach.



*In my 1965 paper (see bibliography) I called collateral structures *zippered lists.* [included in this volume (◊11)]

** A group at Brown University has reportedly worked along these lines since I worked with them, but due to certain personal animosities I have not kept up with their developments. It will be interesting to see what kind of response they can get out of the IBM systems they are using.

Bibliography

Theodor H. Nelson, "A File Structure for the Complex, the Changing and the Indeterminate." Proc. ACM 65, 84–100.

_____, "Simplicity Versus Power in User Systems." Unpublished.

## Decision/Creativity Systems [Thinkertoys]

Theodor H. Nelson
19 July 1970

It has been recognized from the dawn of computer display that the grandest and most important use of the computer display should be to aid decisions and creative thought. The work of Ivan Sutherland (SKETCHPAD) and Douglas Engelbart have really shown how we, may use the display to visualize and effect out creative decisions swiftly and vividly.

For some reason, however, the most important aspect of such systems has been neglected. We do not make important decisions, we should not make delicate decisions, serially and irreversibly. Rather, the power of the computer display (and its computing and filing support) must be so crafted that we may develop alternatives, spin out their complications and interrelationships, and visualize these upon a screen.



No system could do this for us automatically. What design and programming can create, however, is a facility that will allow us to list, sketch, link and annotate the complexities we seek to understand, then present "views" of the complexities in many different forms. Studying these views, annotating and refining, we can reach the final designs and decisions with much more in mind than we could otherwise hold together in the imagination.

Some of the facilities that such systems must have include the following:

*Annotations* to anything, to any remove.

*Alternatives* of decision, design, writing, theory.

*Unlinked or irregular pieces,* hanging as the user wishes.

*Multicoupling,* or complex linkage, between alternatives, annotations or whatever.

*Historical filing* of the user's actions, including each addition and modification, and possibly the viewing actions that preceded them.

*Frozen moments and versions,* which the user may hold as memorable for his thinking.

*Evolutionary coupling,* where the correspondences between evolving versions are automatically maintained, and their differences or relations easily annotated.

In addition, designs for screen "views," the motion, appearance and disappearance of elements, require considerable thought and imagination.




Here's how simple it is to create and edit text with the JOT system. Since your typewriter is now a JOT machine, not every key does what it used to. [When Nelson wrote much "word processing" was through modified typewriters, wihtout graphic displays—eds.]

*CREATING TEXT: just type it in.*
You type: The quick brown fox jumps over the lazy dog.
It types: The quick brown fox jumps over the lazy dog.

*REVIEWING A SENTENCE YOU JUST TYPED: the back-arrow takes you back, the space bar steps you through.*

| | | | | | |
|---|---|---|---|---|---|
| You type: | ← | sp | sp | sp | sp |
| It types: | (bell) | The | quick | brown | fox |

*DELETIONS AND INSERTIONS: the RUBOUT key rejects words you don't want. To insert, merely type.*

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| You type: | ← | sp | sp | RUBOUT | lithe | sp | sp | sp | sp | sp | sp |
| It types: | (bell) | The | quick | /brown/ | lithe | fox | jumps | over | the | lazy | dog. |

*REARRANGING TEXT: first we make three Cuts in the text, signaled by free-standing exclamation points.*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| You type: | sp | ! | sp | ! | sp | ! | fox |
| It types: | The | ! | quick | ! | lithe | ! | fox |

TO REARRRANGE IT, YOU TYPE: LINE FEED key. This exchanges the two pieces between the cuts.
*CHECK THE RESULTS:*

| | | | | | |
|---|---|---|---|---|---|
| | ← | sp | sp | sp | sp |
| | (bell) | The | lithe | quick | fox |

The object is not to burden the user, or make him aware of complexities in which he has no interest. But almost everyone in intellectual and decision pursuits has at some time an implicit need for some of these facilities. If people knew they were possible, they would demand them. It is time for their creation.

We might also think of them as systems for THE MANAGEMENT OF LOOSE ENDS.

A full-fledged decision/creativity system, embracing both text and graphics, is one of the ultimate design goals of Project XANADU.

## The PARALLEL TEXTFACE™

This user-level system is intended to aid in all forms of writing and scholarship, as well as anywhere else that we need to understand and manipulate complex clusterings of text (i.e., *thought*). It will also work with certain animated graphics.

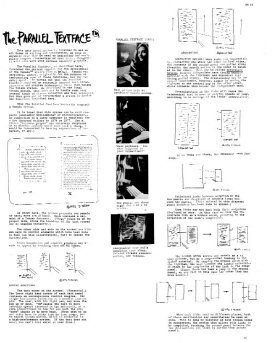
The parallel Textface, as described here, furnished the initial impetus for the development of the Xanadu™ system (see p. 335). Xanadu was developed, indeed, originally for the purpose of implementing some of these functions, but the two split apart. It turned out that the Parallel Textface required an extremely unusual data structure and program techniques; these then became the Xanadu system. As developed in the final Xanadu design, they turn out to handle some very unusual kinds of screen animation and file retrieval. But this grew out of structuring a system to handle the functions described here.

Thus the Parallel Textface basically requires a Xanadu system.

It is hoped that this system can be sold complete (including a minicomputer or microprocessor—no connection to a large computer is required) for a few thousand dollars by 1976 or 1977. (Since "business people" are extremely skeptical as to whether anybody would want such a thing, I would be interested in hearing expressions of interest, if any.)

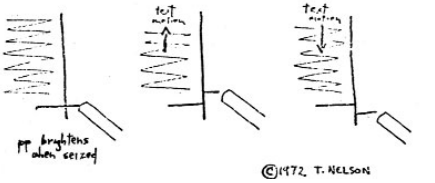
As shown here, the screen presents two panels of text; more are allowed. Each contains a segment of a longer document. ("Page" would be an improper term, since the boundary of the text viewed may be changed instantly.)

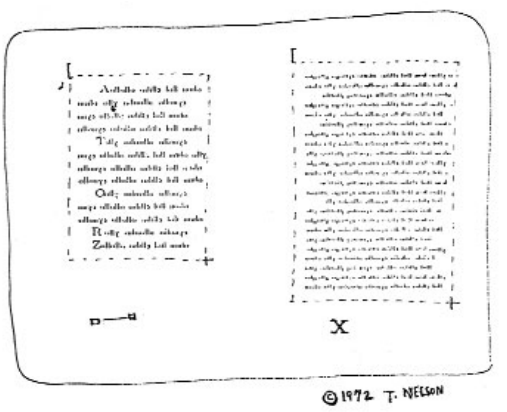




The other odds and ends on the screen are hidden keys to control elements which have been made to fade (in this illustration), just to lessen the distraction.

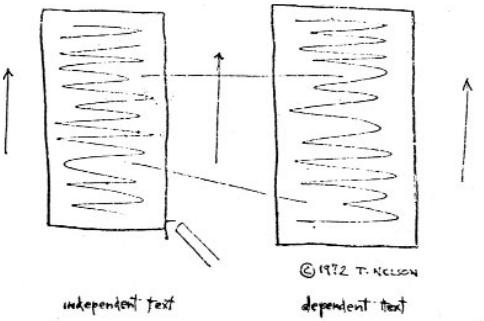
Panel boundaries and control graphics may be made to appear by touching them with the lightpen.




### Roving Functions

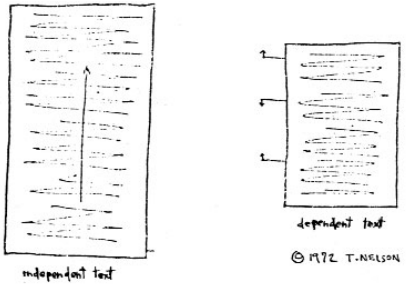
The text moves on the screen! (Essential.) The lower right hand corner of each text panel contains an inconspicuous control diagram. The slight horizontal extension is a movable control pip. The user, with his lightpen, may move the pip up or down. "Up" causes the text to move smoothly upward (forward in the material), at a rate proportional to how far you push the pip; "down" causes it to move back. (Note that we do *not* refer here to jerky line-by-line jumps, but to smooth screen motion, which is essential in a high-performance system. If the text does not move, you can't tell where it came from.)



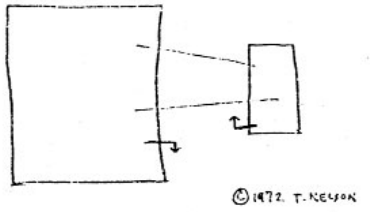

DERIVATIVE MOTION: when links run sequentially, connecting one-after-the-other on both sides, the contents of the second panel are pulled along directly: the smooth motion in one panel is matched in the other. This may be called *derivative motion*, between independent text (being handled directly with the lightpen) and dependent text (being pulled along). The relationship may be reversed immediately, however, simply by moving the lightpen to the control pip of the other panel, whose contents then become the independent text.



Irregularities in the links will cause the independent text to move at varying speeds or jump, according to an average of the links' connectivity.

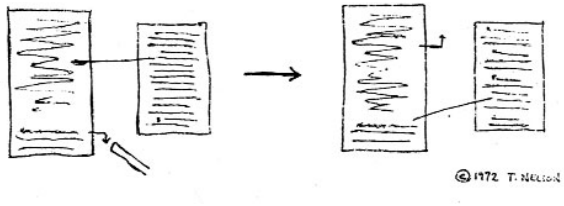



If no links are shown, the dependent text just stops..

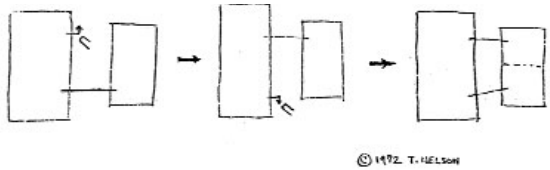



Collateral links between materials in the two panels are displayed as movable lines between the panels. (Text omitted in this diagram; panel boundary has been made to appear.)

Some links may not have both their endpoints displayed at once. In this case we show the incomplete link as a broken arrow, pointing in the direction of the link's completion.




The broken arrow serves not merely as a visual pointer, but as a jump-marker leading to the linked material. By zapping the broken arrow with the lightpen, the user summons the linked material—as shown by the completion of the link to the other panel. (Since there has been a jump in the second panel, we see that in this case the other link has been broken.)




When such links lead to different places, both of these destinations may nevertheless be seen at once. This is done by pointing at both broken links in succession; the system then allows both links to be completed, breaking the second panel between the two destinations (as shown by dotted line across panel).

*Oddly, this has the same logical structure as time-travel in science-fiction.

There are basically three alternative premises of time-travel: 1) that the past cannot be changed, all events having preceded the backstep; 2) that the past *can* be changed; and 3) that while time-travelers may be deluded into thinking (2), that (1) is really the case—leading to various appointment-in-Samarra plots.

Only possibility (2) is of interest here, but there are various alternative logics of mutability and time-line stepping. One of the best I have seen is in *The Man Who Folded Himself* by David Gerrold (Popular Library, 1973): logic expounded pp. 64–8. I am bemused by the parallel between Gerrold's time-controls and these, worked out independently.

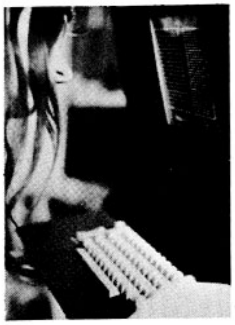
PARALLEL TEXTFACE (1971)



Real person sits at cardboard Xanadu mockup.



"Nice keyboard. But what happened to your typewriter?"



Two panels are about right for a 10 x 10 screen.




Independent text pulls dependent text along. Painted streaks simulate motion, not icicles.



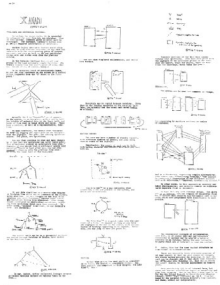



## Fail-Safe and Historical Features

In systems for naive users, it is essential to safeguard the user from his own mistakes. Thus in text systems, commands given in error must be reversible. For instance, Carmody's system requires confirmation of deletions.

Another highly desirable feature would allow the user to view previous versions, to see them collaterally with the corresponding parts of current versions, and even go back to the way particular things were and resume work from the previous version.

In the Parallel Textface this is all comprised in the same extremely simple facility. (Extremely simple from the user's point of view, that is. Inside it is, of course, hairy.)

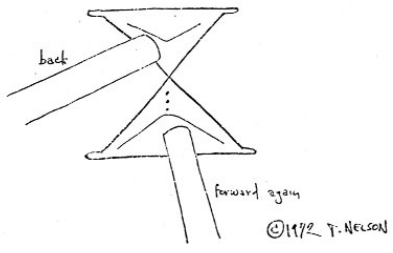


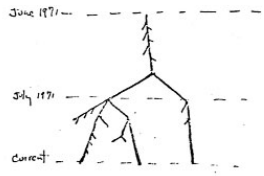
In an egregious touch of narcissistic humor, we use the very trademark on the screen as a control device (expanded from the "X" shown in the first panel).

Actually the X in "Xanadu™," as it appears on the screen, is an hourglass, with a softly falling trickle of animated dots in the lower half, and Sands of Time seen as heaps above and below. These have a control, as well as a representative, function.

TO UNDO SOMETHING, YOU MERELY STEP "BACKWARD IN TIME" by dagging the upper part of the hourglass with the lightpen. One poke, one editing operation undone. Two pokes, two operations.

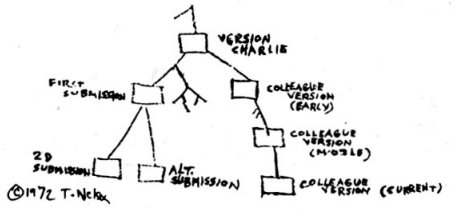
You may then continue to view and make changes as if the last two operations had never taken place. This effectively creates an alternative time-line.* However, *if* you decide that a previously undone edit operation should be kept after all, you may step *forward*—stepping onto the previous time-line—by using the lower half of the hourglass.



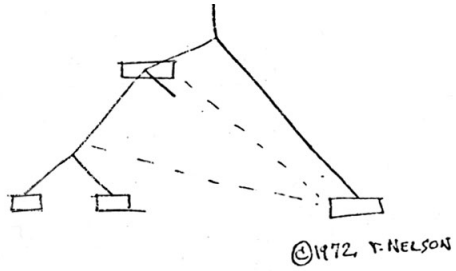

Revision Tree
©1972 T. NELSON

We see this clarified in a master time diagram or Revision Tree which may be summoned to the screen, never mind how. In this example we see that three versions are still "current," various other starts and variations having been abandoned. (The shaggy fronds correspond to short-lived variations, resulting from operations which were then reversed. In other words, "excised" time-lines, to use Gerrold's term—see footnote.)

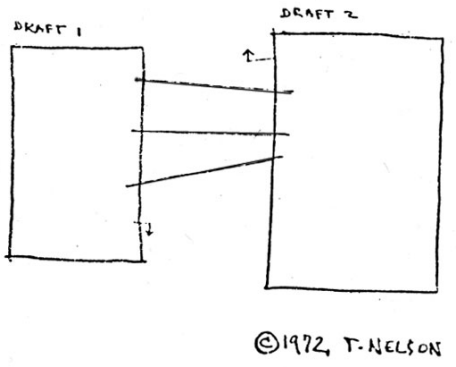




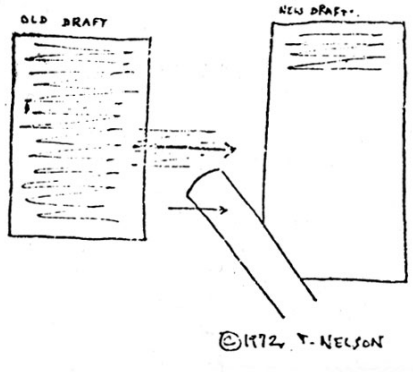

The user—let's say he is a thoughtful writer—may define various Versions or Drafts, here marked on the Revision Tree.



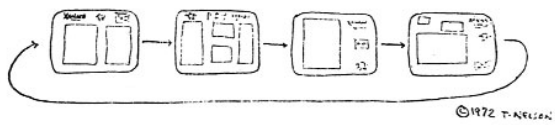

He may, indeed, define collateral linkages between different versions defined at various Times in the Tree . . .




. . . and see them displayed collaterally; and revise them further.



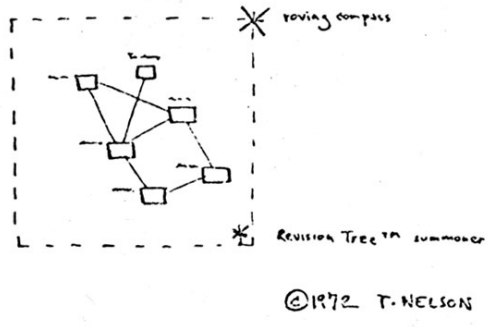

Materials may be copied between versions. (Note that in the copying operation of the Parallel Textface, you actually see the moved text moved *bodily as a block.*)



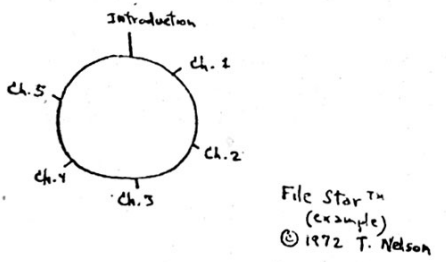

## Getting Around

The user may have a number of standby layouts, with different numbers of panels, and jump among them by stabs of the lightpen.

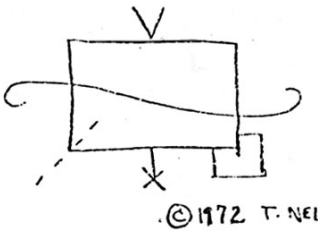
Importantly, *the panels of each can be full,* each having whatever the contents were when you last left it.




The File Web™ is a map indicating what (labeled) files are present in the system, and which are collaterated..

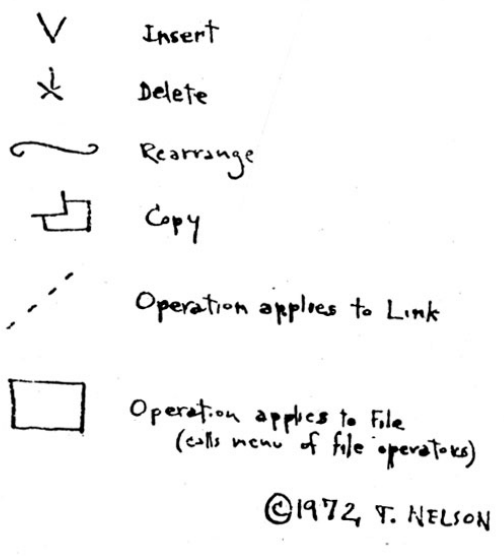



The File Star™ is a quick index into the contents of a file. It expands as long as you hold the lightpen to the dot in the center, with various levels of headings appearing as it expands. Naturally, you may jump to what you point at.

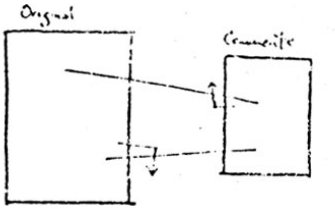



## Editing

Rather than giving the user anything complicated to learn, the system is completely visual. All edit controls are comprised in this diagram, the Edit Rose™. Viz.:

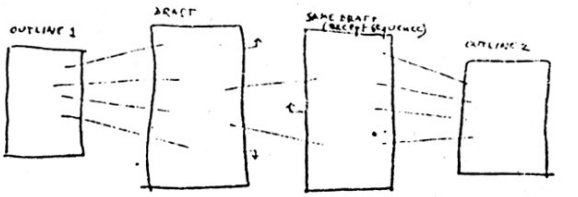



Separate portions of the Edit Rose invoke various edit operations. (You must also point with the lightpen to the necessary points in the text: once for Insert, twice for Delete, three or four times for Rearrange, three times for Copy.)

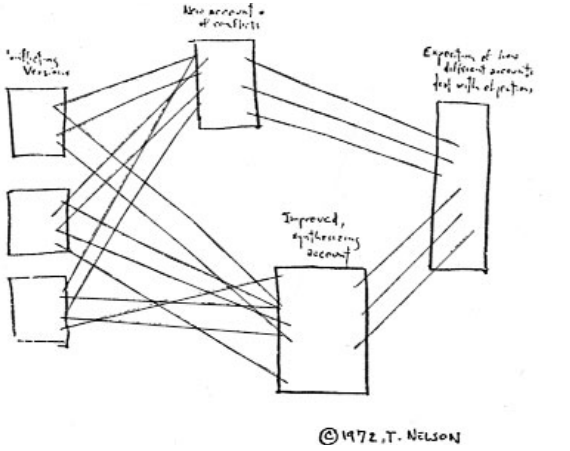



## Generality

The system may be used for comments on things,




for organizing by multiple outlines or tables of contents;




and as a Thinkertoy, organizing complex alternatives. (The labels say: "Conflicting versions," "New account of conflicts," "Exposition of how different accounts deal with objections," "Improved, synthesizing account.")

In other words, in this approach we annotate and label discrepancies, and verbally comment on differences in separate files or documents.

In ways this may seem somewhat obtuse. Yet above all *it is orderly,* and the complex of collateral files has a clarity that could be all-too-easily lost in systems which were programmed more specifically to each problem.

The fundamental strength of collateration, seen here, is of course that any *new* structure collateral to another may be used as a table of contents or an outline, taking the user instantly to parts which are of interest in some new context.

