

# SURFING THE SEA OF STORIES: Riding the Information Revolution

Replacing paper with electronic communication may look like a mere improvement of old tools. It is much more than that. Beneath the surface a revolution is transforming our field and even the way we work together. Twenty-first-century engineering can only reflect our interests if we join the process of shaping our future.

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A revolution is upon us, and it promises to affect us as powerfully as the change from handwritten manuscripts to movable type. The time has come to look at its full sweep, to weigh its implications, and to position ourselves to take our rightful part in it.

Print has been our medium of information exchange for centuries. Papers, reports, and journal articles have served us well for a long time, but now we groan under mountains of paper.

Now, the transition from paper to electronic communication has begun. Most of us already use e-mail. Many of us use library catalogs and periodical indexes on computers. Reference books, handbooks, journals, and con-

ference papers are appearing in electronic form. Soon, many mechanical engineering journals will exist only in that form.

The flexibility of computer communications is creating new information sources. Researchers are sharing their data in computer data banks. Thousands of informal computer discussion groups deal with topics from dairy science to astronomy. During our careers, the ways we talk to one another will change beyond recognition.

What is the scope of the revolution and how do we ride it? Let us begin by looking at our overloaded print communications and the texture of their electronic replacements. Then we will explore the problems and opportunities we face as we join this remarkable change in human affairs and mold it to fit our needs.

## The Mountain of Paper

Change has come not a moment too soon. There are too many journals, papers, and reports for engineers to keep up with. For practicing engineers the task is becoming impossible. Individuals and companies cannot begin to buy, store, or even find what they need. Universities cannot afford so many journals. Library buildings can no longer hold all that paper.

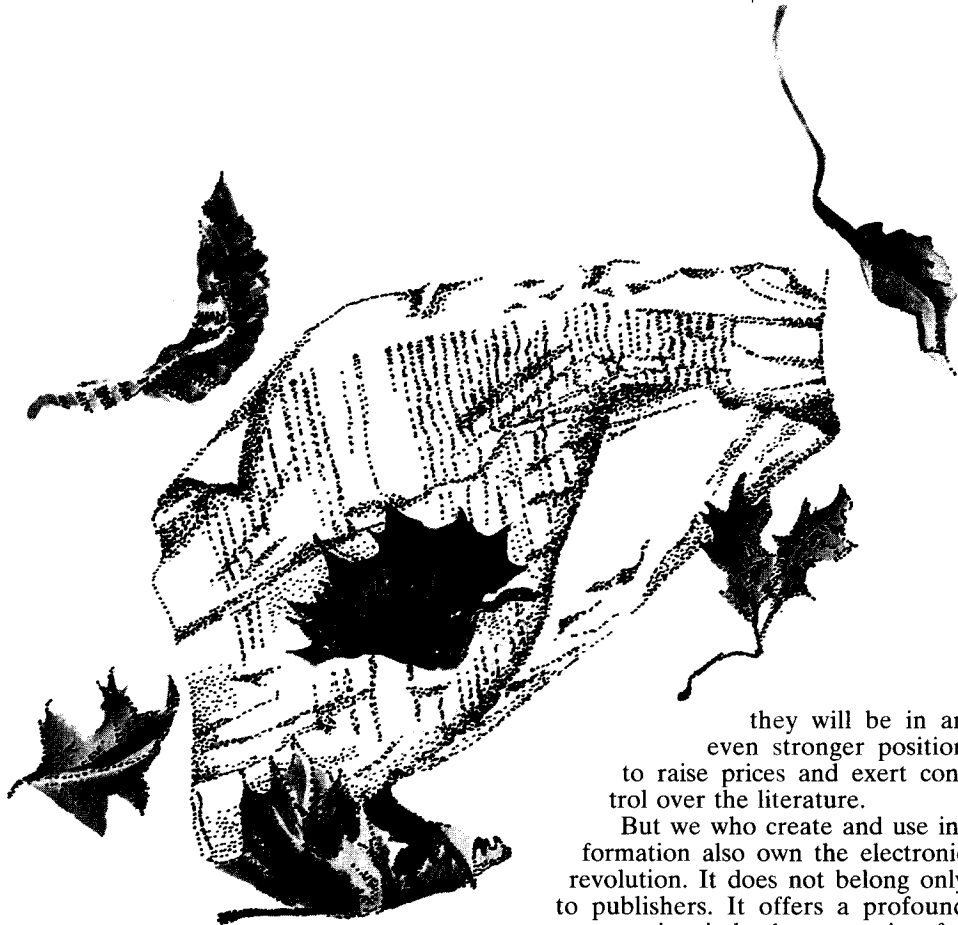
As paper proliferates, the bad conceals the good. G.K. Chesterton's

sleuth, Father Brown, once asked his assistant, "Where would a wise man hide a leaf?" The answer, of course, was, "In a forest." So we hide ideas in the vast forest of our writings. Now our journal papers are isolated from one another by their own great numbers. When there is too much material to chase, we solve the problem by forgetting what others, and even we, have done. The sheer mass of paper is so great that it is becoming unusable.

For example, in 1983 John H. Lienhard heard a paper on the behavior of annular jets in a session at an ASME meeting. It duplicated work he and a student had done a few years earlier. They did not submit that work because they found a Russian had done the analysis before them. After the session, Lienhard



Illustrations by Maria Zsigmond-Baca



wrote and pointed out the prior publication. Yet a few months later the new paper appeared in print without reference to the Russian, whose paper had appeared too long ago and far away to be remembered.

This story is all too familiar. We continue to forget and then replicate. The electronic media offer remedies, including better means for accessing—remembering—our past. Of course, they also promise to expand the sea of information.

We academics have already created far more journals than our professional societies can publish. And the large international publishing houses have accommodated us by starting new journals. We pay more and more to have our work published and distributed. And as publishers move into the new electronic media,

they will be in an even stronger position to raise prices and exert control over the literature.

But we who create and use information also own the electronic revolution. It does not belong only to publishers. It offers a profound opportunity, indeed a necessity, for radical change. The question is, change to what?

#### **A Metaphor for the Future**

In his recent children's book, *Haroun and the Sea of Stories*, Salman Rushdie offers a vision we can apply to 21st-century communications. At one point, a Water Genie tells Haroun about the Ocean of the Streams of Story:

[It] was made up of a thousand thousand thousand...currents, each one a different color, weaving in and out of one another like a liquid tapestry of breathtaking complexity. [Each] colored strand represented and contained a single tale. [The ocean held] all the stories that had ever been told and many that were still in the process of being invented...The Ocean of

the Streams of Story was in fact the biggest library in the universe. And because the stories were held here in fluid form, they retained the ability to change, to become new versions of themselves, to join up with other stories...so that unlike a library of books, the Ocean of the Streams of Story [was] alive. [Here, dip your] cup...you can fill it with water from a single pure Stream of Story...[1]

Rushdie gives a perfect metaphor for what is happening to us. We already swim in new electronic streams. We e-mail ideas back and forth. The streams in this vast ocean of stories really do ebb and flow in various stages of creation and completion.

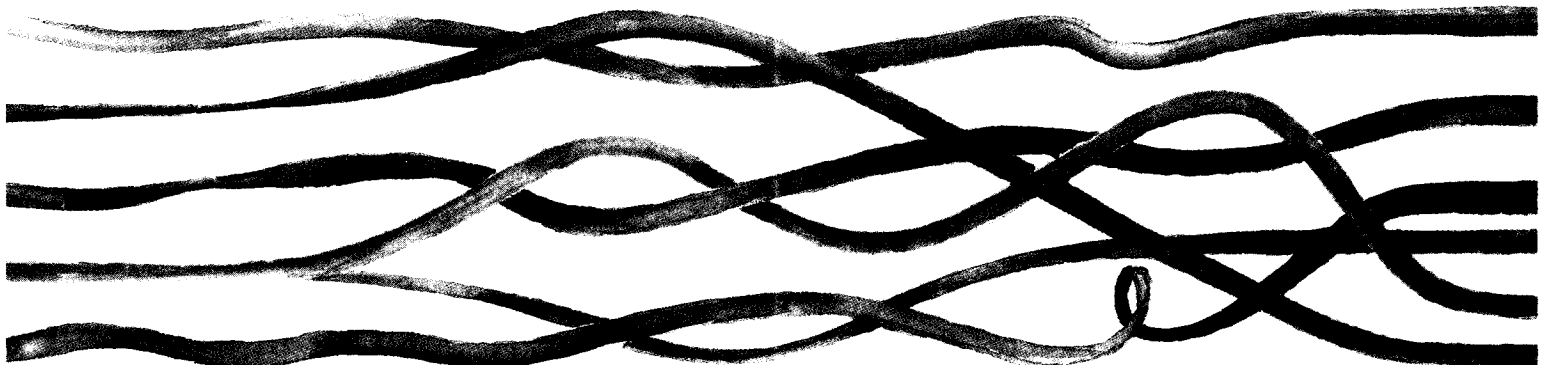
Now our technical literature is poised to plunge into this weaving shifting stream. What new form will it take? How do we begin the process of shaping our future? If we do not seize this opportunity, others surely will.

#### **Creating the Future**

The 3-M Co. (St. Paul, Minn.) was perplexed in 1978. Its new line of yellow Post-it notes had been a huge success within the company. But other firms would not buy them; they could not see the value of Post-its without first using them. 3-M finally gave Post-it pads to companies all over America. Now everyone is hooked [2].

Electronic communications are like that—we have to use them to see their value. With that in mind, we listen as an engineer tells about a morning's work in one of many possible futures:

I sit down at my home computer to check on an article on passive boundary layer control I submitted last week to the *Journal of Fluids Engineering*. Articles in the *JFE* are still peer reviewed, but I posted this new one for public com-



ment during the review period. A reader in India points out a report on torpedo drag published by a Swiss company. A reader in Kansas relates my article to work on fish locomotion and calls my attention to ongoing discussions in an electronic interest group of ichthyologists. I'd better extend my paper. These readers have helped me see my work in a larger context.

I leave the journal and check my e-mail. My news service has selected two articles and four messages from discussion groups. Here's a request from a local class of fourth graders. (I serve as a resource for my city's Free-Net where school-children and interested citizens can talk with faculty members and experts in many fields.) The students ask: "How can dolphins swim so fast?"

I'm not sure whether dolphins use active or passive boundary layer control, so I search the literature for an answer. I follow the trails of authors' citations, calling up any text at will.

I also follow paths that others have traced through the literature, and their comments. Some of these people are anonymous; others have identified themselves. I dip into the current discussions on my topic. I search past records of these discussions. And I scan the Fluid Mechanics Question Bank.

During my session I use information stored on several computers in several locations. ASME is one organization that stores my article and its discussion. It maintains a record of current scholarship in my field and transfers the past record to libraries.

My university provides e-mail and news services. (Similar services are available to companies and individuals.) I have my own copies of important articles, handbooks, and software that lets me add my own notes.

The indexes and texts I consult seem to be provided by my local library, but only a few are located there. My library serves as a gateway to information provided by other libraries.

Such a scenario will occur only if engineering societies and their members join in evolving them. Fortunately, ASME has kept control of its own journals and is ready to work with its members in making a future that serves their needs. In a different future, electronic information might be fragmented and overpriced, as much of it already is.

That is just one reason it is so important for us, the users, to be active participants in creating our future.

Consider what happened a century ago when we created one piece of our present communications technology—and did it badly. A typewriter pioneer designed his keyboard so that salesmen could easily hunt and peck the word "typewriter." He put all those letters on the top row [3].

By the time typing speed became an issue, change was unthinkable. Never mind that the much-used letter "a" lies under our weakest finger and the most-used letter "e" is off the home row. By 1890, today's awkward computer keyboard was determined.

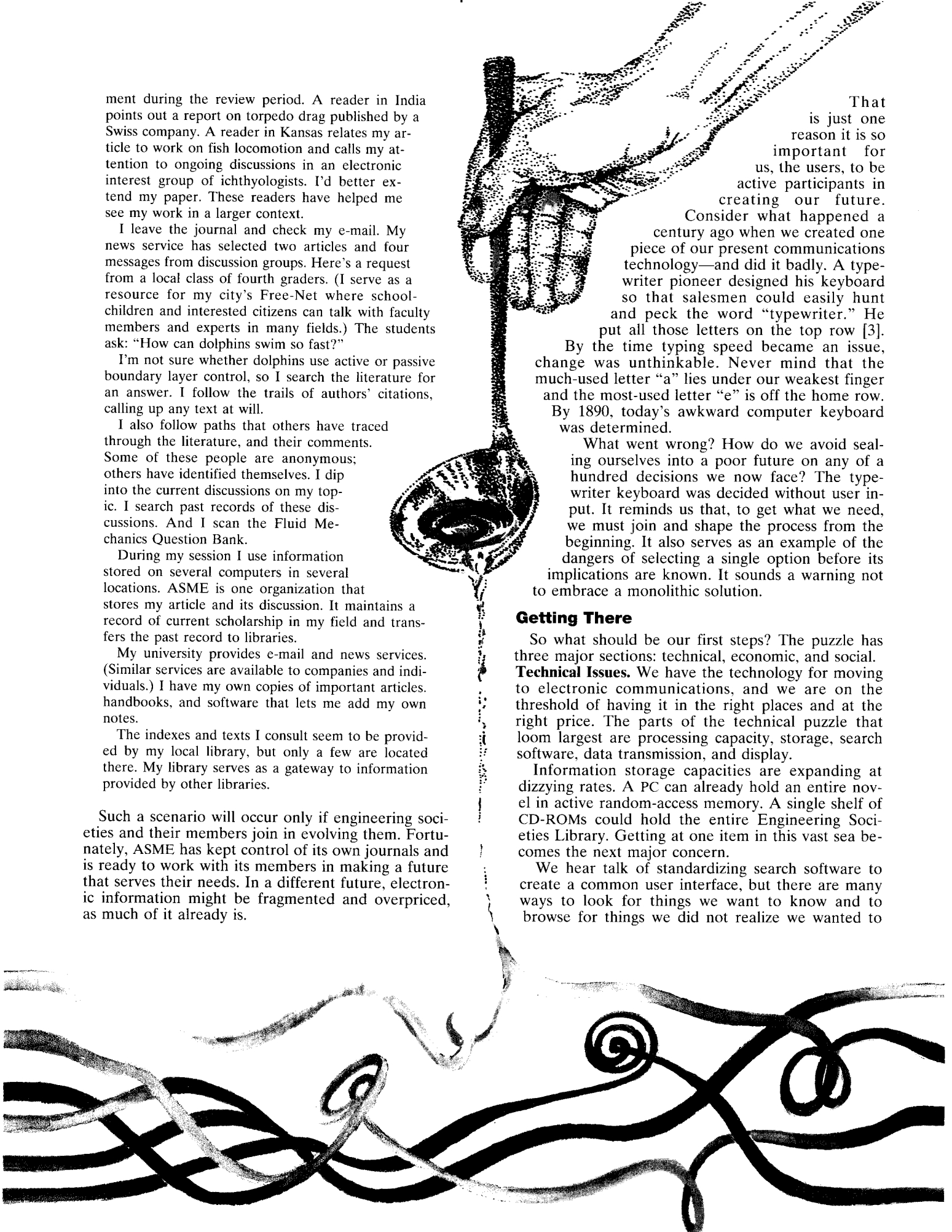
What went wrong? How do we avoid sealing ourselves into a poor future on any of a hundred decisions we now face? The typewriter keyboard was decided without user input. It reminds us that, to get what we need, we must join and shape the process from the beginning. It also serves as an example of the dangers of selecting a single option before its implications are known. It sounds a warning not to embrace a monolithic solution.

### Getting There

So what should be our first steps? The puzzle has three major sections: technical, economic, and social. **Technical Issues.** We have the technology for moving to electronic communications, and we are on the threshold of having it in the right places and at the right price. The parts of the technical puzzle that loom largest are processing capacity, storage, search software, data transmission, and display.

Information storage capacities are expanding at dizzying rates. A PC can already hold an entire novel in active random-access memory. A single shelf of CD-ROMs could hold the entire Engineering Societies Library. Getting at one item in this vast sea becomes the next major concern.

We hear talk of standardizing search software to create a common user interface, but there are many ways to look for things we want to know and to browse for things we did not realize we wanted to



know. Instead of standardizing what the users see and how they interact with it, we should standardize the hooks that connect data to the user interface. That way, we avoid repeating the typewriter scenario by allowing a variety of data base formats and search tools to meet our varying needs.

The electronic highway used by Bitnet and Internet cannot handle a great increase in traffic of full-text files, graphic images, and full-motion video. Fortunately, it should soon undergo an upgrade. The High-Speed Computing Act of 1991, passed by Congress last November, stipulates a new network to replace the U.S. portion of the Internet by 1996. Parts of this new National Research and Educational Network will operate at one gigabit per second. The new network is to connect millions of computer users at colleges, universities, federal laboratories, libraries, hospitals, and businesses in every state. Users will have to bear much of the cost of this expanded system, as we already do with the Internet.

The last step on the technical path of the electronic document is to display it on a terminal. We will have to make decisions and develop software to accomplish this in a world of different display standards for Macintosh, IBM, and Sun computers and for mainframes.

Ideally, a document with both text and graphics would look the same on any display. To accomplish this, we can start with a page markup language, such as T<sub>x</sub> or SGML. These do not look the same on all terminals. But they could be extended to do so.

We can also make a document that will write itself to a variety of terminals, using something like Display PostScript. This gives us graphics- and device-independence, but it is hard to search the text because it has become embedded in the page description language.

Of course we can also treat the display as a pattern of dots. This completely loses the text as text and makes the display very device-dependent. But it is the easiest way to capture existing text with a scanner. University Microfilms International has used this method to distribute the IEEE publications on CD-ROM.

We would find it easier to understand the huge problems of inventing replacements for printed materials if we did not take the technology of books and journals for granted. Those technologies are mature products of an evolutionary process. The features that make books and journals easy to use—legible type, title pages, contents lists, and indexes—evolved over hundreds of years. Now we have the responsibility and the opportunity to reinvent almost everything as we move to an electronic environment.

It is, for example, easy to keep the title page of a book with the rest of the text. The binding takes care of that. But when we photocopy, we copy pages without noting the source. With a document on the computer screen, it is very easy to clip out

a part and save it to a file.

There are several ways to identify the source of this clipping. The clipping can keep the concept of the page and the pages can have footers. Or there can be a layer of information behind the text. A second layer can contain all sorts of organizational structure: sites, dates, versions, and more. It can cause a credit card to be billed when we clip out a section of text (or if we just display it on the screen). What we don't know is which of the possible title page replacements will get to the testing phase or which ones will prevail.

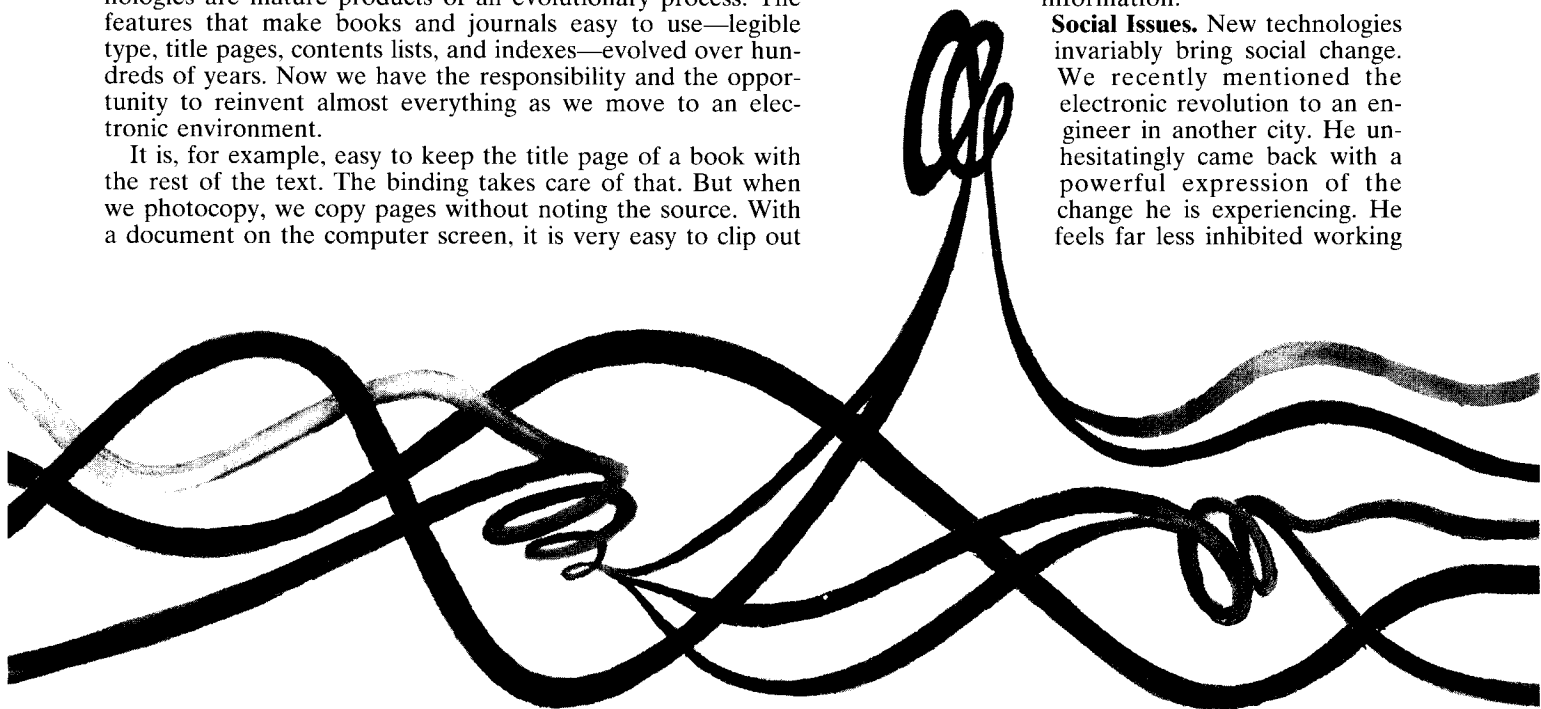
In an electronic environment we will have far more powerful search aids than contents pages and indexes. We will need markers and placeholders to replace our thumb in the book or Post-it notes. To solve these problems, the designers of our future are experimenting with fuzzy-search logic, hyper-text links, and graphic symbols.

**Economic Issues.** Beyond these technical problems lie economic issues of producing, delivering, and charging for electronic publications. Publishers have some of the same interests as authors and users, but they have to be concerned about money and property rights to stay in business.

A group called the Coalition for Networked Information is bringing publishers, librarians, and users together to discuss issues of electronic publishing and ownership of text. The group's very existence highlights a concern. Many players in this game have many interests. We, the users of information, must remain alert or our needs might get lost in the publishers' discussions.

Our engineering societies are our most likely allies. They exist to meet their members' needs and to make the world aware of the field's achievements. For them, revenue is a means of meeting those needs, not an end in itself. Every publisher is concerned about the economic issues of electronic information, but ASME's primary interest is access to engineering information.

**Social Issues.** New technologies invariably bring social change. We recently mentioned the electronic revolution to an engineer in another city. He unhesitatingly came back with a powerful expression of the change he is experiencing. He feels far less inhibited working





on the networks. He is less concerned with saving face. In the networks, he said, people are not under attack and ideas live for their own sake.

This is not an isolated case. By encouraging communal effort, the network is redefining our working mode. Lloyd Trefethen, who created the Fluid Mechanics Question Bank for the computer network, has tried to create a more questioning mode by building a repository of unanswered questions. For a while, people shied away from the Question Bank. As network technologies have improved, the idea is coming into its own. People who were fearful of exposing their ignorance in print speak far more freely over the network [4].

A new working culture is forming around the networks. People who have worked in relative isolation from the technical literature now enter into conversations from which they once felt excluded. Peer structures are being dismantled and recreated even as we write. The electronic communities do not care who

you are. They care only for the quality of your information and your ideas.

We have shaped the print media to Rousseau's 200-year-old observation that science is a form of combat [5]. Journals provided a perfect jousting ground for that combat. The flux and fluidity of the electronic media are far better suited to cooperation and collaboration. They satisfy a hunger in engineers and scientists who are sick of fighting. The change afoot runs far deeper than new forms for old journals. We face change in the very way we work together.

The question of peer review troubles many people. How can we maintain quality when anyone can jump in anywhere, when articles can be changed after they are published, when everything becomes so fluid? Of course peer review can still be applied to a given work. In fact, there are already peer-reviewed journals on the network. The networks also foster new measures of merit, such as endorsements by users.

## Riding the Wave

Many radically different futures are open to us. Electronic communications will not automatically solve our problems. In fact, it might first seem that Rushdie's sea of stories will drown us. But the flood is upon us in any case. The question is not whether to cope with it, but how.

Right now, the only constraints on the evolving electronic medium are its physical ones. The term "electronic journal" does as little to describe this future as the term "horseless carriage" did to capture the promise of the automobile.

We can design a future that offers each of us many more options than we have now. While we cannot see from here exactly what the future will look like, this is the time to debate and come to agree on the elements that are most important to everyone. By this process, we will begin to evolve an information environment that will accommodate our different needs and be a better fit for all of us.

ASME will have to take part in the choice of software and hardware for editing, displaying, storing, searching, and transmitting text and graphics. The highly varied ASME membership must add its voice to this process. We must weigh property rights questions and economic issues in the transition period and for the future.

## Libraries

The electronics revolution is rapidly replacing the kind of printed literature in which we search for answers—handbooks, indexes, and journals. The book is another matter. Books are a superb technology for telling extended stories and making overarching statements. Even when books find some form of electronic expression, printed books will remain a part of our lives.

Libraries as we know them—homes for printed books—will also retain their importance. We shall always need quiet places for study and reflection. Certain physical places will con-



tinue to waken an awe of knowledge.

And so the library experts who organize knowledge in the new medium will retain their kinship with those who do so today. That is an important point as engineers, publishers, librarians, industry, academia, and professional societies all converge upon the new medium.

Information is not self-organizing, and librarians are the ones trained to organize it. But the librarians who take on the new task will need a greatly expanded kit of tools. The word "librarian" will come to include the new designer of indexes. And what is an index? It is a lens with a point of view. Different indexes reveal different cross sections of the huge multidimensional ocean of knowledge. Other new functions will also fall under the old rubric of librarian: guide at the gate of the electronic networks; specialist in the information needs of a new technology; banker of data as well as banker of words.

The word "library" will expand to include a huge variety of new functions. It will include the 24-hour-per-day sources that we call up on a computer screen. It will mean functions with no physical home.

A key question is: How much of the electronic information will be available to libraries? Some of the early purveyors of electronic information are moving from ownership to licensing, giving libraries restricted rights in exchange for continuing payments. Others want to hold their information in a central location and charge for each use. Such designs make libraries unable to provide their basic services of preservation and access for these materials.

We should not assume that electronic information will automatically continue to be preserved and provided by libraries. American libraries are an anomaly. They are the envy of other nations, where access to library stacks is restricted and each photocopy requires payment of a fee. We must work to protect this advantage for the future.



Information is our lifeblood. When Alexander Lyman Holly spoke at the meeting that formed the ASME in 1880, he said the most obvious purpose of the society is "the collection and diffusion of definite and much-needed information, by means of papers and discussions." He added that "the transactions of such societies are now about the only records of our rapidly changing applications of science."

In 1880, the new ASME Transactions was a powerful and important agent of change. That written forum has determined the shape of mechanical engineering today.

Now our forum is about to change beyond all recognition. We are poised to expand knowledge—and our use of it—in ways none of us can yet comprehend. With only a computer and a phone line, we can en-



gage the knowledge of our field wherever we are. The result is an expanded consciousness that brings with it a new sense of community. Change promises to reach beyond information itself and to touch the very way we work together.

We cannot predict the long-term result of these changes. Only by participating in the process can we shape the future to meet our needs. And so, in the end, the quality of our future depends on the degree of daring and intelligence we use as we surf this new sea of stories. ■

### Acknowledgments

For information about the Fluid Mechanics Question Bank, contact L.M. Trefethen by e-mail at QBANK@JADE.TUFTS.EDU.

No discussion of the electronic media can rest primarily on print sources. Our reflections have been informed by ongoing discussions within two electronic interest groups: PACS-L@UHUPVMI.BITNET covers public computer services in libraries and VPIEJ-L@VTVM1.BITNET covers issues related to electronic journals. We've emphasized that the electronic media elicit a new sense of community. We feel that strongly here at the University of Houston. Friends on the computer networks, in the campus and community, and especially members of the University of Houston Library have been wonderfully helpful to us in shaping this commentary.

Edward Tufte, author of "Envisioning Information," used the Rushdie metaphor at the 1992 Clinic on Library Applications of Data Processing, April 5, 1992.

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