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The Microcomputer Catalyst

Introduction

Microcomputer—it is a word many of us first heard only a couple of years ago. Yet the technology this word represents holds promise of tremendous change. The changes catalyzed by microcomputing and its associated technologies may alter the fundamental nature of information handling in all its forms. This, of course, means that libraries and information centers will be profoundly affected by this new technology. This paper attempts to indicate some possible directions of the changes prompted by microcomputing technology. However, these ideas are offered only with the disclaimer that technology in this area is developing so rapidly that no one involved in computing can fully understand its implications. Hardware designers and software engineers involved in microcomputing are themselves still attempting to discern the values and possible uses of microcomputers. The only "given" most would agree upon is the recognition that microcomputers will alter the basic manner in which computers are used and viewed in our society.

General Definitions

Before exploring the implications of the previous statements in relation to information processing, some basic definition of *microcomputer* needs to be established. This task is, unfortunately, much more difficult than it first appears. Most of us presently conceive of micrcomputers as computers physically small enough to be called "desk-top" computers. This definition is readily usable, if not always strictly accurate. Another nontechnical definition would state that a microcomputer is a computer one can purchase at a retail store. This would include, for example, the Radio Shack or Apple computers, widely advertised on television. This definition is fine, too, so long as it is recognized that this expresses only one aspect of microcomputing. The concept of retail outlets for microcomputers has developed only in the past few years, and it should be borne in mind that microcomputers themselves were only invented in 1974 or 1975. So the methods of microcomputer sales and distribution are recent phenomena that may be subject to change. Furthermore, this last definition underplays the vast usage of microcomputers in business and industry, as well as the sale and distribution of these computers through "traditional" computer hardware vendors in a manner similar to the sale and servicing of the larger mainframe or minicomputers.

A Hardware Definition

Another approach to a definition of *microcomputer* can be derived from the technology on which computers are based. The invention of the "microprocesser" by Intel introduced microtechnology in 1971. A microprocesser (MPU) is a dense package of electrical circuitry etched on a piece of silicon typically smaller than a common postage stamp. The essential characteristic of the MPU is that it has the ability to perform the operations of its instruction set. Hence, the MPU can be a processer in the same sense as the central processer unit at the heart of any minicomputer or mainframe. However, at only several dollars per MPU, this technology represents a vastly cheaper form of central processer than was previously available.

It appears quite likely that MPUs will become integrated into a vast array of consumer products in "process control" or "product-specific intelligence" functions. In fact, MPUs already provide intelligence in products ranging from automobiles to microwave ovens and washer/dryers. This paper will not concern itself with these dedicated applications of MPUs, but rather with microcomputers. The difference between the two is simply that the microcomputer represents the addition of other components necessary for the creation of a full-fledged general-purpose computer. (For example, a microcomputer must include internal memory capability. In microcomputers, this memory presently is also based on microchip technology—silicon chips manufactured in a manner very similar to that of the processing unit itself.) A microcomputer must be programmable, and it is, therefore, a general-purpose computer.

A "microcomputing system" connotes the addition of associated hardware to the microcomputer. Storage devices provide the system with mass storage or external storage capability. In large computer systems, magnetic tapes and discs provide this capability. Microcomputer systems have analogous kinds of magnetic storage media. Floppy discs were invented concurrently with microcomputers and represent one common form of storage for those systems. Floppy discs are small discs, usually measuring either (approximately) five or eight inches in diameter. These discs have storage capacities commonly measured in terms of hundreds of thousands of characters (where about a thousand characters is called a kilobyte), or in millions of characters (megabytes). The storage capacity provided by any particular manufacturer depends on that vendor's hardware specifications. Various forms of tapes are also in widespread use in microcomputer systems. Cassette tapes, exactly the same as those used in home tape recorders, have been used. More sophisticated tape systems, similar to those on larger computers, are also available. Other forms of external storage exist, as well. Punched paper tape was popular on early systems, but its use has faded before the durability and recording density of magnetic tapes. Hard disc systems, like those of minicomputers, are a most significant form of magnetic media for microcomputers. Introduced in the late 1970s, these typically offer greater storage capacities than is possible with floppy discs, but the hard disc surfaces are not removable as with floppy technology. For many industrial and library applications, hard discs have quickly become a standard storage peripheral.

For output, printers commonly come in two primary varieties: dot matrix and impact. The dot matrix printers tend to be faster and less expensive, but the print quality varies. Impact printers, such as the "daisywheel" printers, offer letter-quality output. But these are comparatively slow and expensive. An extremely competitive situation has developed among firms attempting to design the first low-cost printers offering both speed and word-processing quality. At the time of this writing, the first letter-quality dot matrix printers are appearing on the market. These printers achieve high print quality by techniques such as dot overlapping and multiple-pass over-printing.

Finally, in characterizing the hardware nature of microcomputer systems, it is important to recognize the online orientation of such systems. The computer terminal, or CRT with keyboard, is the predominant means of interaction with microcomputers. Microcomputer systems have skipped the batch-orientation phase of development evident in the evolution of mainframe systems.

MPU Architectures

The various kinds of hardware commonly associated with microcomputer technology having briefly been mentioned, it is appropriate to discuss further the microprocesser units themselves. Until about 1980, the vast majority of general-purpose microcomputers employed processers with 8-bit word sizes. This means that the instruction set was designed such that the basic unit of information manipulated by the computer was one "byte" (eight bits of information). Three major groups of microprocesser architectures, or "families," established dominance. These microprocesser families are the 8080/Z80, the 6800, and the 6502.

Although microcomputer sales still emphasized 8-bit MPU architecture as of late 1980, the emphasis in microprocesser *design* has definitely shifted toward 16-bit and 32-bit architectures. The 16-bit microprocessers descended from the 8080/Z80 8-bit family include the 8086 and the Z8000. Motorola's 68000 represents the 16-bit evolution of the 6800, while the 16-bit descendant of the 6502 is still a rumor, called the 6516, at the time of this writing. The first 32-bit microprocessers were publicly demonstrated in early 1981. These include the iAPX 432 from Intel, and others from Hewlett-Packard. IBM is said to have a microprocesser utilizing the Series 360 instruction set in a working prototype stage.

There are several reasons for this evolution of microprocesser architecture toward 16- and 32-bit designs. The first is that the 8-bit microcomputers of the 1975-80 era were architecturally limited to maximum internal memory sizes of 64 kilobytes. This is not much of a problem for many personal computers, but it can be a severe limitation on a business or industrially-oriented computer system. Sixteen- and 32-bit MPU designs represent one remedy to this limitation. Second, most minicomputers have 16-bit words, while mainframes most often have 32-bit designs. Thus, creation of microcomputers of these word sizes raises the distinct possibility of various degrees of software compatibility among microcomputers, minicomputers and mainframes. In essence, microtechnology could become just another hardware technique in building what were once considered minicomputers and mainframes. The implications of this idea will be more thoroughly explored later in this paper.

Microcomputer Software

From a computer systems viewpoint, the software, or programs, run on any computer are as important as the hardware itself. Most microcomputers are purchased with various essential software packages. The software may be either included as part of the basic microcomputer-system price, or priced separately for the user to buy as an option. In either case, almost any use of a microcomputer (except for very limited or special-purpose uses) requires certain essential software. Among these programs are: (1) an operating system, which is a basic control program that monitors operation and use of the computer system; (2) various programming languages, which are used in the development of computer programs; (3) text editors, or word processing software, which facilitate the creation and manipulation of textual products (e.g., correspondence or this paper); (4) networking or telecommunications software, which makes it possible to have the microcomputer communicate with other microcomputers or computing systems; and (5) general-purpose utility programs, which perform common tasks for the user (e.g., making backup copies of programs or data).

This list has included only a few of the many kinds of programs available for microcomputer systems. They are all "systems programs," or programming products with which, or upon which, the user's "applications programs" are built. The applications programs are the programs that are created to handle a particular need of the end user. For example, a library circulation program is an application program that fulfills an end user need. Needless to say, as the microcomputer market matures, applications-program products are increasingly being offered for sale for microcomputer systems.

One important trend in computing has been the evolution of the "turnkey" system approach. In this approach, the applications programs required by the end user or purchaser of the computer system are provided by the vendor of the system with the system hardware. The previous example of a library circulation system is pertinent to this concept. A library could purchase a microcomputer system, along with some of the basic systems programs mentioned earlier, and then create its own circulation system applications program(s). Or, it might be possible for the library to purchase an existing or generalized circulation program and avoid some of the costs associated with creating that software itself. In the case of the turnkey system, the necessary applications software is obtained with the hardware directly from one fully responsible vendor. The vendor must provide the computer programs and ensure they operate correctly. This approach has been widely used with circulation systems and minicomputer technology. The principle has been belabored here because the economics of microcomputing technology are such that the turnkey approach may become widely popular with microcomputing systems. This is especially true in that microcomputers are inexpensive enough that they can be economically dedicated to special-purpose or single-purpose applications. In view of microcomputer hardware costs, it is quite realistic to speak of having one turnkey microcomputer system dedicated to one library function, with other microcomputer system(s) dedicated to other computing needs.

Trends in Computer Hardware Costs

In the previous sections, the present characteristics of microcomputer hardware and software have been briefly discussed. It should be kept in mind, however, that the pace of change in this field is unbelievably rapid, and that change itself is an aspect of central importance in considering microcomputer systems. For this reason, I will offer speculation on a few of the directions microtechnology may take; but first, it is appropriate to place the impact of microtechnology in perspective by providing an analysis of historical trends in computing costs. The sketches in figure 1 are rough approximations only, but they serve to tell a significant story.

The first few graphs indicate that the relative prices of major computer hardware components have been dropping since the inception of computers. These major components of computing systems include the "main memory" or "internal memory" of the computer, as well as the "external" or "mass" storage represented by magnetic storage media like tape and disc.

Whether or not the price/performance ratio decreases were constant, and the exact figures involved, is not important for the purposes of comparison. The important point is contained in figure 1b. This diagram shows that the historical decline in central processer prices has not participated in the general hardware price decline to the extent of other computing system components. Even with the introduction of minicomputers in the late 1960s, processers remained somewhat dear. The essential impact of the microprocesser is that it has drastically bent this last curve during the past five or eight years. The fundamental price equation of computing has been altered in a dramatic way—for the first time in history, processers themselves have led the price/performance revolution. For example, the computing power one can purchase in an MPU like Intel's 8080 for $4 today cost approximately $500,000 in 1969.[1] Computing intelligence itself is now being distributed on a massive scale.

Possible Impacts

By isolating the essential fact that intelligence (the central processing unit) has recently become very inexpensive, many of the possible impacts of microtechnology become clearer. The fundamental nature of computing itself will be affected by this new cost reality concerning processers. For example, in order to gain processing efficiencies, mainframe computer systems have long exhibited a hierarchical scheme of intelligence. In the center of the system was the single central processer unit. Around this unique resource, a hierarchy of lesser special-purpose processers was arranged. Peripheral intelligences, including channels, control units and controllers, offered the central processer the opportunity to off-load a certain amount of its work to these special-purpose, limited processers. But now, with the introduction of MPUs and microcomputers, fully intelligent, more flexible processers are available in abundance. Why have a

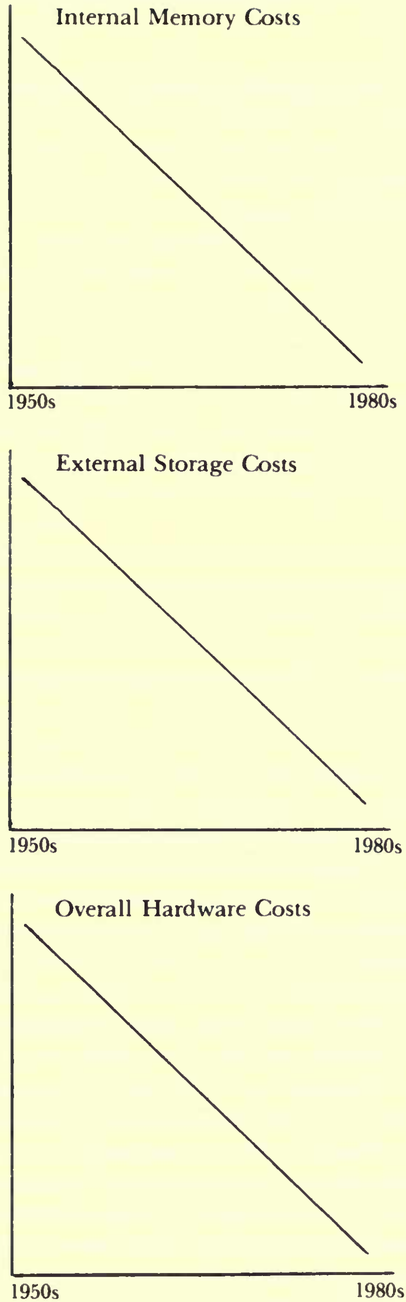

Fig. 1a. Trends in Computer Hardware Costs

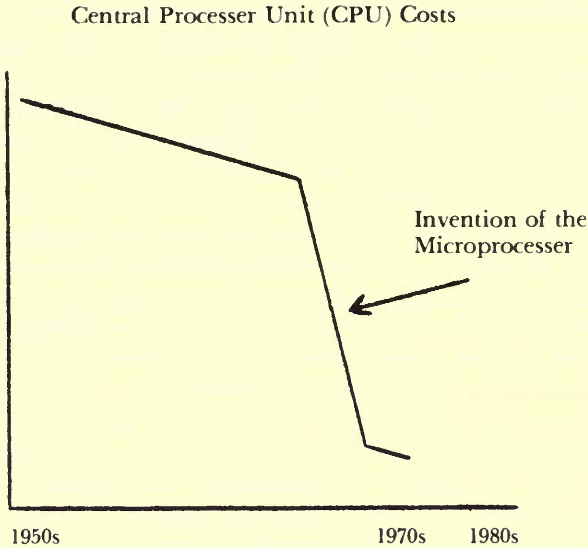

Fig. 1b. Trends in Central Processer Costs

channel, with its limited instruction set, when a more programmable and flexible MPU will cost-effectively fill the same role? I am not necessarily advocating the replacement of channels with MPUs—there are many more technical aspects of such a decision which need not be explored in this paper. The essential point is that microcomputers offer a potential in the design and implementation of large systems that just did not exist before the MPU revolution.

Other, related possible impacts are those of "front-end" and "back-end" processers. "Front-end" processers are computers dedicated to handling communications, as in a mainframe system, for example. "Back-end" processers represent the similar attempt to off-load database processing. Needless to say, inexpensive microcomputer systems may make both these technologies of mainframe design ever more affordable. Most interestingly, microcomputers are so inexpensive that they can be utilized as dedicated "front-ends" or "back-ends" to minicomputers, or even other microcomputers. Again, we do not need to delve into technological specifics to see that microcomputers can have a fundamental impact on computer systems design in this area.

The previous suggestions concerning possible impacts of microcomputer technology have been related to the manner in which microcomputers may affect traditional or preexisting mainframe design approaches.

Such possibilities represent a very basic alteration of the manner in which general-purpose computers can be designed. It would, however, be presumptuous—and almost certainly inaccurate—to limit our view of microcomputers to the ways in which they fit into mainframe design structures. For example, some microcomputer proponents have advocated creation of a computer with mainframe power through groups of full-fledged microcomputer systems closely interconnected by software methodologies. The IMSAI Hypercube is an example of one such attempt to tie microcomputers closely together into software configurations whose aggregate power can compete with mainframes. There are several variations and approaches to implementation of this idea of creating the processing power of a mainframe from a collection of software-interwoven microcomputers. Since the software involved would be sophisticated, such systems will take time to develop, but further experimentation and progress on this theme is certain.

A somewhat related idea is that of the microcomputer network. This concept advocates creation of micro-nets with large aggregate computing power, such as already discussed. However, the emphasis is not on "aggregate power" (a mainframe replacement approach), but rather on the expandability and flexibility offered by microcomputer networks. For example, current "local network" products, such as Zilog's Z-Net, Nestar System's Cluster/One, and Corvus System's Constellation, promote flexibility in network-wide resource sharing. Expansion of the network is natural and convenient, in that one need only add another (compatible) microcomputer. This is in contrast to a minicomputer, for example, where addition of another (dumb) terminal means less power, not more. Traditional minicomputer and mainframe systems configurations can be enhanced only by adding computational power at the center.

In the discussion of MPU families, the migration of MPUs toward 16- and 32-bit architectures was briefly mentioned. This raises the probability that many computers which are today considered minicomputers or mainframes could be built using microtechnology. In fact, several companies have already announced 32-bit MPUs that are clearly intended to evolve into what are being called "micromainframes." In terms of traditional computing, the impacts of this trend could be enormous. An especially intriguing idea related to the micromainframe concept is the possibility of a "370 on a chip." It appears quite possible to create an MPU having the instruction set of the widespread 360/370/4300/303X/3081 series of mainframe computers from IBM on a single microchip. At the time of this writing, it is said that IBM has already accomplished this development.

The possible significance of such a microcomputer mainframe is that the vast universe of software currently available for the 370 family of computers would be instantly accessible. Since the mid-1960s, this computer family and its relations have totally dominated mainframe sales. More programmers are familiar with it than any other general-purpose mainframe, and more software has been created for it than for any other mainframe. At the present time, it is widely agreed that the creation of software of adequate quality, in a reasonable time and for a reasonable cost, is the major problem facing any computer-using organization. This problem has become so serious, it is often referred to as the "software problem." The realization of a "plug-compatible replacement" for a 370-class mainframe through MPU technology could lead to a much greater proliferation of the computer system best positioned to reduce the software problem through existing programming.

The desirability of 32-bit micromainframes of "plug-compatible"—or "code-compatible"—design is not universally acknowledged, however. Some people feel that 370 compatibility is inimical to the basic software simplicity offered in microcomputer-based systems. Others state that microtechnology can best be utilized in new computer designs that do not imitate the computer architectures of the past. For example, some MPU designers feel that the true promise of the technology in attacking the "software problem" lies in using this inexpensive intelligence to move some traditional areas of software concern into the hardware. For example, processers could be dedicated to particular software functions, such as system memory management or programming-language interpretation. Whatever approaches are taken concerning these questions, the implications of micromainframes of one kind or another are sure to be important in terms of current business uses of computers.

The development of "viewdata" and "teletext"-type systems represents another major possible application of microcomputer technology. Clearly, these systems will have an expanding need for intelligence to facilitate and control their services. As such systems evolve and grow, microcomputers will offer a significant, perhaps vital, technology for expansion. For example, where a truly mass market is implied, microprocesser/microcomputer intelligence in the television (the entry-point terminal to the system) appears likely. This would give the end user of such a system local computing power while avoiding excessive telecommunications costs. Thus, the use of microcomputers would appear to offer the designers of these systems one possible method of allowing the necessary aggregate computing power in the systems to expand naturally in response to growth of the total user base.

As stand-alone systems, microcomputers can be put to dozens of uses in libraries. I have not explored their uses in this respect, because they are far too numerous to discuss in a single paper. As significant as the concept of the microcomputer as a stand-alone system, however, is the impetus micro-technology has given to the decentralization of computing. That is, the trend in computing from the mid-1960s through the early 1970s was widely viewed as one of centralization. Large computer systems became increasingly powerful, and even with the advent of the minicomputer, much of the attention in computing was focused on the evolution of these large computer centers. In the mid- and late 1970s, however, the microcomputer entered the picture. The vast cost reductions of semiconductor technology in terms of memory and MPU intelligence led to the ascendancy of the "distributed processing" concept. With inexpensive intelligence available, it could now be applied in "distributed systems," essentially closely interwoven networks of computer resources. Processers themselves, once so dear, would be a common resource within the distributed processing scheme. As networking and communications software are developed, we can expect to see microcomputers having impacts far beyond those immediately apparent in their uses in dedicated and stand-alone systems.

Conclusion

In this discussion, only a few of the many impacts microcomputing is likely to have on the basic nature of computing have been mentioned. Clearly, it lies beyond the scope of a single paper to do much more than suggest a few of the present and future impacts and uses of microcomputers. But from this confusion of possibilities, two facts emerge most distinctly. The first is that microcomputers will change the fundamental nature of computing in ways that cannot yet be fathomed. One should not restrict one's views of microcomputing to limited or preconceived notions, nor should one blithely assume that the present impacts of microcomputers foreshadow or determine their future uses. Second, each of us should be fully and consciously aware of the unbelievable rate of change and development in this area. Such change is itself a major aspect of microcomputing, and it must be considered and included in any plan or outlook pertaining to the use of microcomputing technology.

For Further Information

In the space of the past five years of microtechnological hardware development, several technologies related to microcomputers have already risen and fallen in importance and usage. For example, punched paper tape has already reached near-obsolescence as a storage medium, while microcomputer hard disc capabilities and 16-bit processers, both introduced about 1978, are becoming standard in many industrial systems. And computer technologies such as optical disc loom as potentially prominent in the future.

With the pace of microcomputer hardware development so unbelievably rapid, a paper such as this is truly outdated the moment it is published. Furthermore, it can be simply misleading after several years. For this reason, a list of current microcomputer journals and newspapers has been included as appendix A. The reader is cautioned that only very recent issues of these computer magazines and newspapers will provide current information concerning the state of the art in microcomputer hardware, software and pricing. Books are useful for background information and concepts concerning microcomputers, but the time lag inevitably involved in their publication prevents them from providing current hardware and software specifications. With this caution, a brief listing of sources for further information on microcomputers follows in appendix B.

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APPENDIX A

Microcomputer Magazines and Newspapers

Key: B = Of likely interest to persons beginning in microcomputers; or, particularly oriented toward the hobbyist market.
M = Of medium difficulty/readability. May be of interest to persons from neophytes to professionals.
P = Oriented toward, or most useful to, computer professionals; or, requiring substantial technical background or training.

Byte (M)
—articles on hardware & software, widely popular

Computer Design (P)
—computer electronics

Computerworld (M)
—general computing news, special section on mini's & micro's

Creative Computing (B)
—game orientation, hobbyist market

Disk/Trend Report (P)
—current news on hardware advances useful to industry insiders

Dr. Dobb's Journal of Computer Calisthenics and Orthodontia (M)
—has published some of the more widely recognized articles

Electronic Design (P)
—a weekly magazine on computer electronics

Electronic Engineering Times (P)
—weekly newspaper for microcomputer hardware professionals

IEEE Micro (P)
—new technical microcomputer publication from the IEEE

Infoworld (M)
—perhaps the best single news source for software professionals

Interface Age (M)
—similar to *Byte*, has a wide coverage, esp. for small businesses

Microsystems (M)
—new source devoted to S-100 and CP/M systems

Mini-Micro Computer Reports (P)
—up-to-the-minute news in the mini/micro industry

Mini-Micro Systems (M)
—excellent overview articles and product surveys, also tutorials

onComputing (M)
—quarterly with many nice articles for micro enthusiasts

Personal Computing (B)
—another of the popular magazines on personal computers

Random Access International (P)
—expensive information on new hardware for industry insiders

Recreational Computing (B)
—describes interesting applications, oriented toward hobbyists

Appendix A—*Continued*

Silicon Gulch Gazette (B)
—gossip and news from the valley, news on new micro applications

Small Business Computers Magazine (M)
—oriented toward common business uses of microcomputers

Small Systems World (M)
—particularly good for tutorials for mini- and micro-software

APPENDIX B

Sources for Microcomputer Information

Clubs—
A wide variety of microcomputer clubs exists, ranging from local to national organizations. Some consist purely of local hobbyists, whereas others are "official" product or company user groups. Clubs are an excellent source of information from experienced users concerning specific hardware and software products.

Newsletters—
A myriad of microcomputer newsletters address the needs of user groups of particular hardware and/or software. Many also serve as organs for either independent or partisan clubs and vendors. Newsletters are most often special-interest in their orientations.

Computer consultants—
In the business world, computing talent is not inexpensive. But, a system proposal or programming project of large size or sophistication may well present a need for professional consultants or a permanent professional staff. Advertisements in the magazines and newspapers enumerated in Appendix A are one source of consultant listings.

Conferences/shows—
Personal computer shows as well as microcomputer exhibits at traditional computer conventions provide an excellent chance to meet hardware manufacturers, software vendors, large retailers and interesting and creative individuals all under one roof. There are now dozens of such shows of national and local import; two of the best known are the West Coast Computer Faire, and the National Computer Conference (NCC).

Books—
Hardback and softbound books are available on almost any aspect of microcomputing, from programming through advanced hardware internals. In general, books are best for learning fundamentals and principles.

Retail stores—
The burgeoning growth of microcomputer retail outlets has resulted in another major source of information for microcomputer users. Local store owners can provide names of clubs, newsletters and other organizations pertinent to microcomputing in their locale.

Appendix B—*Continued*

Magazines—

Newspapers and magazines devoted to microcomputing are perhaps the best sources for current information in printed form. This is as opposed to: (1) books, and (2) articles in library journals. (These sources generally suffer from publication lead times that are unreasonable in terms of microcomputer evolution.) Since periodicals are so vital, a list of some of the major ones is provided here. Some indication as to the general readability and orientations of the magazines is given by the associated key. This key should not be taken literally—it is only the author's casual opinion and is intended simply as an initial guide in information-seeking.

REFERENCE

1. *Datamation*, vol. 27, no. 2, Feb. 1981, p. 56.