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INERTIAL ELECTROSTATIC CONFINEMENT AS A POWER SOURCE FOR ELECTRIC PROPULSION

G.H. Miley, R. Burton*, J. Javedani, Y. Yamamoto, A. Satsangi, Y. Gu, P. Heck,
R. Nebel**, N. Schulze+, J. Christensen, D. Strellis, J. DeMora,
S. Cooper, A. Ochao, J. Fluhrer
University of Illinois
Urbana, IL

ABSTRACT

The potential use of an **INERTIAL ELECTROSTATIC CONFINEMENT** (IEC) power source for space propulsion has previously been suggested by the authors and others. In the past, these discussions have generally followed the charged-particle electric-discharge engine (QED) concept proposed by Bussard, in which the IEC is used to generate an electron beam which vaporizes liquid hydrogen for use as a propellant. However, in the present study, we consider an alternate approach, using the IEC to drive a "conventional" electric thruster unit. This has the advantage of building on the rapidly developing technology for such thrusters, which operate at higher specific impulse. Key issues related to this approach include the continued successful development of the physics and engineering of the IEC unit, as well as the development of efficient step-down dc voltage transformers.

The IEC operates by radial injection of energetic ions into a spherical vessel. A very high ion density is created in a small core region at the center of the vessel, resulting in extremely high fusion power density in the core. Present experiments at the U. of Illinois in small IEC devices (<60-cm. dia.) have demonstrated much of the basic physics underlying this concept, e.g. producing $\sim 10^6$ D-D neutrons/sec steady-state with deuterium gas flow injection. The ultimate goal is to increase the power densities by several orders of magnitude and to convert to D-^{3}He injection. If successful, such an experiment would represent a milestone proof-of-principle device for eventual space power use.

Further discussion of IEC physics and status will be presented with a description of the overall propulsion system and estimated performance.

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* Dept of Aeronautical and Astronautical Engineering, U. of Illinois, Urbana, IL 61801
** Los Alamos National Laboratory, MSF 642, T-15, P.O. Box 1663, Los Alamos, NM 87545
+ NASA Headquarters, Washington, DC 20546

INTRODUCTION

Fusion energy offers an extremely attractive power source for fusion propulsion.[1-3] However, conventional approaches to fusion reactors for terrestrial use employ heavy components, i.e. offer too low a power-to-weight ratio, to be considered for space applications. In addition, in order to reduce neutron and radioactive propellants in space, the use of advanced fuels such as D-^{3}He is desirable. Conventional approaches such as the Tokamak appear marginal for burning such fuels. Consequently, new confinement approaches for space propulsion or power are needed. While several possibilities have been suggested,[4-9] inertial electrostatic confinement (IEC) appears to be one of the most attractive approaches because of ultra-low inert mass and advanced fuel-burning efficiency, as a result of a highly non-Maxwellian energy distribution for reacting ions.[10-12]

A difficulty in projecting the use of the IEC for propulsion is that the experimental data base is inadequate. Thus the extrapolation of design principles to a reactor design contains many uncertainties. Still, it was thought to be worthwhile to carry out the conceptual design study presented here, in order to understand issues that need further study and to illustrate the potential advantages of this approach.

The design goal was to use the IEC as the primary power source propulsion system, capable of making a trip to Mars in less than 120 days. A Direct Electrical Converter (DEC) is used to convert the IEC energy to a megavolt dc current. A unique electrical system transforms this voltage and current to levels required by the thrusters, which use hydrogen propellant to achieve the necessary thrust and specific impulse.

The total weight of the Mars-bound spacecraft is apportioned as follows: 120 metric tons for the propellant and tanks; 120 metric tons for the propulsion system (60% DEC, 15% IEC, 15% electrical system, and 10% thrusters); and 60 metric tons for crew compartment, cargo, and shielding material. To complete the mission in the required time, a specific impulse, I_{sp}, of 3000 seconds is necessary. To achieve this, the five parallel thrusters deliver a mass flow rate of 11.5 g/s and a thrust of 340 N.

The craft is launched from a low Earth orbit. Succeeding sections contain a description of the various subsystems in more detail. An earlier concept for IEC-based propulsion was proposed by R.W. Bussard,[9] who envisioned an advanced electron beam-heated thruster. Here we explore the use of an alternate thruster based on magneto-plasma-dynamic (MPD) and arcjet concepts.

INERTIAL ELECTROSTATIC CONFINEMENT (IEC)

The proposed power source is a fusion system, based on the principles of the IEC, a method of electrostatically confining a fusion plasma first proposed by Salisbury[13] and Farnsworth.[14] Early experimental studies were carried out by Hirsch,[15] but little was done after that until recent experiments at the U. of Illinois.[12, 16-18] The IEC device is spherical and consists of two concentric spherical grids. (Fig. 1) The inner grid, the cathode, is placed at a large negative potential with respect to the outer grid, which is grounded. When small amounts of gas are puffed into the grids, the high electric field ionizes the gas and accelerates the ions towards the center of the device. As these ions converge upon the center, they form a dense core region where fusion can take place. Because of space charge build-up of the ions and electrons in the core region, virtual anodes and cathodes are formed in a spherical potential well structure.[12, 15] This serves to enhance the ion confinement and to produce a very dense center spot where fusion occurs. U. of Illinois experiments have been quite successful to date, achieving a measurement of the potential well during low current operation (20 mA) and also achieving strong (1.2×10^6/sec) 2.45-MeV neutron emission when deuterium fill gas is used. Still, these experiments are 3 to 4 orders of magnitude (in current) below breakeven. Consequently, several key scale-up experiments are needed to confirm the feasibility of this approach. In the discussion below, we examine fundamental IEC design concepts to produce a fusion propulsion system of 21.4 MW.

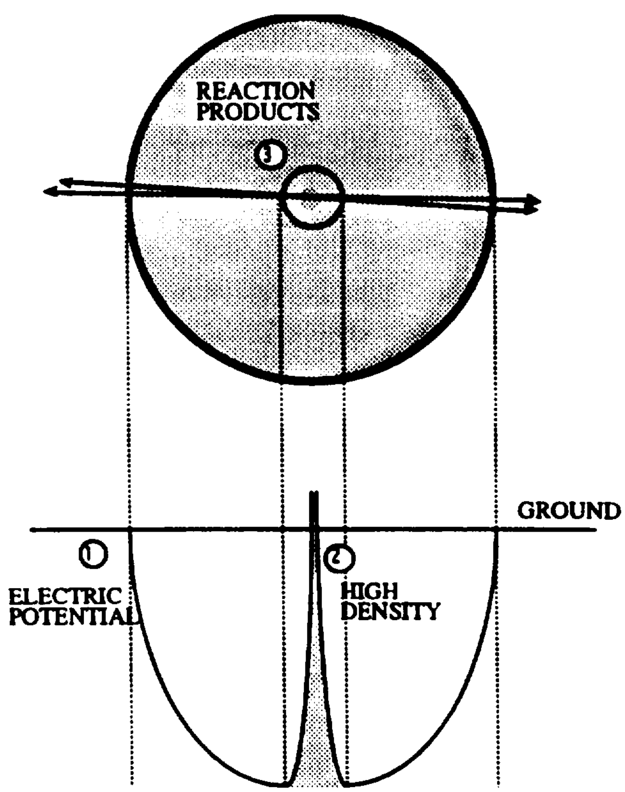


Figure 1. IEC concept

POWER FLOW

The power analysis of the IEC requires an assumption of how the fusion rate scales with current. A graph of the fusion rate scaling is shown in Fig. 2. Calculations are shown for I^5 and also a more pessimistic I^3 scaling to illustrate the range of possibilities. For the final rocket design, I^5 scaling has been chosen. This assumes that a fully-developed potential well structure is achieved.

Figure 2. Scaling laws for IEC with potential wells and (ICC) compression

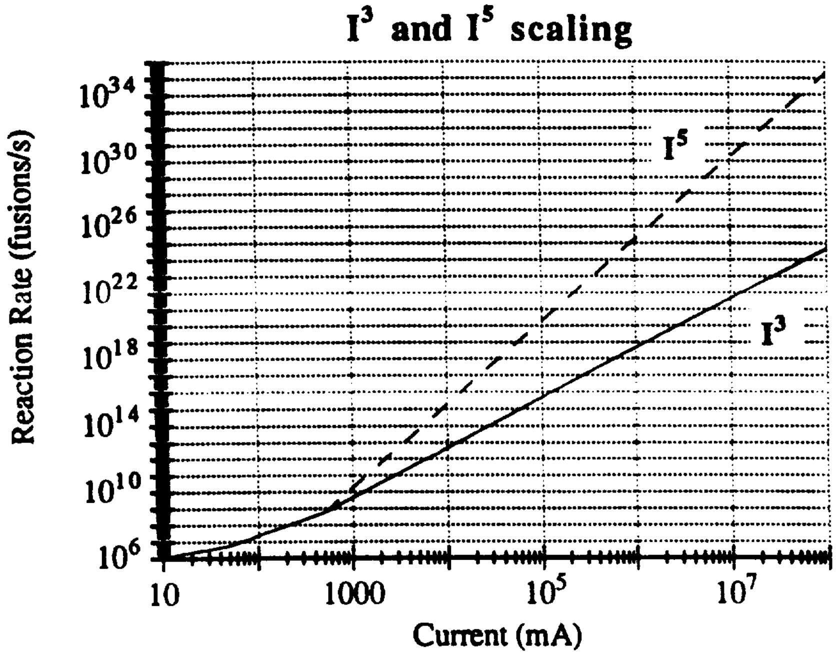


Fig. 3 shows a power flow chart for the overall system, while the specified subsystem parameters are given in Table I. The results of calculations based on these parameters are shown in Table II. An attractive fusion energy gain is predicted, giving 21.4 MW to the DEC with only 4.16 MW of injected power. This design gives a thruster power of 10 MW.

Figure 3. IEC fusion rocket power flow chart

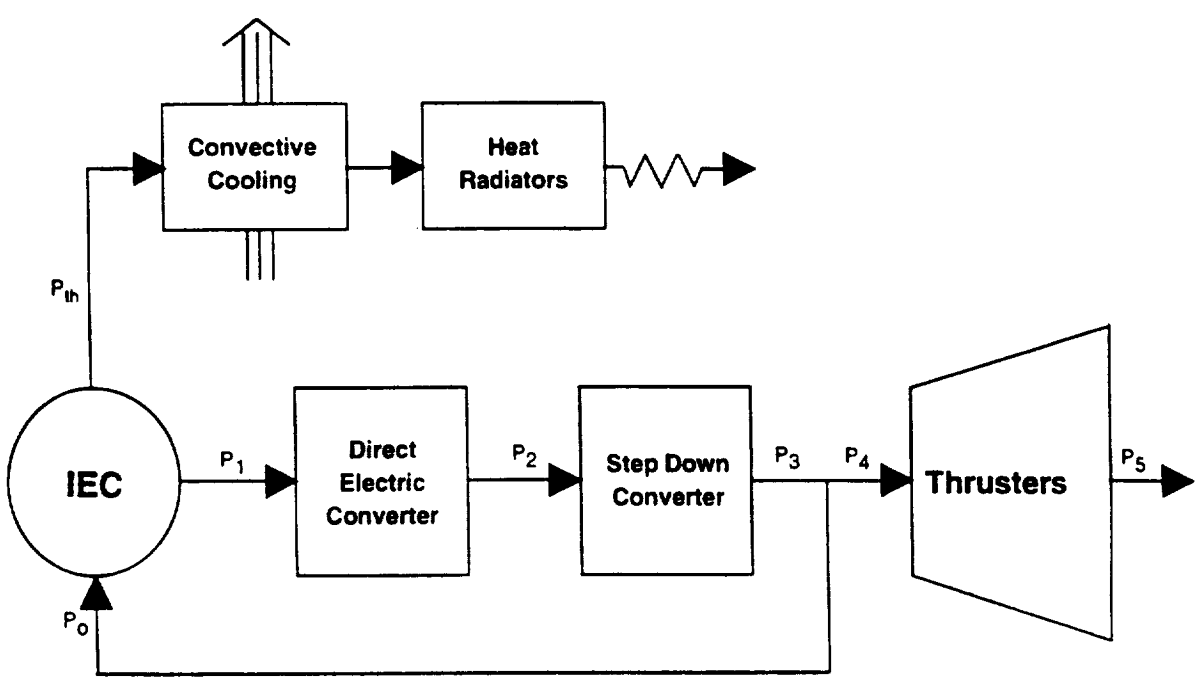


Table I. Estimated efficiencies of various components

COMPONENT	EFFICIENCY
Direct Electric Converter	$\eta_{DEC} = 0.80$
Step-Down Converter	$\eta_{STD} = 0.95$
Thruster	$\eta_{TH} = 0.50$

Table II. Power flows corresponding to Fig. 3

$P_0 = 4.16$ MW	$P_1 = 21.40$ MW
$P_2 = 17.12$ MW	$P_3 = 16.26$ MW
$P_4 = 12.00$ MW	$P_5 = 6.00$ MW
$P_{excess} = 0.104$ MW†	

†P_{excess} is excess power which is available for use for extraneous ship functions such as life support systems, communication devices and experimental research.

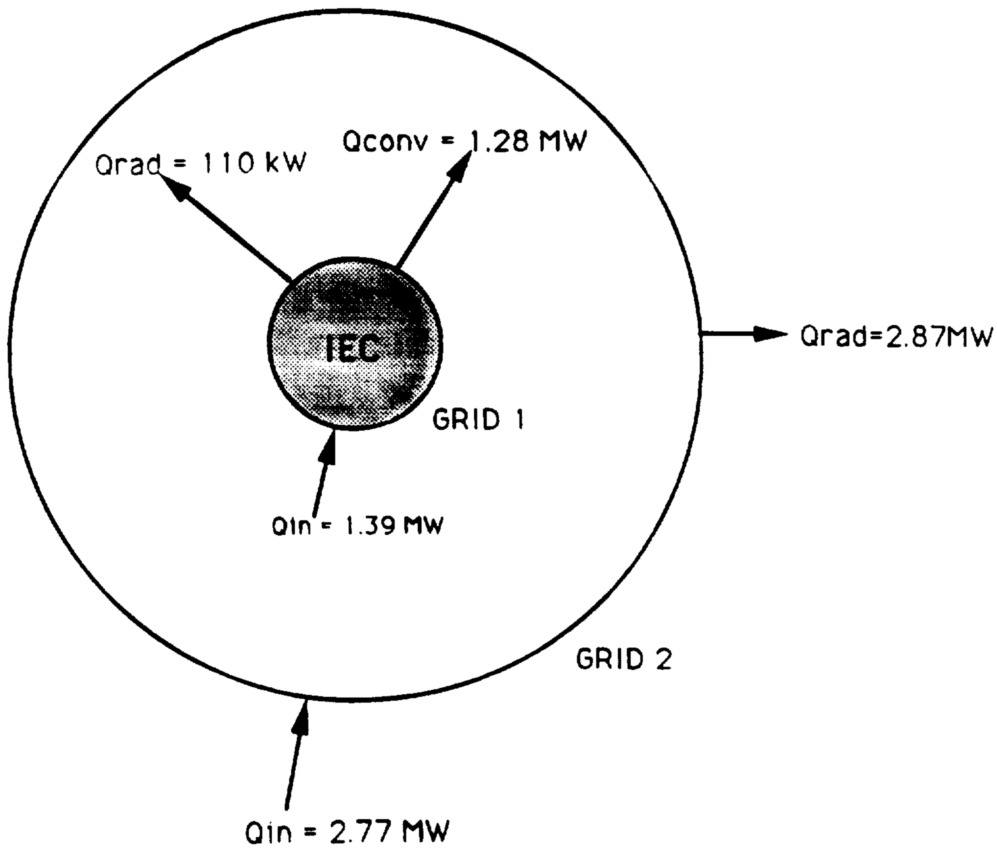
There are several major concerns to be addressed. One is a need to recirculate the fusion fuels, ^3He and deuterium. Only a small fraction of the fuel is actually burned, ~5%, and the rest must either be retained in the system or collected and returned to the IEC. This is especially important for the ^3He because of its high cost. Another concern to be addressed is the accumulation of reaction products, such as tritium, in the IEC core.

GRID HEAT REMOVAL

The IEC grid structure is comprised of a network of equilateral triangles forming a geodesic structure. This structure maintains the electrostatic field necessary for IEC operation. In order to maintain the desired transparency of 95%, the ratio $d/a < 0.0577$ is necessary, where the grid tubing diameter is given by "d" and the length of a triangle side is "a". The grid is constructed of tungsten which melts at 3683 K; the surface temperature of the inner grid will be 2121 K (0.58 T_m).

The radius of the inner grid is $r = 0.75$ m, roughly a minimum value, in view of the strong heating as a result of plasma particles and radiation hitting it. The diameter of the grid tubing is 0.5" (0.0127 m) which yields a triangle side length of $a = 0.722'$ (0.22 m). The heat dissipated to the two IEC grids is determined to be $P_0 = 4.16$ MW. (See Fig. 4) The inner grid will dissipate one-third of this energy while the remainder will be deposited on the outer grid. The outer grid can successfully dissipate its heat by radiative cooling, while the inner grid requires additional forced cooling. The following discussion will focus on the inner-grid heat removal. The total power incident on the inner grid is 1.39 MW. Q_{rad} is calculated to be 110 kW, so the remainder, Q_{conv} = 1.28 MW must be removed by a coolant flowing inside the tubular grid. The cooling system will be closed loop with a separate H_2 tank at 0.01 MPa. The coolant will circulate through the inner grid and dissipate the heat evenly. The total mass flow rate required is 61.4 g/s, and the coolant will leave the grid at 1420 K. The convected coolant will be radiated into space by radiators with a surface area of 200 m^2. The coolant exits the radiators at 300 K.

Figure 4. Heat flow diagram for IEC grids



SHIELDING CONSIDERATIONS

Shielding must be provided for both solar and IEC radiation. Solar radiation consists primarily of protons and heavy ions (Galactic Cosmic Rays), while the IEC radiation consists of neutrons and x-rays.[19] One goal is to keep the crew's exposure to under 47 Rem for the 270 day mission, 3 Rem less than the annual dose limit set for astronauts. The other goal is to minimize the shielding mass, 45 metric tons being the maximum design goal. For solar particle shielding, polyethylene shields of 9-g/cm^2 and 8-g/cm^2 surround the entire crew quarters, a compartment of 10 x 5 x 3 meters. Part of the shielding will be movable in the event of an anomalously large (AL) solar flare. By doubling up some of the polyethylene, a smaller triangular compartment of 2.5 x 2.5 x 3 meters can be constructed. The "storm shield" will then be shielded by a double thickness of polyethylene. Table III shows the radiation doses received for a 270-day mission to Mars. These results are based on 9-g/cm^2 of polyethylene shielding during normal solar activity, and 18-g/cm^2 during the one AL flare expected for the mission. Results are given for both solar minimum and solar maximum conditions. This table also shows the mass of the needed shielding.

Table III. 270-Day Dose from Galactic Cosmic Rays

SOLAR CONDITION	NORMAL DOSE	AL DOSE	OR DOSE	TOTAL DOSE	SHIELD MASS
Maximum	19 Rem	8 Rem	4 Rem	31 Rem	17.1 Metric Tons
Minimum	47 Rem	0 Rem	0 Rem	47 Rem	17.1 Metric Tons

Even though there are no flares expected for periods of solar minimum, the shielding appears to be more than adequate to handle a mission during a period of solar maximum. These periods are fairly easily predicted, as the sun has about an 11-year cycle of sun spot events.

The other area of concern is the IEC radiation. Neutrons will be produced from both D-D and D-T reactions. Calculations indicate a D-D to D-^{3}He reaction rate ratio of 8.69%, giving a D-D reaction rate of 3.475×10^{17}-neutrons/sec. This reaction also produces tritium. We assume that all of the tritium then fuses via D-T reactions, giving a 14.1-MeV neutron. The result is a total neutron source rate of 6.95×10^{17}-n/sec.

The 50-m long hydrogen propellant tanks will provide significant shielding between the IEC and the crew compartment. The hydrogen in the tanks will thermalize the IEC neutrons and allow them to be absorbed before reaching the crew. The resulting flux at 50-m (the length of the propellant tanks) away from the IEC was found to be completely negligible, even at the minimum hydrogen residuals in the tanks at the end of the mission. Therefore, no additional shielding is used between the IEC and the crew.

There are still several issues to be addressed in this analysis. Most of the electronics will have to be protected from radiation. The neutrons going away from the crew, towards the DEC, can easily be moderated and absorbed; and solar radiation can also be shielded against. However, this added shielding has not yet been included in the weight estimates for the craft.

DIRECT ELECTRIC CONVERTER (DEC)

The objective of the DEC is to convert the kinetic energy of the fusion products to electrical current to be used by the thrusters to propel the ship. The direct fusion products of the D + ^{3}He reaction employed in the IEC are a 14.7-MeV proton and a 3.5-MeV alpha particle. Other charged products come from "side" D + D reactions in the form of an 0.8-MeV ^{3}He atom and a 3.1-MeV proton. In addition, a side D + T reaction produces a 3.5-MeV alpha. A "Venetian-blind"-type electrostatic energy converter is employed.[20, 21] Its collectors are charged to a potential slightly below the average energy of the particle to be collected. This design will utilize three separate sets of collector plates. (See Fig. 5.) One will be at a voltage of 1.5 MV to capture the tritium atoms produced through D + D reactions before they fall back into the IEC plasma. Another will be at 3 MV to collect the D + D alpha products. The outer collector will be at 14 MV to collect the D + ^{3}He proton products.

Since the fusion products will be emitted isotropically from the core of the IEC, the DEC will utilize spherical geometry. The 1.5-MV and 3-MV collectors will be nearly perpendicular to the outer spherical surface of the IEC, while the 14-MV collector will be tangent to the outer surface. The orientation of the first two collectors allow the 14-MeV protons to pass these plates and collect on the outermost plate. Thus, the lower potential collectors are highly "transparent" to the 14-MeV proton.

Secondary electrons emitted when the charged particles hit the collector surfaces can result in unwanted leakage currents between the high voltage plates.[20] Electron suppressor grids are employed to prevent this. High voltage breakdown on the surface of the insulators separating the collectors will limit the distances between each successive plate. The suppressors are placed in the "shadow" of the collectors in order to prevent excessive interaction with the high energy ions.

This "Venetian-blind"-type DEC potentially offers a high conversion efficiency.[21] The distance between the 1.5-MV, 3-MV, and 14-MV collectors are limited by the high voltage breakdown field along the surface of the insulator being used. Teflon has been selected as the insulator. A fluted surface-type insulator design has been analyzed, giving the distances between successive plates as indicated in Table IV. Due to the limitations on the size of the rocket, a safety factor of 2 will be the design's goal.

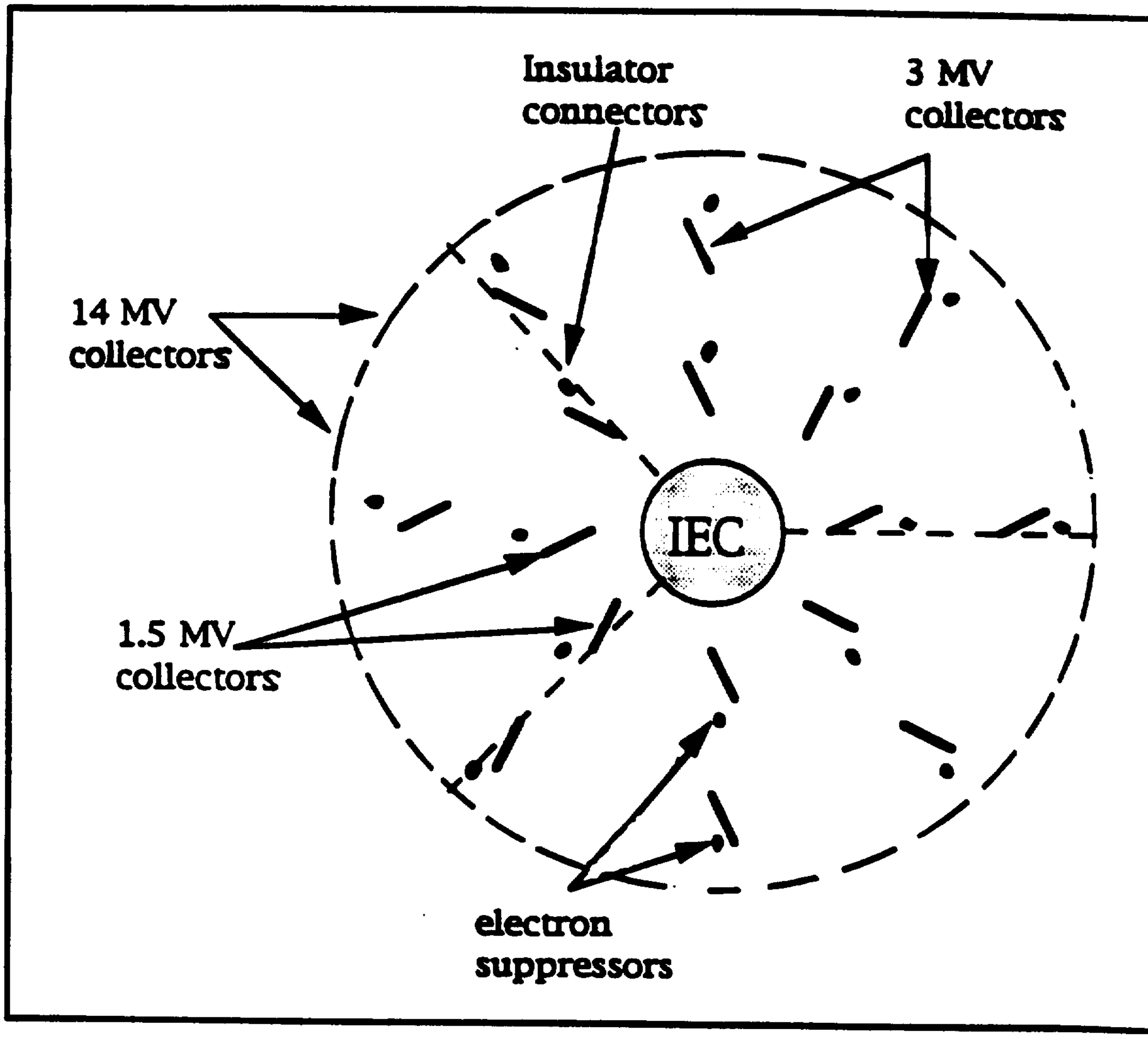
Table IV. Distances between collectors in the DEC‡

FROM COLLECTOR (MV)	TO COLLECTOR (MV)	DISTANCE (cm)
0.0	-0.1	3.3
-0.1	1.5	53.3
1.5	-0.1	53.3
-0.1	3.0	103.3
3.0	-0.1	103.3
-0.1	14.0	407.0

‡Positive potentials signify high energy particle collectors, while negative potentials signify electron suppressors.

The approximate length of each collector plate is 5 cm. Thus, the DEC system will have an outer radius of 754 cm beyond the outer grid of the IEC. This is rather small, considering the IEC has an outer radius of 6 m. Therefore, the IEC and DEC system have a combined radius of 13.5 m.

Figure 5. A cross-sectional view of the DEC outside the IEC. For simplicity, only representative collector plates are shown. A close packed configuration is envisioned for the actual design.



ELECTRICAL CONVERSION SYSTEM

The electricity produced by the DEC must be converted into a form that can be used by the thrusters and also be fed back to the IEC. For this purpose, the 14-MW potential output from the DEC must be converted to 1 kV and ~10^4 A. A capacitor storage system is used to provide the 10,000 pulses per second required to drive the thrusters.

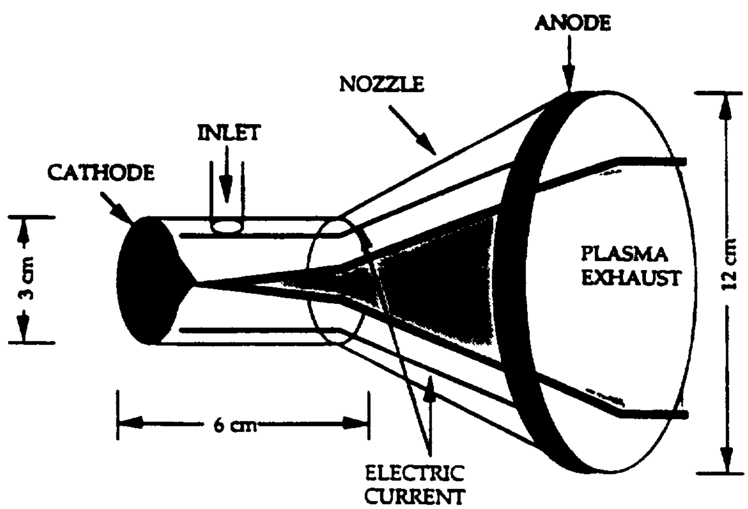
The converter works on the principle of an electrostatic (ES) generator. The charge on the DEC induces a charge on the probe which charges a capacitor. As the relay allows the probe to be grounded, the capacitor charges. As the relay connects to capacitor to the load, the capacitor is placed in parallel with the ion thruster. With an additional parallel RC circuit, the output from the charged capacitor to the ion thruster can be "smoothed out."

ELECTRIC THRUSTER

The thruster envisioned for this mission is a new hybrid design. It combines features of the traditional arcjet thruster and the magneto-plasma-dynamic thruster (MPD). The design (Fig. 6), uses the same electric current to provide both an electrothermal and a magnetic acceleration, yielding an I_{sp} of 3000 seconds and a thrust of 68 N per thruster.

Hydrogen gas is continuously fed into a 3-cm diameter by 6-cm long thruster chamber at a rate of 2.3 g/s. As the gas fills the chamber, a charge builds up on a small capacitor bank, coupled to the two electrodes. When the electrodes reach a potential of 1 kV, they discharge an electrical pulse with a current of 20 kA, dissociating and ionizing the hydrogen, sharply raising its pressure, and accelerating it toward the conical nozzle region. As the hydrogen reaches the nozzle section of the thruster, it is further accelerated by an azimuthal magnetic field generated by the current flowing between the anode and the cathode, accelerating it in an axial direction.

Figure 6. The hybrid thruster design



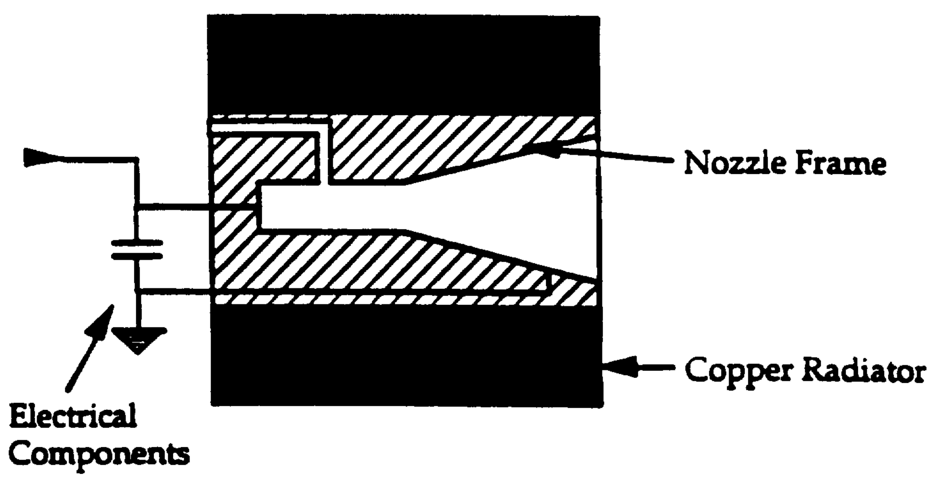
The thruster is operated with a pulsing frequency of 10,000 per second. This is necessary to prevent overheating and to increase chamber pressure. Between pulses, the hydrogen collects in the chamber, increasing the pressure. By the time the hydrogen escapes the nozzle, another electrical pulse expels the gas from the chamber. The increase of the pressure in the nozzle to a few atmospheres offers several benefits. Dissociation and ionization losses are reduced, energy is gained from hydrogen recombination within the nozzle, and the Reynolds number is increased. The energy gained by recombination further accelerates the flow and the increased Reynolds number reduces frictional forces on the wall of the thruster.

Each thruster has an average power input of 2 MW, with a peak power of 10 MW. Although it has an efficiency of only 50%, each thruster can deliver 2.3 g/s of propellant at a velocity of 29.4 km/s, producing 68 N of thrust with an I_{sp} of 3000 seconds. Since there will be five thrusters, the total thrust will be 340 N.

A large amount of propellant is required for this mission. Although the mass flow rate appears small (11.5 g/s), the total mass needed over the 120 days is 127.5 metric tons, including 5% added for reserve. Stored as liquid hydrogen,[22] this requires a volume of 1960 m^3, which will be divided among fourteen tanks.

Each thruster has three main components, as shown in Fig. 7. The nozzle and capillary tube are constructed using an insulator with a high melting point, such as Si_3N_4. The electrical components include the charging capacitors and the electrodes. Copper heat radiators are required, weighing about 700 kg per thruster. A 3-cm thick radiator of this type would occupy 13 m^2, which can easily be accommodated. The estimated total mass of each thruster is 1760 kg, or 8800 kg for all five thrusters.

Figure 7. Diagram of complete thruster

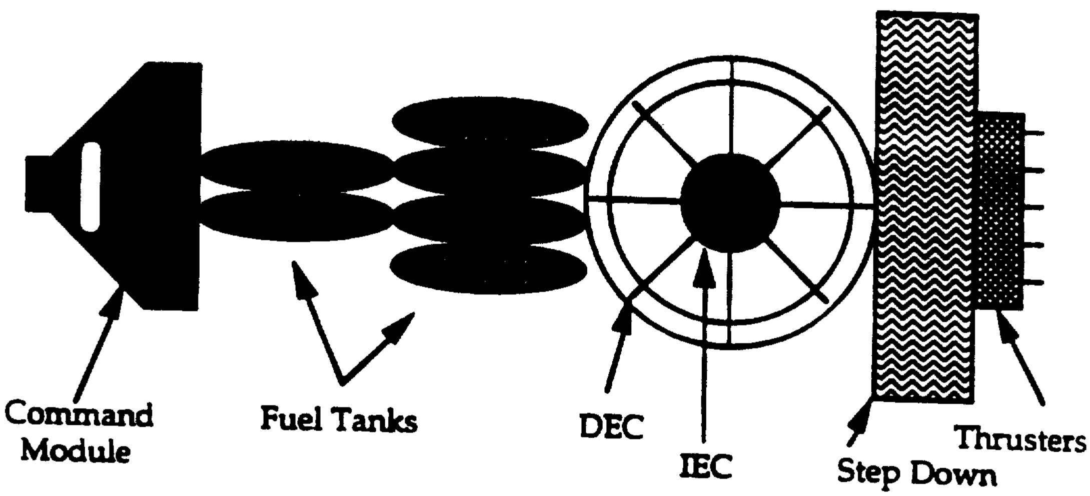


CONCLUSION

A schematic drawing of the approximate positioning of the various components is shown in Fig. 8. As discussed earlier, the propellant tanks are located between the IEC and command module to provide shielding from IEC neutrons. The step-down and pulse forming subsystem, located between the IEC and the thrusters, required added shielding for sensitive electronic components.

This design must be viewed as very preliminary, since many issues have been uncovered that require much more exploration before the feasibility of this concept can be fully verified. However, the results confirm the initial view that the IEC could provide an exceptionally attractive spacecraft for deep missions such as MARS, provided the physics of this approach works out as anticipated. Thus, in the present design, a 21-MW IEC provides the power needed for the hybrid thrusters giving 340 N and an I_{sp} = 3000 sec. in a spacecraft configuration of overall weight of 300 metric tons. This allows an attractive 120-day trip time to Mars for a manned exploration mission.

Figure 8. Possible configuration of the IEC fusion rocket components



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THE THRESHOLD OF CHANGE

"Journalism," says Timothy Crouse, "is probably the slowest-moving, most tradition-bound profession in America. It refuses to budge until it is shoved into the future by some irresistible external force."

Today, the traditions are losing their grip and the external forces are gathering strength.

Mass media are under assault from all sides. The public calls the official information and expert analysis presented by the press biased. They complain about "sound bite news," but few read the newspaper from front to back. They say the news lacks depth, but they read only *USA Today*. They condemn the superficiality and sensationalism of newspapers, yet many voraciously consume the outlandish stories presented by Geraldo Rivera and the *National Enquirer*, undignified mutations of the American free press.

Among journalists, there is concern about lack of diversity both within their ranks and among the media corporations that employ them. There is concern about the growing dependence on advertising revenues (Bagdikian 1990).

Newspaper journalists worry that "the medium might not survive" (Pease 1992) because their employers, frightened by the public's shift to television news, are attempting "to beat television at its own game" (p. 48-9). Broadcast journalists struggle to compete in a sea of mind-numbing entertainment and an ever-expanding range of viewing alternatives.

These problems are not new. Criticisms have been leveled at the mass media since the days of Thomas Jefferson. Once-great media companies have failed. But in years past, concern about these problems was tempered by the knowledge that people would continue to but newspapers and watch the newscasts and that advertisers would always be there. As a result, minor renovations were sufficient; there was no need to rebuild the foundation.

But today, there is a critical difference: competing news and information alternatives are beginning to appear, encroaching on the time some people spend engaged in the daily rituals of reading the newspaper and watching the nightly news. They are providing much of the useful information that some people once obtained from magazines.

These information media lack the ease of use and visual appeal of newspapers and television. But what sets them apart from these products is that they allow audiences to be both active seekers and contributors of information instead of what Innis called "a reading and listening audience positioned on the dumb end of a one-way conversation" (Gladney 1992). And what will expand their share of the public's time, money, and attention is a convergence of computing and communications technologies that is making these alternatives more accessible and engaging, along with a changing economy, in which information is becoming a commodity.

Today's mass media companies are not ignoring these new information media. They have adopted many new technologies in the past two decades for their own use, and they have introduced new products that make use of these technologies. The details of a future "electronic newspaper" are beginning to take shape. Knight-Ridder's Information Design Laboratory and Gannett's Advanced Technology Lab are exploring the technology and defining the content of future media. Journalism think tanks, such as the Freedom Forum, are discussing potential impacts on society of a coming national information service. The mass media seems to be moving in the right direction.

But are they moving fast enough? Are they reacting to mature and imminent technology developments and never trying to guess what is beyond the technological horizon?

Will they have the technological resources at their disposal to compete in the new environment or will they have to depend on other industries who own these resources?

Will today's high tech industries, which are relentlessly advancing technology and championing innovation among their employees, dominate the news and information of the future? Or will the technologies they put into the hands of citizens create a nationwide news medium that is heterogeneous and democratic beyond anything envisioned?

What will journalism's role be. Will the principles it values today govern the future high tech news and information environment? Will the positive control measures always employed by the mass media remain effective, will they be subverted, or will new control measures rise to the surface? Who will employ these control measures?

Too many unknown variables now obscure the full answers to these questions. But they need to be asked continually by journalists.

This paper is an attempt to take some initial steps toward clarifying and examining the technological potentialities of the future. Its intent is to frame a new dimension for debate about the media's social role in an economy based on information.

This paper presents a vision of the future based on today's technology and today's mass media to provoke the thought that perhaps change will be more sweeping than anyone has imagined. It then frames three questions about the future that journalists must begin asking now when they have a chance to influence the answers.

The questions are these:

- Who will control the technology?

- Who will control the media?

- Who will control the marketplace of ideas?

The technological visions and possible outcomes presented here are based on an assumption that it is valid to construct visions of the future based on an incomplete picture. A helpful guideline comes from conservationist David Ehrenfield (1993, p. 9):

> The business of prophecy is not foretelling the future; rather it is *describing the present* with exceptional truthfulness and accuracy. Once this is done--and it is an overwhelmingly difficult task--then it can be seen that certain broad aspects of the future have become self-evident, while other features, including many of the details, remain shrouded in mystery.

NEWS IN THE 21st CENTURY:
Personal, Interactive, and Experiential

With today's processing, networking, display, and software technologies, it is already possible to manipulate multimedia information, interact with computers in a conversational fashion, communicate meaningfully with other computer users, and even experience artificial worlds. However, many of the technologies that make these activities possible are too expensive for most people to buy. Others are not yet perfected or not yet widely available on the market. But these technologies can be perfected and mass-produced, and they can be integrated in new ways.

Any vision of the 21st century must be based on assumptions. This vision assumes that the information needs of society will continue to increase and that the "knowledge sector" of the economy will continue to grow. It assumes that the current course of today's computing and communications research will continue, just as most technologies have followed an evolutionary development course toward meeting and exceeding an original need. It assumes that most technologies existing today in limited form will continue to mature and decrease in cost and that diffusion of these technologies will occur, just as has been the case with other formerly exotic, little-known technologies, such as telephones, television, and personal computers.

These technologies can change the information environment that today is dominated by newspapers, magazines, and television.

This is what could happen:

Future citizens will obtain news and information in a highly individualized fashion. They will have the ability, according to their own needs and preferences, to obtain not only specific data, images, news, and information, but also knowledge that is packaged in a variety of ways by media professionals, by other users, and by software. They will automatically receive less information that is irrelevant to them and more information that they can use. This information will be presented to them in ways that are organized, understandable, and engaging. They will be able to interact with the information, controlling their own movements from one idea to another, asking questions and receiving answers, instantly retrieving from libraries and other storehouses all over the world whatever information they need in the form of text, photos, graphics, and audio and video recordings.

Citizens will have the ability to interact with knowledge providers, with other recipients of knowledge, and with the knowledge itself. From their homes, citizens will interact face-to-face with other people in distant locations. Those with the desire will publish their own writing, even their own electronic newspapers and magazines. They will be able to create and broadcast their own documentaries.

Citizens will experience knowledge in new ways. They will be able to enter and even create artificial worlds, and they will be able experience some of the sensations of traveling to a variety of places around the globe.

LITERATURE REVIEW

Few visionary thinkers in computer science and technology have even addressed thoroughly the potential their field offers for news media. However, a vision of 21st century news media can be drawn from their works and from a survey of technologies now being developed or marketed.

Brand (1987) establishes that advanced research in interactive media is being done and helps to define the cutting edge in areas such as artificial intelligence, parallel processing, and networking. Krueger's speculative thinking (1991) on possibilities for new forms of interaction and experience in responsive environments provides many original ideas.

Helpful for developing a broad perspective is an extensive review of computing periodicals, particularly Seybold's *Digital Media*, *Byte*, IEEE *Spectrum* and IEEE *Engineering Times*. Rheingold (1991) provides useful information on the potential of virtual reality, Gilder (1989, 1990) on future television, and Laurel (1991) on human interface design. Also interesting to examine is the potential for the mass media of Moravec's work in the areas of intelligent robots and mind-computer linkages (1988, 1993), Drexler's work in nanotechnology (1986), and Zeltzer's (1992) work in "virtual actors."

Examining various aspects of future society and the role technology will play creates a larger framework for the idea of new media and some specific ideas for how technologies will be applied. Perleman's vision (1992) of a computer-based system for lifelong learning, Toffler's forecast (1990) of a coming "knowledge-based economy," and McLuhan's amazingly prescient views (1964) suggest the dramatically heightened role knowledge will play. A collection of essays edited by Benedikt (1992) illustrates the growing vividness of a cyberspace metaphor that suggests the eventual evolution of a new "super-medium" that is the foundation of all other media.

Finally, the confidence to present this vision comes from conversations with a number of technically knowledgeable people at NASA Lewis Research Center, particularly Fredric Goldberg of the Telecommunications and Networking Branch, Roger Dyson of the Mainframe Systems Branch, and Laszlo Berke of the Structures Division.

THE SYSTEM: A COMING TECHNOLOGY SYNTHESIS

The potential for this new type of news will depend on an integrated system of hardware, software, and networks.

The Network: Gateway to a world of information

A National Public Network (NPN) or as many have called it an "Information Superhighway," will be the basis of tomorrow's information media. Capable of transmitting voice, data, and video at speeds of one gigabit per second (gbps), and higher, the NPN will be linked to Metropolitan Area Networks (MANs) and ultimately to local area networks (LANS) in businesses and to Small Area Network (SANs) in each home. This linkage will provide anyone with a terminal access to a variety of general- and special-purpose computers in universities, businesses, hospitals, libraries, and national research labs.

In homes, SANs will link televisions, telephones, and computers, as well as appliances, automobiles, home environmental control systems, home security systems, and other devices. People will be able to communicate instantly, accessing the network with a variety of personal devices. They also will be able to tap into commercially available devices, making it possible to run a home from the office or an office from the home, to shop, bank, and obtain professional services, and even to pursue training without ever leaving home (Miles 1989).

Also, because each person will be assigned a unique, lifetime i.d. number, it will be possible to plug into the network from any location--- the doctor's waiting room, for example --- and use many of the same services available in the home.

Through the NPN, homes may be provided with computing bandwidth in the same way that the utilities provide units of gas, electricity, or phone service. In fact, since the network can be used for telemetry from home energy and security systems and carry voices, it may happen that homes will receive one utility bill that includes a measure of the computing resources they used.

Just as with heating and phone usage today, some buyers will have to be careful and conservative in their consumption, buying only the minimum number of channels, limiting hours of usage, and accessing only the least expensive services. Similarly, just as some buyers today are willing to pay the price for more usage of utilities because they can afford to run their air conditioning and use 900 numbers liberally or because they have an over-riding need for high usage, such as running a medical apparatus or making long-distance calls in search of a job, some buyers will buy more bandwidth than others. Those who can afford it will have "infinite bandwidth" (Brand 1987).

The NPN will be a gateway to whatever information exists for public consumption. Its ability to provide virtually unlimited bandwidth and its connection to computers and mass storage systems in virtually every school, library, research lab, business, and home will enable any person to request from any source text, computer software, computer data, still or animated art, photographs, audio recordings, or video selections that are made publically available. As a result, each individual will be the hub of his or her own entertainment and news network.

The Hardware: Many ways to interact

The focal point for each home's personal entertainment and news network will be a digital device, referred to in this paper by George Gilder's term, the "telecomputer" (1989, p. 312). The phone companies like to call it a teleputer, or, better yet, a telephone. The cable companies like to call it a "smart" cable box. The computer companies like to call it a videoconferencing computer. Whatever name results, it will probably combine many of the functions of today's telephones, televisions, stereo systems, and personal computers.

Although telecomputers will rely on public domain computers for many of their capabilities, they will also have significant computational power of their own---processing speed, memory, and hard-wired intelligence far beyond anything that exists today. They will be knowledge processing machines, capable of a high level of autonomy, decision-making abilities, and perception. As such, they will be able to take over many of the tedious activities that occupy humans' time, to interact with humans in a natural manner, and to learn about the information needs of their owners.

As nanotechnology researchers achieve their vision of microscopic integrated circuits, it will be possible to combine a variety of special purpose processors---some suited for fast processing of data entered by the user, others capable of rendering high resolution graphics and images and decompressing images sent over the network, and others possessing the necessary pattern recognition capabilities needed for speech recognition, language processing, and other intuitive functions.

Each home's telecomputer will have a variety of input devices, including the traditional keyboard, a wireless mouse-type device that can interact with the screen from the comfort of the couch, a microphone with eye-tracking capabilities that picks up speech directed at the system (Brand 1987), and an array of electronic pens, pencils, and paintbrushes that allow handwriting on the screen by pressure on a graphics pad or just by pointing to the screen (Krueger 1991). Each telecomputer will have a built-in video camera, hopefully one that can be switched off sometimes (Krueger 1991, Brand 1987).

The main output device will be the telecomputer screen, which will be used for direct viewing of visual media obtained through interactions with the network. It will yield a three-dimensional picture so sharp and clear that it will be difficult to distinguish objects that appear on it from their real counterparts; text that is displayed for reading will be easier on the eyes than books (Gilder 1990, Rheingold 1991)). Many people will opt for a very large screen or for multiple screens. Some might even have wall-to wall, screens that will allow them to reconfigure their surroundings (Krueger 1991). In addition, a spatial sound system will allow the user to experience realistically every sound produced by the medium (Esserlieu 1991). With advances in holography, systems may even become available that make objects spring from the TV screen and materialize in the middle of the room (Esserlieu 1991).

High capacity storage devices, capable of containing vast amounts of digitized text, photographs, graphics audio, and video, will enable users to combine information they obtain from the network and save it for later use. Storage systems will be hierarchical: information accessed most frequently remains on a local storage server for quick access and information accessed infrequently is transferred to remote storage, which is accessed less rapidly. Users with the greatest information needs will purchase high-capacity servers as their first level of storage; this will enable them to gain fast access to large quantities of information. Large public storage facilities, also configured hierarchically, will make stored information available over the network.

Users will be able to choose from among many types of portable devices, capable of exchanging information with the home system or of being connected to network outlets in other locations. Some devices may also allow people to interact with their home systems from any other location without any outlet needed (Perleman 1993).

Portable input/output devices may include book-like or paper-like portable computers that can be plugged into the main system for downloading of information (Fidler 1992). Special glasses will provide a variety of visual effects (Moravec 1988), perhaps allowing a user greater immersion in the action being shown on the news or projecting a high resolution newspaper in the empty space in front of a user, allowing him or her to read without using the hands (Krueger 1991). Users may prefer to take book-sized versions of their personalized newspapers and magazines on the subway with them but wear glasses on the beach or in bed.

Also part of the system will be special body attachments, successors to the suits, datagloves, and head mounted displays used in today's "virtual reality" applications (Rheingold 1991).

The Software: The user's information navigator

The software applications that reside in the user's telecomputer, as well as in the computers accessed over the network, will serve many roles. First, they will be the user's information "comptroller." Also, they will be the user's interface and interpreter to other software on the network. Finally, they will be the user's guide and assistant in obtaining information.

One of the most perplexing issues people associate with disseminating information electronically is one of remuneration: how will copyrights be enforced, intellectual property guarded, and publications sold?

In fact, all of these needs can be met in a global network. Just as today there are libraries and computer bulletin boards that provide public domain information, the information superhighway will provide much free information. Information packages that are perceived to be more valuable, however, will be paid for monthly like long distance telephone services and pay-for-view programs ordered from cable companies, or perhaps they will be purchased via automatic electronic funds transfers.

The same software that will handle the user's shopping transactions and monthly bills will initiate electronic funds transfers when the user has obtained copyrighted information from the network. Likewise, they will accept electronic funds when the user's own copyrighted information has been accessed by someone else. Users may even be able to designate a monthly information allocation that fits their financial abilities and leave it to expert software to make sure the "information budget" is not exceeded.

Intelligent software will also act as an "agent" for its human owner. Acting predictably and on the user's behalf, (Laurel 1991) these agents will eliminate the time-consuming, hard-to-learn processes that today stand between people and the information and services available via computers. In fact, they will even handle many of the tasks involved in reading or watching today's news, such as searching for the items that one wants to read, sitting through televised news one does not want to hear, looking for alternative viewpoints or corroborating information for stories that are considered important, and attempting to analyze, synopsize, and synthesize information about a topic. All that the user will have to do is the mental work that is uniquely human---reacting to news with emotion, forming opinions about news, linking news to mental pictures and past experiences, making personal decisions about news, generating creative ideas based on news, and talking to others about the news.

The network itself will perform the first level of decision-making about what news to process. It will seek and assemble this information from information sources and prioritize it. As data is transmitted from all of the many sources world-wide, the network will add value by "collecting, integrating, and evaluating data, drawing automatic inferences, and running input through sophisticated models" (Toffler 1990). This "extra-intelligence" will, one would hope, be employed to help prevent libel, false advertising, and fraud and to help temper the effect of information that encourages illegal or dangerous activities, bigotry, or any other potentially harmful actions. It will not, one would hope, be used to censor unpopular ideas.

The second level of selection will be made by the user's own software agents, which will be programmed by the user to search for certain information on certain days or at a certain frequencies of time, to order information according to the user's priorities, and to present information according to the user's level of comprehension and reading/learning style.

Although not always visible, agents will be represented graphically to the user so that interaction with them will have the ease of conversation and the information value of eye contact and cues from facial expression and tone of voice (Santo 1992). Some users may prefer to have more than one agent -- perhaps one for hard news and another for sports news. Users may even prefer to design their own agents (Laurel 1991).

When the user first interacts with the agent, he or she will spend time providing a profile that will be used in the system's information-seeking. The user will answer in whatever mode is most convenient -- sometimes by writing, other times by speaking. The agent will request information, such as age, occupation, educational level, income, interests, hobbies, political orientation, fashion taste, or any other general characteristics that classify readers. Menus of information categories, (e.g. "city government", "heavy metal music", "pets", etc.) may also be presented from which the user can select the major topics that are of the greatest interest. So, for example, a user who selects "city government" as a major area of interest may get a large portion of each day's news about city government --- film of every council meeting and transcripts of every speech by the mayor, along with all the historical, economic, and sociological background information needed to understand the events --- while a user who gives city government a low priority or no priority may receive only brief accounts of major decisions or may receive news of city government only when it coincides with his or her interest in heavy metal music or pets.

Deciding how much control to give the system over the information presented each day can be left to the user. Control may vary from using the machine as an intelligent servant that only fulfills requests made by the user to using it as a mentor, a therapist, or a conscience. Some may use the system only for narrowing down choice, preferring to be offered a long list of choices from which they will do their own selecting and prioritizing. Others may prefer to be offered the same topics each day in a specified order.

To ensure awareness of important world events, many users will want to spend a portion of their time browsing as newspaper readers do today. They will request local and national newspaper services that present editors' judgments of what is newsworthy. They will be able to choose whatever paper they want for national news, read a different paper every day of the week, or read the sports section from one paper and the editorial page from another. From this newspaper, with help from their expert system, they will be able to access additional information, including video, about stories.

Some users may choose to carry on daily human-like "conversations" with their systems, which in turn, could incorporate each day's moods, desires, insights, and concerns into the search for information to ensure that the user will engage in the type of interaction that suits his or her state of mind.

If, for example, a user has had a stressful day and is exhibiting mostly negative thoughts, the system will filter out or shorten any bad news that is not necessary information and select primarily light, positive, encouraging news items. If the system detects that the user's negativity and depression are continuing beyond a day or two, it might seek out and present self-help information that addresses the statements the user made, or it may refer the user to a support group on the network.

Also, the system could act upon user reactions to each news item. If a news story provokes strong feelings of dismay or interest, the system could generate information about what steps citizens could take to contribute to a solution or seek out new experiences.

As information continues to be fed to the system daily through each choice a user makes, as well as the length of time the user spends on different types of items and the number of times a user requests additional information on a type of item, the system will continue "learning" about him or her (Miles 302).

For example, based on the information provided to the system, an 8-year-old who is interested in space travel and her mother with a degree in mechanical engineering might be provided the same news about space travel, but in different news items or in the same item with definitions of terms included in the child's version. As the eight-year-old gets older and learns more, the vocabulary level of her items may be upgraded slightly each time she shows an interest in the most technical of the items presented. Similarly, her mother may begin getting increasing numbers of articles on electric propulsion because she always reads the journal articles presented in this area.

Some users may even allow the system to compile psychological profiles and present messages that fit their personalities, maximize and minimize their cognitive strengths and weaknesses, and counteract their prejudices.

For example, if a person continually reacts to issues with statements that show evidence of emotionalism and lack of recognition for the practical facts, the system could counter with analytical information. On the other hand, if a person rarely acknowledges emotional reactions to an issue, the system might provide items that illustrate the human suffering and damage related to the issue.

The Information: Dynamic and multi-dimensional

News and information will be presented in a multitude of ways with endless variations possible. Many users will specify a type of "newscast" that they like. For example, some might request that news items be presented in text form with classical music playing in the background. Some users may want to scan or listen to summaries of pre-selected items and then choose the information they want to consume while others may want the system to choose for them. Others may ask to hear a high percentage of anecdotes and human interest material about items or to be told a joke at appropriate moments. Others may ask to see a high percentage of pictures, charts, and graphs. Some might request to hear a voice speaking just the facts.

Users will personalize the way the system presents information by selecting a variety of special attributes to accompany certain categories of information. Some users might request to see boxed text definitions that appear in the lower left corner of the screen every time a foreign or technical word is used. Some might ask for periodic stock exchange information, or occasional music breaks in information sessions. It will also be possible for a user to create or select a life-like agent or "virtual actor" (Zeltzer 1992) to act as a personal news anchor: one who looks and sounds just like a beloved news anchor of old, such as Walter Cronkite, or one who is created to project an image the user likes.

Although software will package much information up front, users will still be much more active in using the new media. They will be able to explore ideas presented to them with complete freedom, retrieving multimedia information from remote locations on the network and from their own CD-ROM libraries when they want to learn more about a fact. They will select a different level of complexity if a story gets confusing, request video footage or pictures to supplement text stories, or request text transcripts when spoken passages require in-depth examination.

Users will be able to receive answers to specific questions about each news story. They will be able to ask for corroborating information if the statistics mentioned in a story don't sound right. They will request pictures or biographical sketches or filmed interviews if persons mentioned in news stories interest them. They will ask for additional opinions about issues presented in news stories, and the system will go out on the network and find a cross-section of them. They will be able to ask what a certain person has to say --- for example, "what does Ralph Nader say about this policy?" or "what was my state representative's reaction to this proposal?" --- and the system will immediately find whatever information is published by that person. If a child asks a parent a question about the story, the parent will request multimedia information at the appropriate grade level about the topic.

Users also will be able to ask the system to help explore their thoughts about the information presented, arguing with the logic of the story and receiving an analysis of their own logic. They may even choose, with help from their agent, to run a simulation as a way of exploring ideas. If, for example, users who believe hunting should be banned could choose to run a simulation of this decision and see the results.

The audience: news as a shared experience

Some of the information on the network that is accessible to users will be information provided by other users, each with an equal opportunity to make his or her views known to anyone interested. These opportunities for sharing information will be organized in a variety of ways.

One way will be the electronic group. Just as today people choose magazines that address the topics that interest them, people will belong to special groups who consistently seek to share information with each other and to buy information presented by experts in the topic area.

For example, people interested in business management will access the "business management" group daily and exchange ideas and experiences, just as they do with today's bulletin boards. A difference will be that rather than text messages, the groups will be able to communicate with pictures, video, and even face to face.

Another way news could be organized resembles the traditional method of reserving regularly scheduled times for attending to world and local news. In this way, the interactive qualities will be utilized to the fullest. Audience members could take part in nightly surveys about news topics. Or they could turn on their video cameras, express their views, and multi-cast them to anyone who is listening. Of course, they also will be able to tune into special channels and watch as other people do the same. In some cases, it may be arranged to have the person responsible for the news on camera to answer questions. If a user wants to argue with someone who is still online, the exchange can be transmitted to others just as if the two were in the same room.

A user who likes to express opinions in writing will be able to write a commentary, create or select graphics, photos, or film from a remote or personal database to go with it, and multicast it. Anyone who wants a copy will be able to print it at home or transfer it to local storage. In some situations, consultants will offer their services, providing their written information for a fee.

Some users may totally abandon the types of information-gathering activities used today. They may prefer, for example, to witness and experience events for themselves.

Users will be able to access a system of tiny cameras planted in various locations around the world that allow them to become observers of the action taking place in distant places (Krueger 1991). If, for example, users want to see the pictures in the Louvre, they will be able to access cameras located there and see each piece of art from many different angles. Krueger (1991, p. 232) envisions "tiny robot insects, wearing stereo cameras that fly around a site and transmit images to receivers nearby." By wearing reality goggles, users could see the scene as if they were actually present.

For some news stories, viewers may want to enter more extensive artificial realities to heighten their awareness of the story. Through virtual reality and telepresence technology, they will be able to see, hear, and feel sensations that provide a realistic idea of what it's like to traverse a battlefield or see the earth from space through a camera mounted on an astronaut's helmet.

The Information Sources: A diverse flow

When opening the newspaper or a magazine or turning on the six o'clock news today, most people do not give much thought to the source of the information they are receiving. They may have favorite columnists or feature writers that make them feel comfortable, and they may prefer the personalities and skills of certain news anchors or TV reporters, but for the most part, news comes from reporters who are considered interchangeable by the public. With the many-to-many capabilities of the information superhighway, this will change dramatically.

Professional or amateur communicators --- writers, film-makers, lecturers, and even artists and musicians --- will access the group in search of buyers for their work. Some of these communicators will be independent individuals or individuals represented by agents (either human or computer-generated). Others will be contributors to entire packages assembled by media organizations reminiscent of today's newspaper, magazines or television new shows.

For example, members who select "business management" as their primary group might on a given day be informed by their agents that Peter Drucker has a new article on global competition available at a cost of $x, that Tom Peters is offering a new video on employee motivation available at a cost of $x, that Business Week just published a special issue on profit-sharing, and that a well-known consultant who specializes in employee recruitment is willing to consult with clients electronically for $x per hour. There might also be a notice that 10 subscribers are going to watch the Peters video on Monday night and hold a face-to-face electronic dialogue session immediately afterward. Each group member would then make decisions on these items, viewing them when convenient, and the appropriate funds will be transferred to the appropriate recipients.

Advertising might be found in special groups or might be integrated with other electronic information. Ads would appear in the right niches rather than being wasted on people who would never respond.

Companies may have different options for advertising. Some may buy time in various electronic groups for their commercials, which will be shown each time someone accesses the group. This type of advertising may be the highest priced because it will reach everyone in a group. Less costly ads could be in the form of brief notices, such as "XYZ Company will show their new line of golf clubs to anyone who is interested." Ads might be created that can be explored in ways similar to news stories. Those whose interest an ad attracts would have the option of seeing more of the product line, reading magazine articles about the product, or talking to a sales representative.

The personalized, interactive, experiential media system described above may be a wild idea. There are technical barriers, industry practices, and human issues that could easily slow its progress. By today's standards, it is impossibly complex, expensive, and foreign. It would certainly take years to achieve.

However, when one considers the progress that has been made in two decades, the technologies and consumer needs in existence today that were not envisioned twenty years ago, this vision begins to sound less bizarre. It could happen--maybe not exactly as described, but in some form to some degree.

Today's journalists, particularly those who are just starting their careers, should seriously consider this vision. It is technologically challenging, and it will require major adjustments in society. But if it is realized, even partially, it will mean a revolution in journalism.

Journalists have two choices: they can shape the revolution or look for a niche after others have done so.

PART II
SEEDS OF A NEW MEDIA

So far, only cable television has equaled the networks in performing the task of providing up-to-the-minute, global news or achieving a high visual impact. No technology, by itself, can provide the quality of writing and the analysis provided in newspapers. None is as easy to acquire and use as newspapers, magazines, and broadcasts. None is as much a part of life as reading newspapers and magazines and watching the news on TV. In short, new technologies must overcome serious obstacles before any of them replaces the traditional news media.

However, these new technologies are already competing with some functions of today's newspapers and news broadcasts, and the competition could increase as these technologies evolve and become more widely used.

THE CONSUMER MARKET: Preparing for the Future Media

The shift to a new media paradigm has already begun. Communication technologies now on the market have caused consumers to become accustomed to and to value expanded choice, increased interactivity, and heightened experience.

Technologies of Choice

Technologies of choice add flexibility and convenience to lives that are becoming increasingly busy. They allow individuals to maximize the time they have available for communication by restricting the information and entertainment they consume to what is important or desirable to them.

One of the most popular technologies of choice is cable television, which began to grow in usage during the 1970s and became relatively widespread during the 1980s. Another is direct broadcast satellite technology. These technologies represent a first step in a media environment of choice. The videocassette recorder is a step beyond, allowing individuals to learn what they are motivated to learn at their convenience. In addition, plans are currently underway among consumer electronics companies, cable TV companies and direct-broadcast satellite companies to deliver digitally encoded movies to home users. Seybold believes that this service "will establish transmission of high-bandwidth digital data into the home" (1991, p. 7).

Some researchers say these technologies of choice are creating new viewing patterns. Rubin and Bantz (1987), for example, provide evidence that individual

VCR viewing is goal-directed. Walker and Bellamy (1991) find that television and VCR exposure, as well as remote control devices, may be creating patterns of selective avoidance. Levy (1989) suggests that VCR viewing may be characterized by "higher levels of audience member activity" with viewers becoming more selective and involved. Perse (1990) also finds increased capacity for audience selectivity with cable and remote control devices.

These patterns may be preparing consumers for the more active, goal-oriented processes that will be possible in a future media environment.

Another area that represents the increasing value of choice is the growing number of newsletters and "zines" (small magazines targeted to small segments of the population). These communication media are not for everybody, and that is precisely why their readers choose them. They provide detailed information on topics that are important to their readers and they bring diversity to the total information pool. Today, with desktop publishing software and a relatively inexpensive laser printer, any citizen can produce an attractive information product to be distributed to interested parties--and thousands are doing just that.

Technologies of Interaction

Today's online commercial databases, accessed via networked personal computers, and CD-ROM systems in libraries, broaden the range of choices by allowing users to search for the precise information they want instead of passively accepting a static information agenda.

Because the user's choices determine what information is accessed, these technologies are setting the stage for a new environment in which the user is actively interacting with a system to obtain news.

The telephone, always an interactive technology, has become another interactive information alternative. Increasing numbers of people in search of specific information are picking up the phone and using audiotext services. Some newspapers provide audiotext to update readers on running stories and to provide information on weather and entertainment (Mathes, 1992), but non-media organizations are also beginning to provide it. For example, in the Cleveland area phone book, audiotext numbers listed include one for legal information (provided by a law firm), one for medical information (provided by a doctor), and one for real estate information (provided by a realtor). In each of these and several other categories, separate numbers are given for several subtopics, and callers can stay on the line to ask questions of a person, if they wish.

A more visually appealing interactive information technology is interactive cable television, which provides such services as broadcasting from the home, request video services, facsimile newspapers, and videotext (Dutton, Blumler, and Kraemer, 1987). After experiments during the 1970s in the U.S, Japan, France, Germany, and Britain demonstrated the technical feasibility of videotext, it became a fairly popular medium in France and great Britain (Chorafas, 1981) and slowly began to be offered in American communities, most notably by Knight Ridder newspapers (Mayer, 1983).

Videotext is considered by many to be a dead technology since Knight-Ridder's attempt failed, as did attempts by Warner-Amex, AT&T, and an IBM-Sears-CBS consortium. However, according to Forester, videotext services were rejected because the applications offered, such as home shopping and banking, are inappropriate and because videotext services are hard to use, slow, and inflexible (1988). A resurrection may be underway, however, with recent advances in personal computers, software, and networking and alliances between cable and computer companies.

Technologies of interaction also are allowing average citizens to play a part in the media. With low cost video camcorders, citizens are providing action footage to their local news channels. Some news shows even encourage citizens to telephone from their cars if they see anything newsworthy unfolding.

Of all the alternative sources of information today, the most interactive is the electronic bulletin board. For many, accessing this information source via a personal computer is as much a part of the day's routine as reading the morning paper or watching the news. DeFleur et al (1992) have demonstrated that audience recall of news story text presented on a computer screen almost equals recall of stories in a newspaper.

Electronic bulletin boards allow users freedom to pursue their own information needs. They also allow them to provide information and express opinions instantly.

Users on Cleveland's Freenet, the Internet's USENET, and other bulletin boards, are choosing from a broad range of subjects that were selected, not by an editor, but by the public, and they are interacting with the news, blending their own thoughts and ideas with those of others. Some USENET users have become "opinion leaders" on specific topics; they provide news stories and extensive analyses of events, and they engage in long-running, quite complex and quite heated arguments that, because of the continuing interaction, can be much more intellectually stimulating than a newspaper's letters to the editor or a broadcast's 60-second "man on the street" spot.

During the recent elections, for example, users of the USENET bulletin board rejected the editorial section for an electronic forum. They read the position papers of Clinton and Bush in their entirety, as well as Ross Perot's *United We Stand.* They read the original press releases of Clinton's Communications Director, George Stephanopoulous. They even exchanged extensive information about Libertarian candidate Andre Marrou's positions, information that was, unfortunately, difficult to find in mainstream newspapers and news broadcasts.

In a sense, each USENET user is a reporter. When multimedia technologies become available, more people may take on this role. Underwood predicts that users will eventually be able to pull text, animated graphics, video images, music, and special effects from a computer's memory to "create their own multimedia productions."

Technologies of Experience: On the Horizon

With the current technologies of interaction, users play an active role in the process of obtaining news and information. They influence the outcome of the information they receive by varying their input. However, by the standards used in developing today's computer technologies, interactivity is severely limited with these media.

According to Laurel, degrees of interactivity can be assessed by examining the frequency of interaction possible, the range of choices available, and the significance of choices (1986). According to these criteria, audiotext, videotext, and online databases are not very interactive.

Laurel adds a new variable to interactivity: the degree to which users feel themselves to be participants in the ongoing action of a computer's representation of reality (1991). Today's information technologies fall far short of this definition because not only are users quite aware of a machine's presence, they also perceive the information as something out there separate from themselves.

However, future technologies will fulfill Laurel's definition of interactivity, allowing users to gain knowledge through direct experience.

True technologies of experience do not exist today. Video games probably come closest in that they present artificial worlds in which players can adopt alternate identities and shape the action. Although their use of a television screen leads many to discount video game usage as passive TV watching, Turkle says video games are "something you do, something you do to your head, a world that you enter, and, to a certain extent, they are something you 'become'" (1984, p. 67). This provides a definition for the technologies of experience that eventually will allow users more direct participation in news and information.

One information technology that could well become a technology of experience is the personal computer equipped with a CD-ROM drive and hypermedia software. Today, consumers are purchasing CD-ROM drives for their home computers. Personal CD-ROMs contain multimedia information, usually encyclopedia or other reference works. Hypermedia software makes it possible for users to explore information in an almost infinite number of ways, defining their own paths to knowledge and thinking--through reading digitized text, looking at photographs or graphics, watching video recordings, listening to audio recordings, or combining these media.

Even higher quality interaction is becoming available with CD-I players, which offer more audio and video components than the CD-ROM products, as well as larger screen displays. Some hypermedia packages are entering the realm of experience by providing information through simulations and games. For example, a popular package called *Where in the World is Carmen Sandiego?* involves chasing a spy around the world and learning geography in the process; simulation games called *SimCity* and *SimEarth* allow users to design a city or an entire planet and then observe the results of their decisions (Perleman 1993).

JOURNALISM RESPONDS: Laying the Groundwork

Although not much change seems to be taking place, the groundwork is being laid for news organizations to take advantage of the new media environment.

The Visionaries: They have the concept

Advanced technology and the "new media" it engenders have not been ignored by visionary mass media scholars.

McLuhan's *Understanding Media* (1964) hardly acknowledges the coming advances in computers yet presents a vision of "our new electric technology that extends our senses and nerves in a global embrace" (83).

Edwin Parker, according to Rice et al, also began to consider the new media in the early 1960s. Realizing while studying television effects that the policy decisions on television had already been made ten years earlier, Parker realized he should to "look forward, instead of backward, to shape and determine possible (and desired) effects of new media." He saw, says Rice, that "the medium he was using as a tool for research --- the computer --- was going to have much more social impact and be a factor in social change, than the medium he was then studying --- television" (1984, p. 24).

Bagdikian, as early as 1971, identifies access and interactivity as the key elements of a future information system. He proposes the possibilities of "a news system with a richer variety of information, a rapid way to detect what is available, easy pursuit of subjects of maximum interest to the individual beyond the standard presentation, and control over the time the information is presented" (68).

In a 1982 work, Dizard predicts a universal network and says the first two stages of the information age -- adoption of new technologies by the "primary information sector" and by public and private industries and organizations -- are underway. The third stage, he says, is the "mass consumerization of high-technology information services" (7), which would allow any person or group to transmit information globally.

Denis says the "technological revolution," along with changing patterns of media ownership, are "changing the shape of the media in America" (1989, p. 11).

Two books about to be published on advanced technology and the mass media are Roger Fidler's *Mediamorphosis* and John Pavlik's *Demystifying Media Technology*.

The Trade Journals: Their interest is piqued

Nora Paul, research librarian at the Poynter Institute, says computer bulletin boards are still relatively mysterious to many journalists. However, the vision of a new media can be found in today's mass media trade publications. Articles in *Columbia Journalism Review*, *Washington Journalism Review*, *ASNE Bulletin*, and *Editor and Publisher* show that journalists are beginning to survey the new communication media and reflect upon their potential. Underwood (1992) creates a picture of the multimedia newspaper. Katz (1992) enumerates several emerging technologies, including high definition television, dial up music videos, interactive controls for sports that allow viewers to choose camera angles, and interactive television services for shopping, paying bills, and other transactions. Silk (1991) predicts the advent of two-way switched video that will allow viewers to access any movie, video, or television show at any time, two-way videophones that may lead to video networks analogous to "chat" telephone, and multimedia newspapers, magazines books, and catalogues.

The Journals: Living in the present

Mass media journals, probably because of their tradition of quantitative research, most often address the topic of "new media" by referring to those that already exist: videocassette recorders, cable television, remote control devices, electronic databases, and bulletin board systems. Their major focus seems to be on determining characteristics of those who use new media and comparisons between the usage of the new and traditional media. However, many journals, particularly the *Journal of Communication*, are beginning to address the important issue of the future national network, the policies that it will involve, and its possible effects on democracy (Markus 1987, Braman 1989, Noam 1989, Murdock and Golding 1989, etc.)

The Freedom Forum

Media scholars have been participating in panel sessions at the Freedom Forum, a journalism think tank at Columbia University. Composed of university scholars, journalists, media corporation executives, FCC officials, and telecommunications experts, the panels are discussing the prospects for a national information service (FitzSimon 1992).

Media Industry Initiatives: Adopting the new technologies

According to John Pavlik, technology director of the Freedom Forum, precursors to the future media environment in broadcasting are beginning to be seen. Time Warner has recently established a 500 channel cable pilot project in Orlando, Florida, that allows customers to dial up for videos to watch on television. Serving as a preview of what future small entrepreneurs will be able to do with new satellite technology, Adam Clayton Powell III has established KMPT in San Franscisco for a few thousand dollars. Similarly, New York I runs on a small budget because of its use of inexpensive high eight video technology.

Pavlik says many newspaper companies are interested in new technology and managers are becoming more knowledgeable about the future network. Markoff (1992) says *Knight-Ridder*, the *Washington Post*, the *New York Times*, *Tribune*, and *Hearst* are all exploring electronic publishing. The *Washington Post* now distributes a fax version and the *Tribune* an online version, says Conniff (1993). Markoff also sees, however, much skepticism among newspaper veterans about whether electronic information will be workable and valuable to consumers.

Gannett serves as an example of how large media corporations are responding to new technology. Carolyn Wimbly Martin of Gannett's New Media Division says the company is using new technology to expand its information services. They are packaging information and news in a variety of ways and making it available via fax or computer and modem.

Since 1987, full-text versions of *USA Today, The Gannett News Service,* and *USA Weekend* have been provided to several online vendors 24 hours after press, and they have just begun real-time delivery of *USA Today*'s News and Money Sections and of *Gannett News Service* to online vendors. Their electronic news services also are distributed to several gateway systems of Regional Bell Operating Companies, to corporate and university clients, and to consumers' homes.

In addition to providing full-text news to computer owners, they offer compiled information called "Lifestyle Reports" that inform users on sports, TV, video releases, various statistics on news, money, and other areas, and a feature called "Lifeline," which tells "what people are talking about in the USA." They also deliver Decisionline via modem; this service provides summaries of news in 18 areas, including business law, health, technology, and U.S. news.

They are providing via fax the greater detail that some users need or want, such as company earnings reports. This past summer, they provided full transcripts of their interviews with the presidential candidates as a fax-on-demand option.

They also have an extensive range of audiotext offerings, including weather and travel information, stock quotes, used auto prices, sports scores, movie reviews, and an advice line.

Gannett explores advanced technology, particularly display technology. Gannett's Advanced Systems Lab (ASL) has been experimenting with pen-based computing devices, but the emphasis has been on technologies for the newsroom.

Knight-Ridder also is interested in newsroom technology. A testbed called *The Mercury Center* at the *San Jose Mercury*, is an experiment in integrating technology with an actual newspaper's mission.

Knight-Ridder's Information Design Lab, which opened in Fall 1992, seems to demonstrate the forefront in thinking about the high tech future of newspapers. Although investigating advances in audiotext and other current media technologies, IDL's centerpiece is an electronic newspaper.

Director Roger Fidler envisions in five years having a product based on today's notebook-sized computers. It will be a lightweight, battery-operated pen-based computer with a high resolution flat panel display (Fidler 1992). His vision includes a screen that displays the headlines, columns, and other typographic features of a newspaper but also can display video footage. Information for the electronic newspaper will be downloaded from the network and pages turned by a touch of the pen. The reader will be able to browse through summaries of items and advertising and select the ones they want to read with the pen. Selecting an item will display the entire text, as well as options for choosing sidebars, videos, and even graphics that allow the user to add personal data. (Fidler gives the example of entering his salary in a graphic chart which would compute how a new surtax would affect him.) Text on the page can be enlarged to any size. The pen, in addition to being able to work crossword puzzles, will be used to mark text or to do other information work.

RECOMMENDATIONS

The media industry seems to be moving toward the future in its adoption of existing technologies and its exploration of leading edge innovations. This initiative needs to continue. Technologies such as audiotext and online services are areas in which media organizations face competition from other non-media industries, who at any time may develop better technology. Media organizations should look closely at this arena to get an idea of what competition may be like in the future.

Second, media organizations should encourage many pilot projects, both large and small, like the Information Design Lab's electronic newspaper. One person's vision, pursued by the five people currently employed at the IDL, cannot create a new paradigm. The IDL states their intention to set the standards for the future electronic publishing industry. This can put Knight-Ridder in the position that IBM held until only recently, and other media corporations would be at a disadvantage. Also, Fidler's vision is, in many ways, a continuation of the paper and ink tradition, and there is good reason to pursue this course. However, it may happen that a completely different product will emerge from what are today non-media corporations. The media industry should give some though to what this completely new product might be.

PART III
HIGH TECH MEDIA: NEW REVOLUTION OR NEW SOCIAL MACHINE?

All citizens in a free society have the right to access information that will inform them of their rights, to register their opinions about political issues, and to recognize and shape conceptions in the media of the groups they represent (Murdock and Golding 1989, 183). Individuals and groups in the United States have never enjoyed these rights to the fullest, however, because publishers, editors, and reporters have always been required to exercise "information control" for the purpose of overcoming the constraints of time, space, complexity, and economics, and, some say, for the purpose of pleasing advertisers and maintaining the status of elite classes.

But new computing and communications technologies create new visions of democratization. Ithiel de Sola Pool uses the phrase "technologies of freedom." Others have spoken of "teledemocracy" and "electronic town halls." Several scholars have addressed the benefits of communications technology for community groups that do not have resources for mass communication (Rubinyi 1989, Gates 1984). Herbert S. Dordick asserts that a national information service should be "available to all, regardless of income, education, literacy and language proficiency, geographic location, class, race, and any other of the potentially divisive and discriminatory issues that often corrupt our society" (FitzSimon 1992, 23).

Unquestionably, technologies of choice, interaction, and experience present opportunities to change society dramatically. They can enhance freedom by fostering an inclusive, heterogeneous, democratic press that adds daily to a balanced knowledge base that enlightens and serves each individual. However, these advanced technologies also will have constraints that require the use of information control, and through the need for this control, they provide opportunities for an elite group of communicators, composed of the privileged and powerful, to enhance their influence and manipulate the public for the purpose of increasing their wealth and power.

The nucleus for the coming change is today's mass media.

New media technologies pose a challenge for journalists who believe in their responsibility to the public to join with concerned citizens in making the network, as well as the new information tools it makes possible, a medium that allows each person to know the truth and understand world events and that gives a voice to each citizen, especially those who are powerless.

The ultimate success of this ideal will be determined by the resolution of three conflicts of control that have already begun.

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