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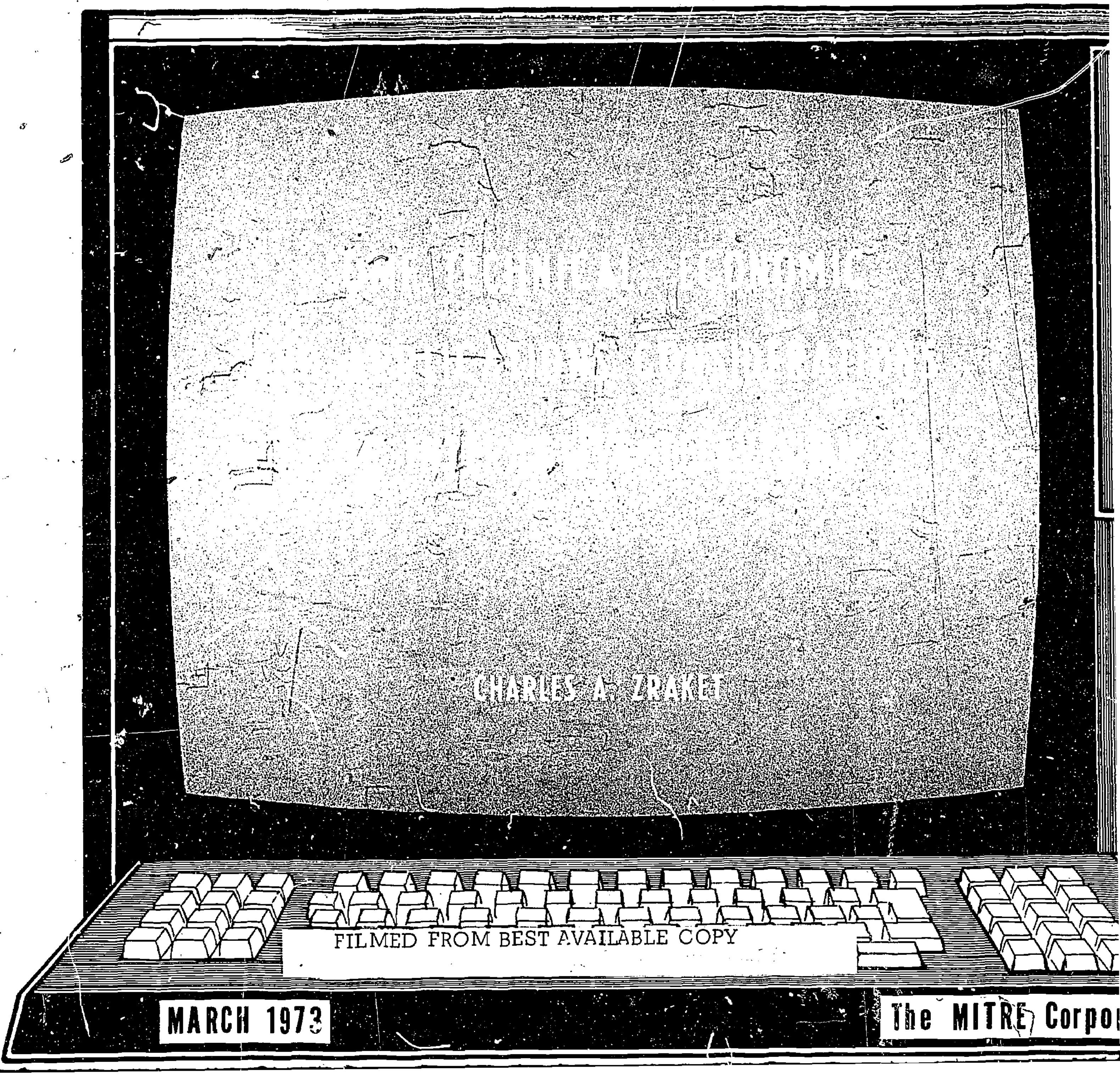
ABSTRACT

During the present decade cable television (CATV) systems will be franchised in most metropolitan areas of the nation. Previously, CATV has mainly transmitted over-the-air broadcast signals to small communities, but in the urban setting the capabilities of wideband cable (e.g., 30 channels per cable) can be expanded and applied to new communication needs. First, however, CATV must outgrow its identity as a retransmitter and become the medium for delivering a wide range of broadband communications services. Linked with computers, interactive cable systems can serve social, cultural, civic, education, governmental, business and commercial interests. The utility and importance of interactive CATV systems stem from the following characteristics: 1) they are individualized and respond instantly, privately, and economically to the user's needs; 2) they are computerized, offering search and calculation capabilities otherwise not available; 3) they provide unlimited points of entry and delivery of information, in addition to controlled storage, access, and retrieval; and 4) they are multimedia, encompassing video, audio, graphics, pictures, and alphanumeric text, and offer the potential of a common carrier between people. (Author/PB)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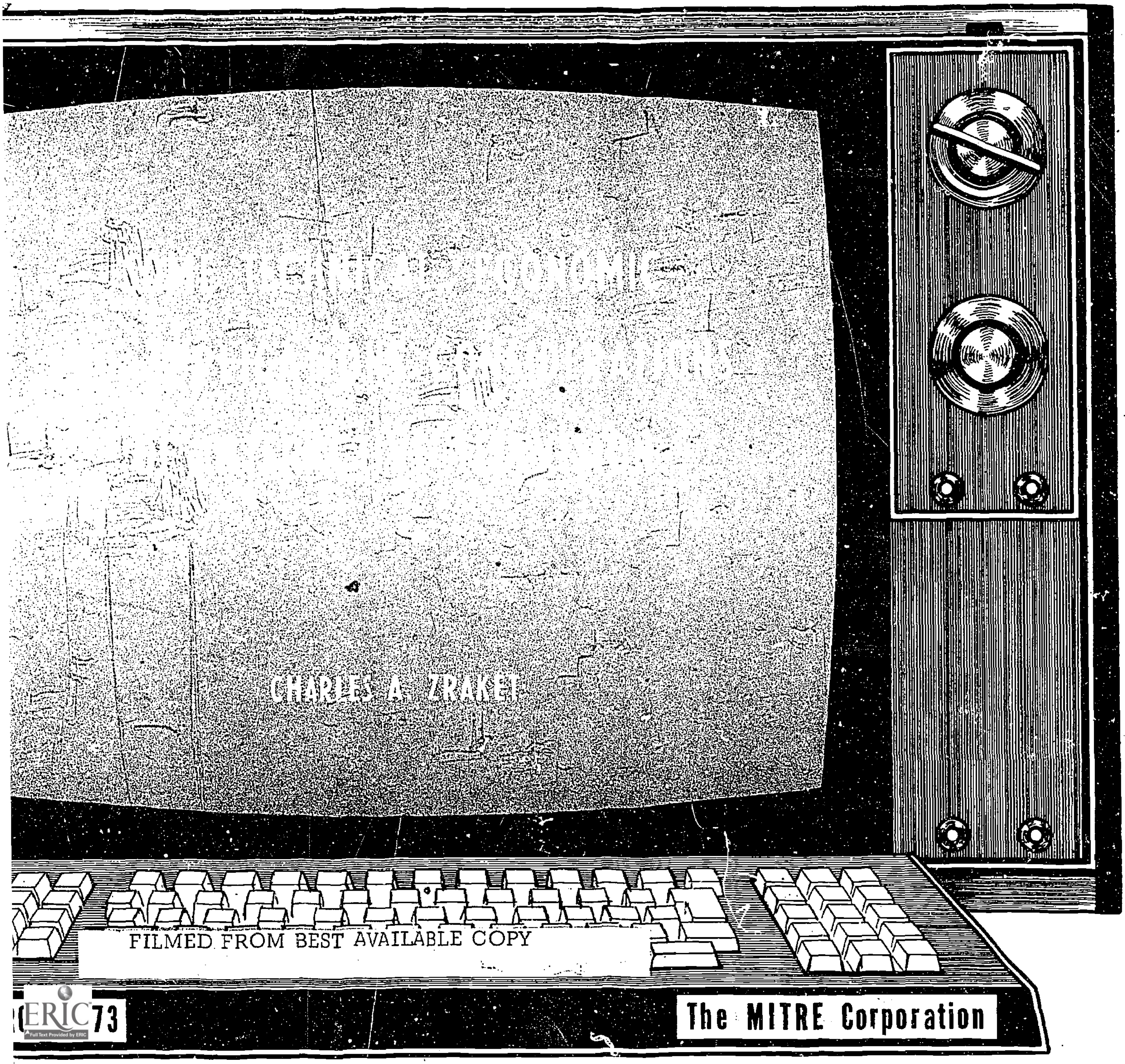

SOME TECHNICAL, ECONOMIC AND APPLICATIONS CONSIDERATIONS OF INTERACTIVE TELEVISION

BY

CHARLES A. ZRAKET

TEXT OF PAPER GIVEN AT THE SEMINAR ON THE "PROMISE OF CABLE AND SATELLITE COMMUNICATIONS," 1 MARCH 1973

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WASHINGTON OPERATIONS

ABSTRACT

During the present decade, it is expected that cable television systems will be franchised and built in most of the cities in metropolitan areas of the nation. Up to now, cable television has served mostly to retransmit over-the-air broadcast signals into small towns and communities.

In this new urban setting, the capabilities of wideband cable (e.g., 30 TV channels per cable) can be expanded greatly and applied to important, but yet unmet, communication needs of our cities and their society.

The use of wideband cable systems in conjunction with computer systems offers great opportunities in exploiting the potential of interactive television for business, commercial, social, cultural, educational, and governmental needs. Current technology is capable of making such a system economically viable.

ACKNOWLEDGEMENTS

I wish to thank John Volk, Lee Bertman, and Rodney Lay of MITRE for their assistance in assembling the material for this paper.

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Technical Problems Relating to the Future of Broadband Communications by W. F. Utlaut, Institute for Telecommunication Sciences

Cable TV and Satellites by R. Marsten, NASA

Interactive Television by C. Zraket, MITRE Corporation

INTRODUCTION

During the present decade, it is expected that cable television systems will be franchised and built in most of the cities in metropolitan areas of the nation. Up to now, cable television has served mostly to retransmit over-the-air broadcast signals into small towns and communities.

In this new urban setting, the capabilities of wideband cable (e.g., 30 TV channels per cable) can be expanded greatly and applied to important, but yet unmet, communication needs of our cities and their society. Cable will thus have the opportunity to effect and even transform many features of urban life, but to do this successfully it must, itself, be transformed. To play its potential role as the cutting edge of the coming communications revolution, cable must outgrow its identity as a simple retransmitter of over-the-air TV signals, and become the medium for delivering a wide range of broadband two-way communications services to fulfill many of the social, cultural, civic, educational, governmental, business, and commercial needs of the city. Introducing this new form of communication into the main stream of American society, in such a way that its promises will not be abridged or underplayed, is one of the most important and complex tasks of the 1970's. The MITRE Corporation, through its reports and developmental activities, has been attempting to provide information and guidance designed to assist cable owners and operators, program groups, government officials, community leaders, and civic groups to achieve that goal.

MITRE has, for the past five years, been working in the areas of cable and interactive television. This has included a broad study of the needs and requirements for cable television in an urban area, sponsored by the John and Mary Markle Foundation; the development of a computer-assisted instruction system for community colleges and the introduction of the first truly interactive television system in Reston, Virginia, both under the sponsorship of the National Science Foundation.

This paper is meant to provide an overview of a particular set of concepts of interactive television developed at MITRE by first discussing the technology and economics of interactive television, and then by showing some illustrative applications of this new medium and the status of our Reston experimental system. The importance of interactive television stems from the following characteristics:

(1) Interactive television is individualized. It responds "instantly" to the demands of each viewer, permitting him to receive detailed information economically and privately.

(2) It is computerized, offering search and calculation of broad data banks of information that might otherwise be difficult to obtain.

(3) It provides unlimited points of entry and delivery of information (similar to the advantages of the telephone and the mail); but, in addition, it offers controlled storage, access, and unparalleled speed and convenience of retrieval.

(4) It is multimedia, providing video, audio, graphics, pictures and alphanumeric text, and computer assistance all within one system, and offering the potential of a common carrier between people (i.e., two-way videophone "snapshots" updated periodically).

Most of today's cable television systems have achieved economic success because they deliver a large selection of over-the-air broadcast TV signals, or at least clearer pictures in areas where reception is inferior. In most urban areas, however, residents already receive large numbers of TV signals with acceptable clarity. If cable systems are to be viable in the 100 or so, large urban areas in the U. S., they will have to deliver a variety of new and attractive programs and special services to obtain subscribers. Examples of these new services include pay television, interactive television, and special communications facilities for businesses and government offices.

A cable television system for an urban area could include facilities for both broadband TV to all homes from a central headend and, in addition, point-to-point broadband communication (switched at the headend) for business and government offices. There are many variations in the network design of cable systems being discussed for urban areas. The variations have to do with the number, placement, and interconnection of regional headends in the city (e.g., tree vs. hub networks); the choice of a single or dual-cable system; and the technical approaches for two-way capability. The costs for an urban cable system are sensitive to many parameters and in particular, the density of subscribers which affects the length of feeder lines needed, the percentage of cable that must be run underground, and the subscriber penetration. Typically, the cost per subscriber drop ranges from $100 to $200 per home. One favorite network configuration today is to use a dual-trunk, single-feeder system equipped for two-way transmission. Transmission is by standard TV analog signal; concepts are now under experimentation using digital transmission for special point-to-point networks.

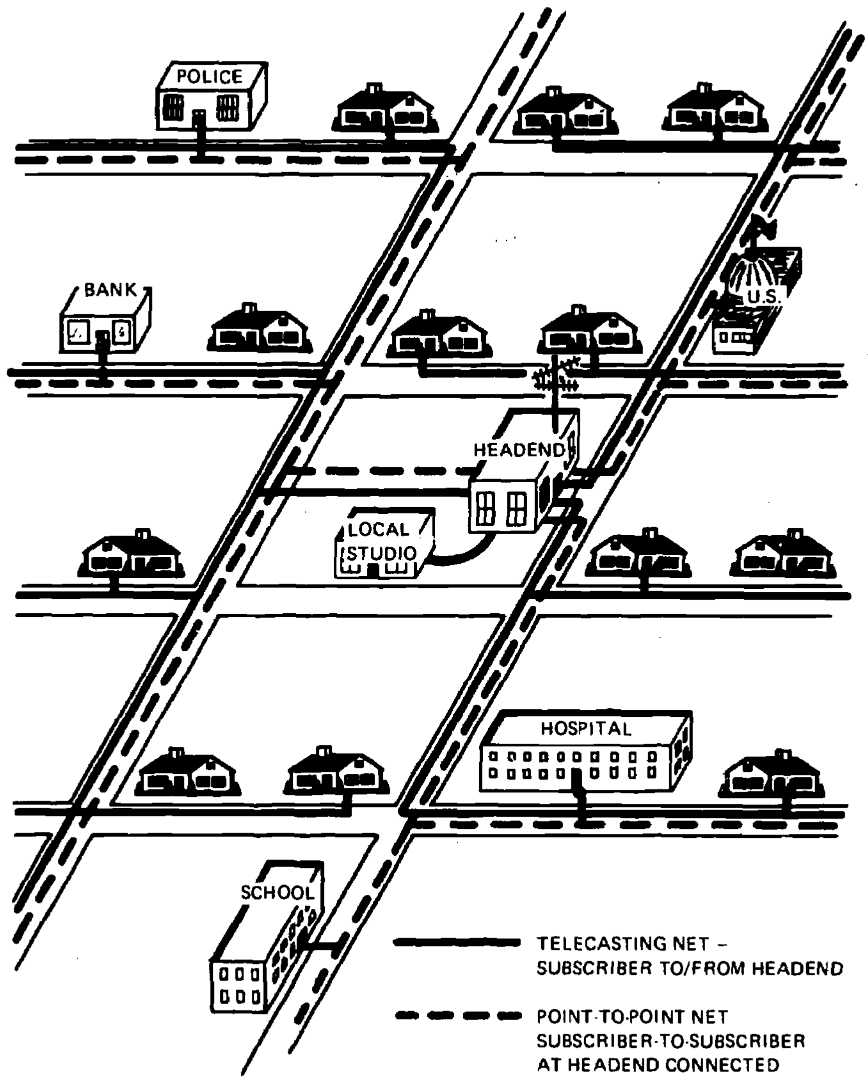
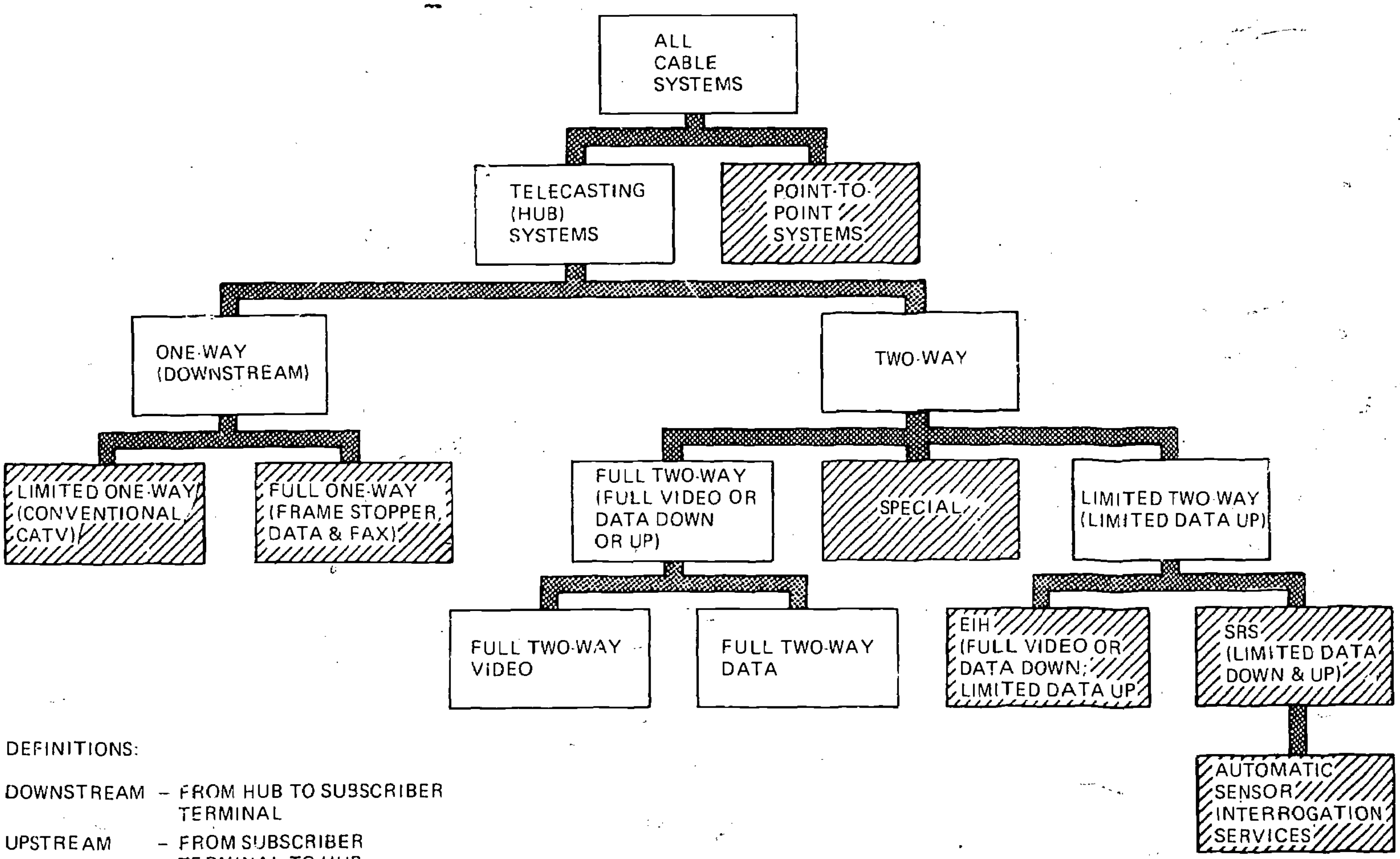


FIGURE 1
TELECASTING AND POINT-TO-POINT NETS

Cable systems can be categorized into the systems outlined on this chart. This paper is concerned primarily with limited two-way systems.



DEFINITIONS:

DOWNSTREAM – FROM HUB TO SUBSCRIBER TERMINAL

UPSTREAM – FROM SUBSCRIBER TERMINAL TO HUB

FIGURE 2
HIERARCHY OF CABLE TELEVISION SYSTEMS

TECHNICAL DISCUSSION

An interactive television system (e.g., MITRE's TICCIT, Time-Shared Interactive Computer-Controlled Information Television) uses the home TV receiver as a display of computer-generated information and data retrieved from computer-controlled data bases. Communication between the home and computer is provided by a two-way cable TV system that also brings broadcast and pay TV into the home. The home viewer can command the computer to provide information with a small keyboard like that used on a pocket calculator or can enter information into the computer's data base with a larger typewriter-like keyboard. The kinds of consumer-oriented computer services being proposed include teleshopping, telebanking, reservations, computer-assisted instruction, information retrieval (like, "When does the next bus leave for downtown," "What is my congressman's address," etc.), computer-mediated games, polls and straw votes, hospital-doctor-patient communications, and many, many more. It should be noted that retrievable information is not limited to text but may also include graphics, photographs, audio messages, and video tapes.

A home viewer may be inhibited in his use of certain interactive television services if he knew his neighbor could easily monitor his interactions with the computer. To provide the viewer with a reasonable degree of privacy, simple electronic signal-scrambling techniques can be employed. It appears that the same techniques and devices being proposed to scramble pay TV would be applicable to interactive television; e.g., scrambler systems, channel-shifting and address coder-decoder systems, and switching systems.

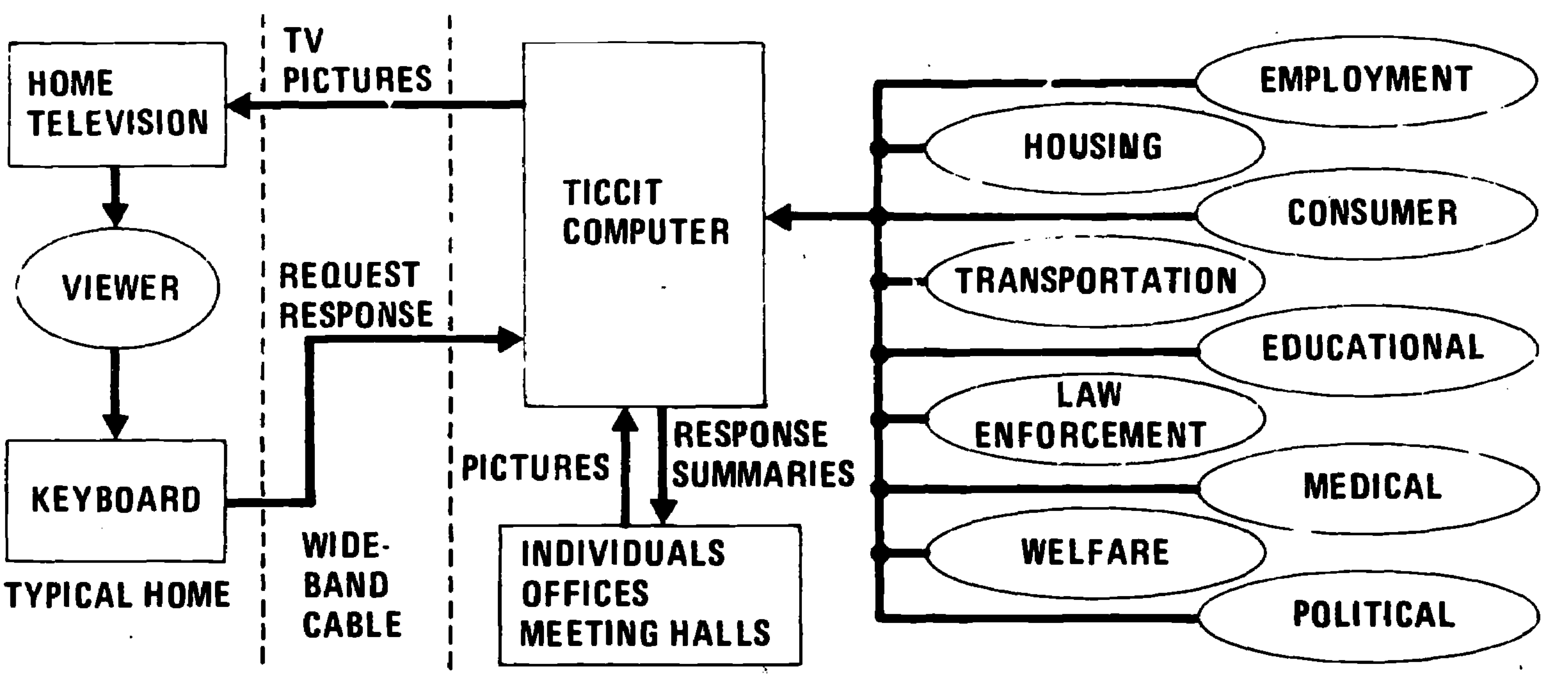


FIGURE 3
INTERACTIVE TV SYSTEM

FIGURE 3
INTERACTIVE TV SYSTEM

The TICCIT computer system separates foreground and background tasks with a minicomputer devoted to each. The terminal processor performs all fast reaction, highly stereotyped functions interacting with the home terminals, including display generation, as well as keyboard input multiplexing. The main processor utilizing the TICCIT data base assembles pages to be displayed as a function of the data base and user requests. Tasks of the main processor are diverse and relatively slow paced.

The main processor, a Data General Nova 800, is configured as a time-sharing minicomputer with 49,152 words of core storage, special hardware time-sharing protection features, and the usual host of standard peripherals, in addition to two large moving-head disc drives and a small fixed-head disc unit.

The terminal processor, a Nova 800, is similar to the main processor but with less memory. As its name implies, it services the TICCIT terminals by receiving and processing keyboard entries and by generating new displays to be sent to the home terminal (for instance, "echoing" characters to the home terminal as they are typed). The processor-to-processor link uses a direct memory-to-memory data transfer system to provide fast inter-computer data communications.

The TICCIT data base is split between two large moving-head disc drives. The disc drive on the terminal processor stores predominantly graphic material while the data base disc on the main processor stores text and program logic. Another moving-head disc of the same type connected to the main processor holds user records.

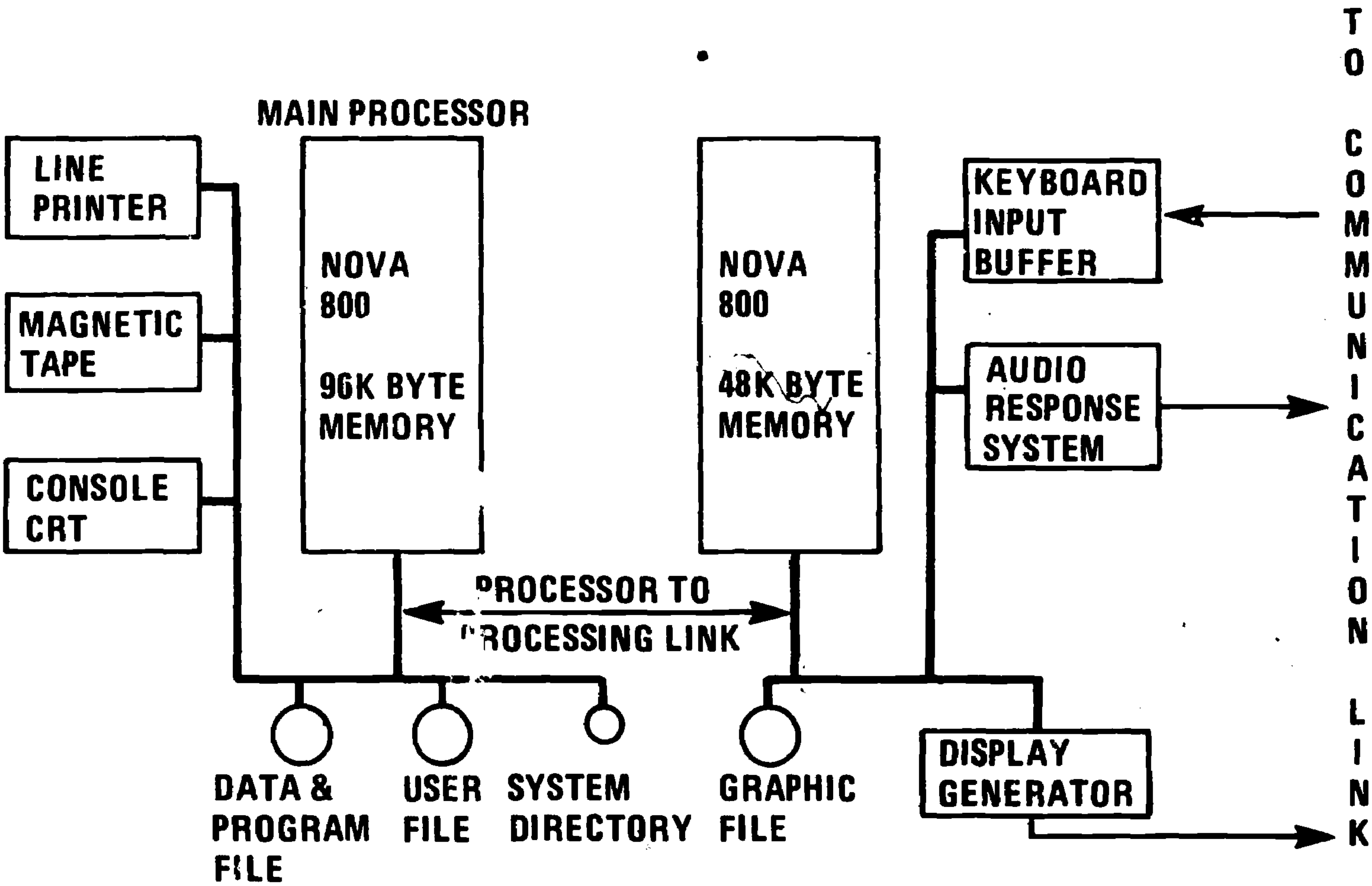


FIGURE 4
TICCIT COMPUTER SYSTEM

The main technical design decision to be made in an interactive television system is how the computer should send displays to the home. It is our belief that the interactive TV system should be able not only to send text, but also graphics and photographic information. The basic elements of a system to support this capability are shown here. The computer can cause the generation of text and graphic displays, as well as retrieve photographic images. All displays are converted to a TV signal format and passed to a video refresh memory in no more than 1/30 of a second. The video refresh memory captures and holds this video image for continuous playback on a home TV. The refresh memory allows one display generator and photographic file to be shared by many users. The basic design question is where to insert the communications link in this block diagram. Two approaches look promising.

The first approach which MITRE demonstrated in its Reston, Virginia test of interactive television, uses a refresh memory in the home. The output of the display generator and the photo file is distributed to the users of the system over a single TV channel that is time-shared by as many as several hundred simultaneous users, each getting a different "still picture" of his choice.

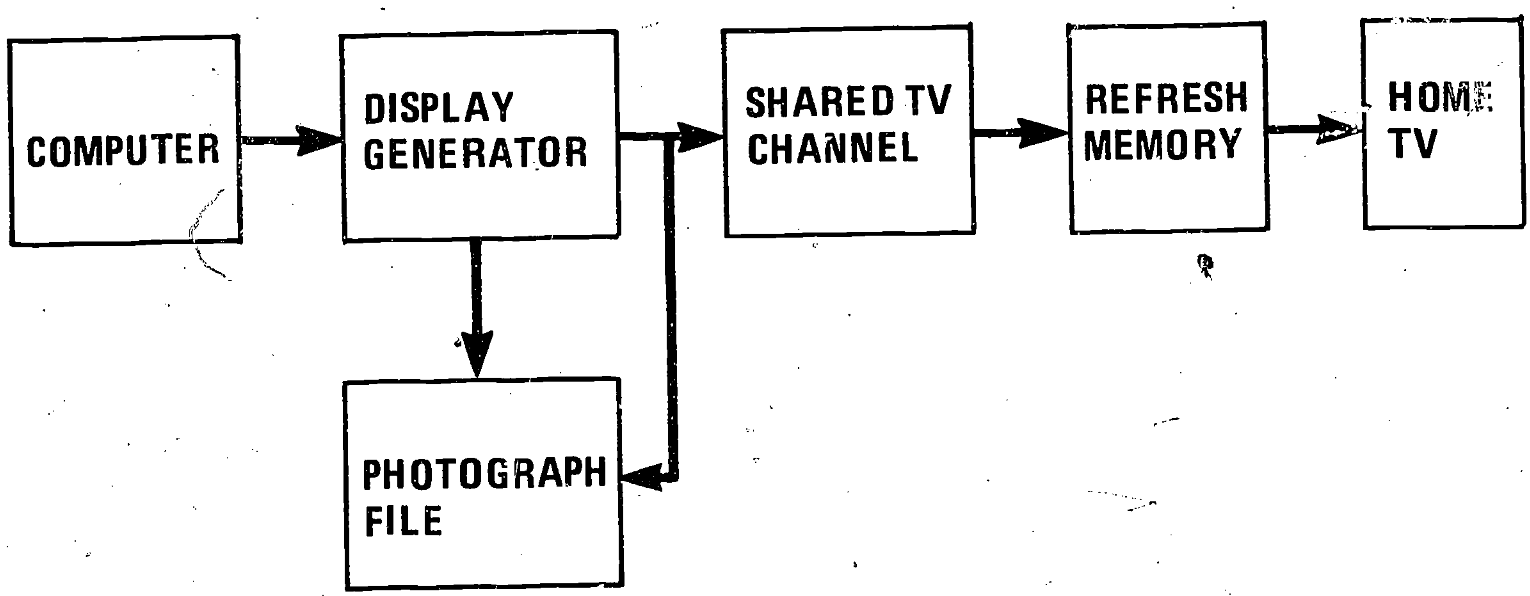


FIGURE 5
FRAME CATCHER APPROACH

Each image generated or retrieved from the photo file has a coded address added to it which indicates to which home it is being sent. The video refresh memory in each home is looking for its own address and when it sees a TV image on the cable with its address, it captures the picture. The photograph shows how the "address" is placed in the vertical retrace interval of a standard TV picture.

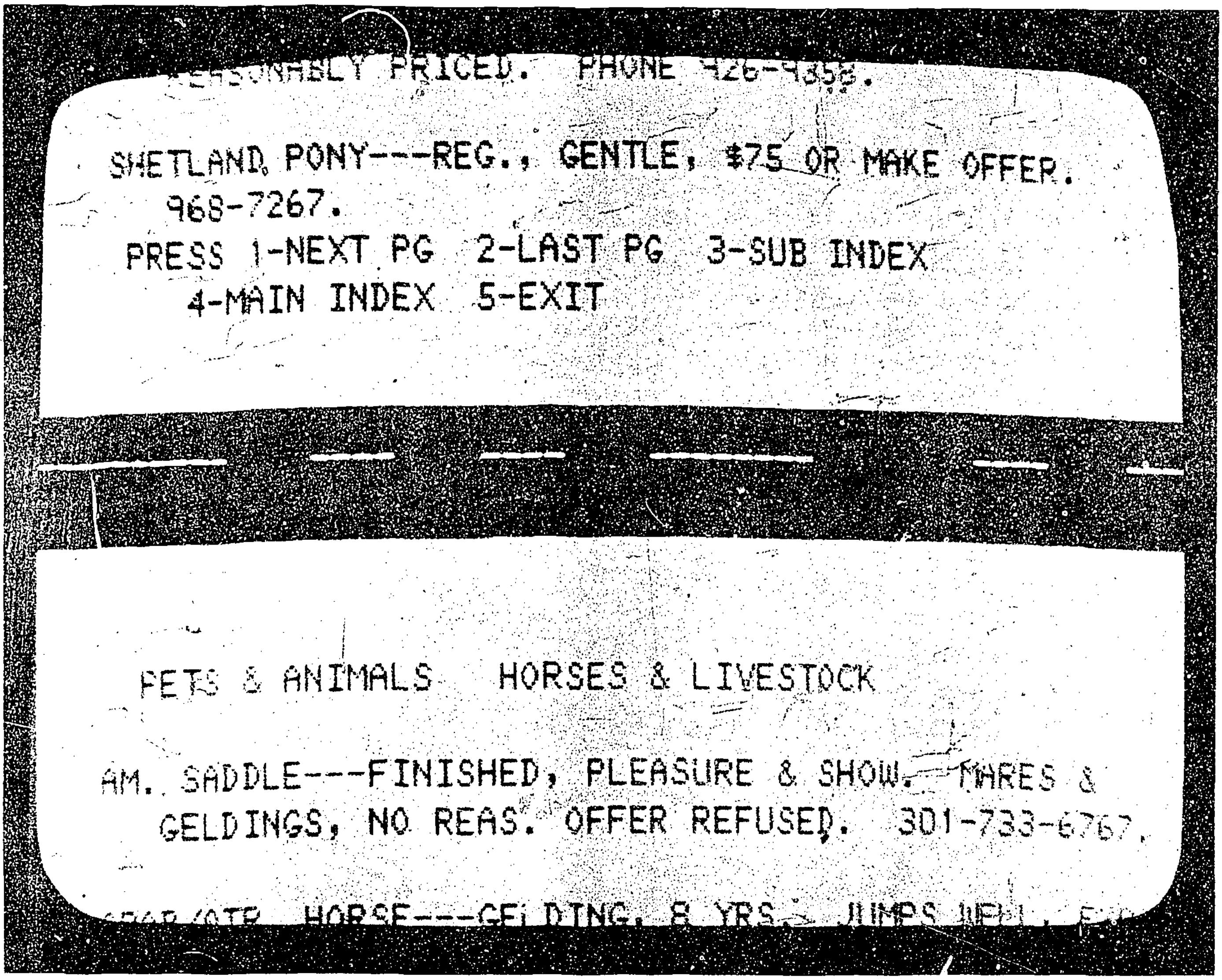


FIGURE 6
TV IMAGE PHOTO SHOWING FRAME ADDRESS

If home viewers, on the average, only use interactive television services for tens of minutes per day, another system approach is attractive. In this approach, the refresh memories are located with the display generator and the computer. Each refresh memory is connected to a different TV channel and, when the home viewer wishes to use the interactive system, he is told to tune to a channel with a then unused refresh memory. The advantage of this approach is that both the display generator cost and the video refresh memory cost are prorated over many users. The disadvantage of this approach is that it requires what, today, is an untraditional cable television system configuration, using many hubs to achieve, through space division multiplexing, the equivalent of thousands of separate TV channels in the city.

MITRE is presently implementing this approach in Reston, Virginia.

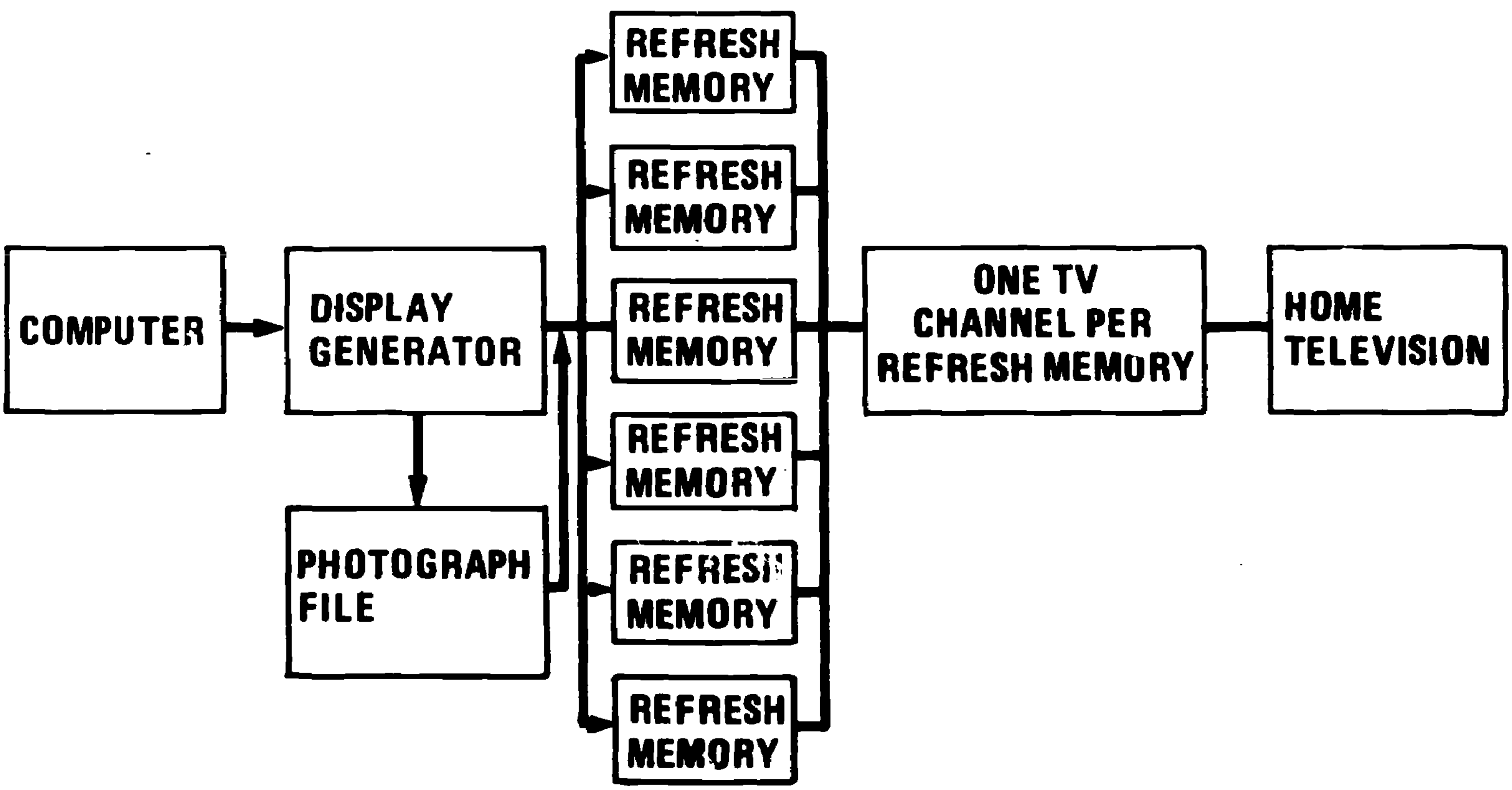


FIGURE 7
CENTRALIZED REFRESH APPROACH

Each hub would have a computer system and several trunk lines (e.g., 10) emanating from it. Each trunk would feed several hundred homes. While broadcast TV channels would be common in all trunks, each trunk would have its own set of interactive TV channels connected to video refresh memories. This hub-type configuration is also less sensitive to spurious signal pick-up than traditional tree-type CATV configurations.

The hub approach with centralized refresh appears today to be the best approach for phasing interactive television into an area, because it maximizes use of available channels and time-shares expensive equipment to reduce initial investments. After the demand for interactive television is established and the cost of home refresh memories becomes more economical, "tree" type CATV configurations could be used.

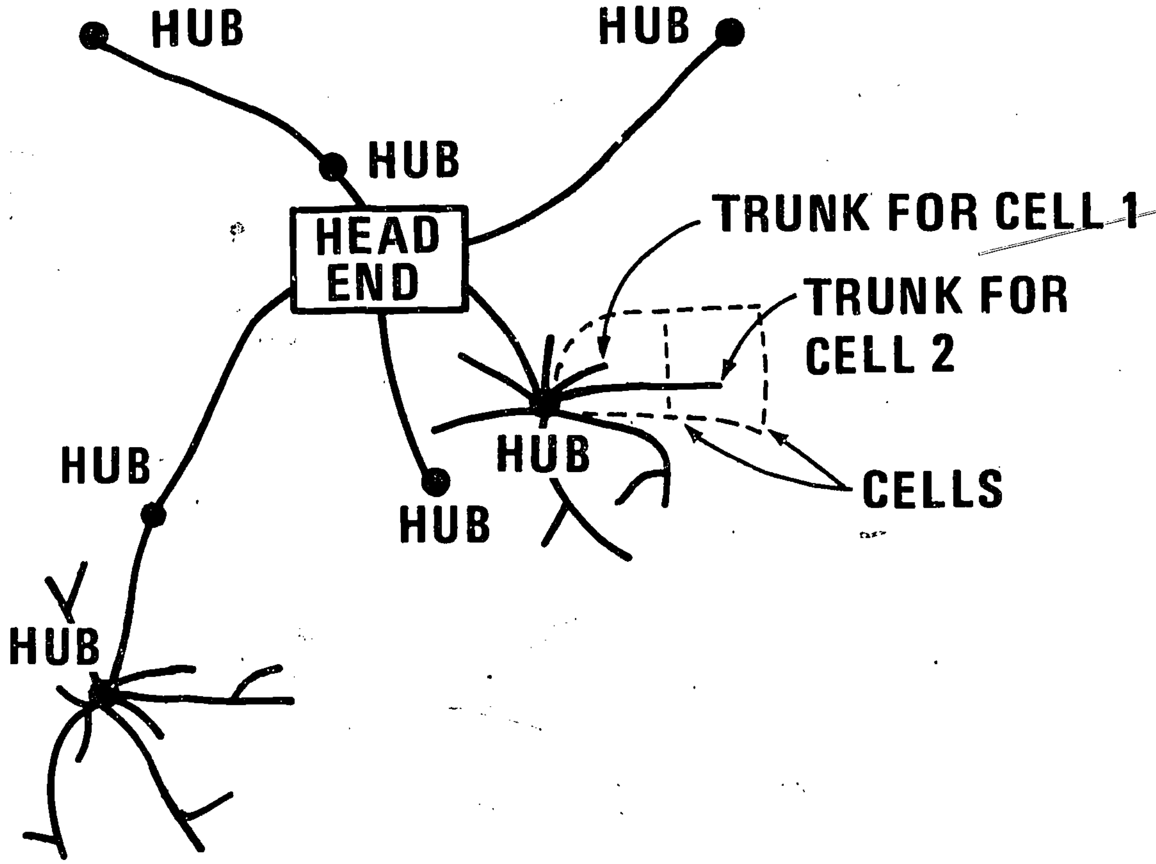
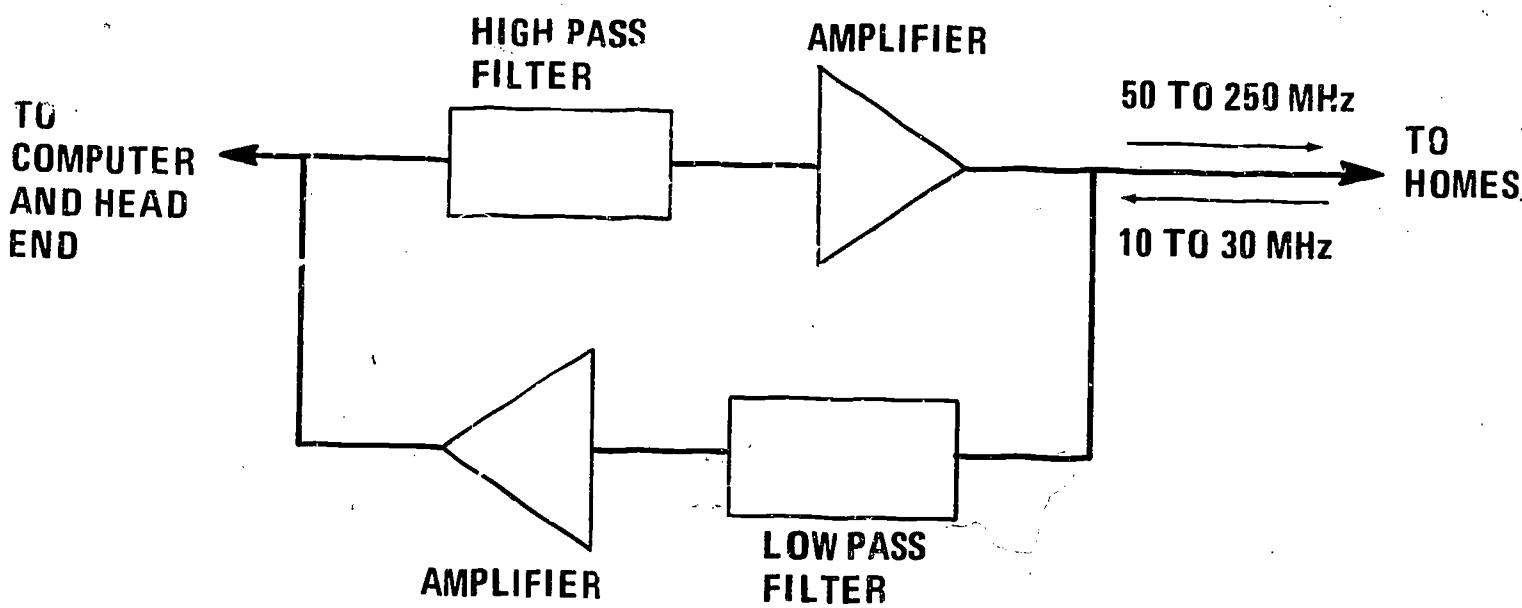


FIGURE 8
HUB TYPE CATV CONFIGURATION PROVIDES CHANNELS NEEDED FOR CENTRALIZED REFRESH APPROACH

Communication between the home and the computer will be via two-way cable TV. A single cable can carry information in both directions. The TV signals, broadcast, pay TV, and interactive TV, will be carried down the cable on the higher frequencies. Keyboard information from the homes to the computer will be carried back up the cable on the lower frequencies. Many cable television equipment manufacturers are now building and installing systems with this two-way capability. Other approaches for two-way cable TV systems have also been proposed. One of the more interesting approaches uses a single coaxial cable feeder line as described above, but uses two trunk lines--one for carrying TV signals from the head-end to the feed lines, and the other for carrying keyboard signals from the feeder lines back to the computer. The communication multiplexing technique most commonly suggested for keyboard input is sequential polling. This approach is much less expensive than frequency multiplexing and can be a more efficient user of bandwidth than simpler time-division multiplexing techniques. MITRE's early experiments with interactive television used a touchtone telephone for communications back to the computer; and we expect that, in future experiments, this type of communications will also be used. But, as time passes, because of the economic advantage of the two-way cable, the separate keyboard and cable return link will become predominant.

We calculate that a 10,000-subscriber system can be polled in 1.75 to 3.0 seconds, depending on the efficiency of the polling system and assuming about 1 megabit data rates with 31 bits/second/subscriber.

We estimate that the terminal equipment in the home, exclusive of the TV set, would cost $150-$250 including a 12-character keyboard.



SINGLE CABLE CAN CARRY SIGNALS IN BOTH DIRECTIONS

FIGURE 9
TWO-WAY CABLE AMPLIFIER

As can be seen, video refresh memories are a very key element in interactive television, and, as a consequence, we have experimented with many types. The most promising devices we know of today are a magnetic disc recorder and a digital shift register. The magnetic disc, being manufactured by Hitachi, has the advantage that it is low in cost--it is being offered in small quantities for about $200--and it has an excellent picture quality. This unit has a bandwidth of 5 MHz, excellent gray scale, and records one black-and-white frame in one disc revolution.

The digital-shift-register video-refresh-memory which we feel also has a good potential was designed at MITRE, and is being built by Intel Corporation. While this device, at present, does not have a gray scale capability (by that I mean it cannot reproduce photographs--only text and graphics because, with black-and-white photographs, four to five times as many bits would be required), it has no moving parts, and hence, it is extremely reliable.

The refresh memory is composed of two MOS memory subsystems. The first memory, which contains luminance information for the display, is an 88,000-bit dynamic shift register, operating at about a 10 MHz rate. The color information is contained in MOS random-access memory, organized as three bits by 1,500 words. The luminance refresh contains the bit-by-bit detail of the display, while the color refresh holds the color on essentially a character-by-character basis. (In fact, color information is stored separately for the top half and bottom half of each character to allow more flexibility with colored line drawings.) The luminance refresh is quite small, requiring only a single 8" x 10" printed circuit board; the color refresh is much smaller--four such units can mount on a similar-sized board. The benefits of this digital solid-state refresh over earlier refresh techniques (such as electronic storage tubes) are much greater reliability, simplified maintenance (no analog adjustments), resolution two to three times better, and comparable cost.

TYPES OF VIDEO REFRESH MEMORIES

- MAGNETIC DISC
- ELECTRONIC STORAGE TUBES
- DIGITAL SHIFT REGISTERS
- VIDEO TAPE RECORDERS

FIGURE 10
TYPES OF VIDEO REFRESH MEMORIES

This is an example of the quality of black-and-white display possible with Hitachi's low-cost magnetic disc.

FIGURE 11
PHOTO OF HITACHI REFRESH MEMORY OUTPUT

This figure shows how TV pictures are passed from the computer center to the TICCIT terminal in the Digicolor System being developed for use in schools by MITRE. Under computer control, a single character vector generator is time-shared by all terminals. Its output (typically 1/60 of a second TV picture) is selectively passed to the video refresh memory of the appropriate student terminal. The refresh memory repetitiously sends a single TV picture, originally generated by the display generator, to its associated color TV receiver.

A bank of video cassette tape players (computer directed, but manually operated in the demonstration systems) provides the source of full-color movies. Each TV receiver is switched to receive video either from its video-refresh memory or a selected videotape player. It is anticipated that this manual selection of videotapes will be replaced with an automated video "jukebox".

The terminals may be located up to 1,500 feet from the computer center. Audio information being sent to the terminal and keyboard signals coming to the computer are carried on separate twisted pairs in the same multiconductor cable that carries the video information to the terminal.

The computer-generated display has the capability of being coded (via software) in seven different colors, including white. The display format is 17 rows of 43 characters per row, each character being a 10 x 12 bit matrix. The computer software controls character shape.

Graphics are drawn as straight-line segments on a grid of 200 vertical and 256 horizontal elements. Digitized frames are generated and stored beforehand in disc memory.

Audio is digitized and stored on disc as a 4,000-word and phrase library.

The same system can be used for delivery of information to the home through a cable system with less resolution than the self-contained system within a building.

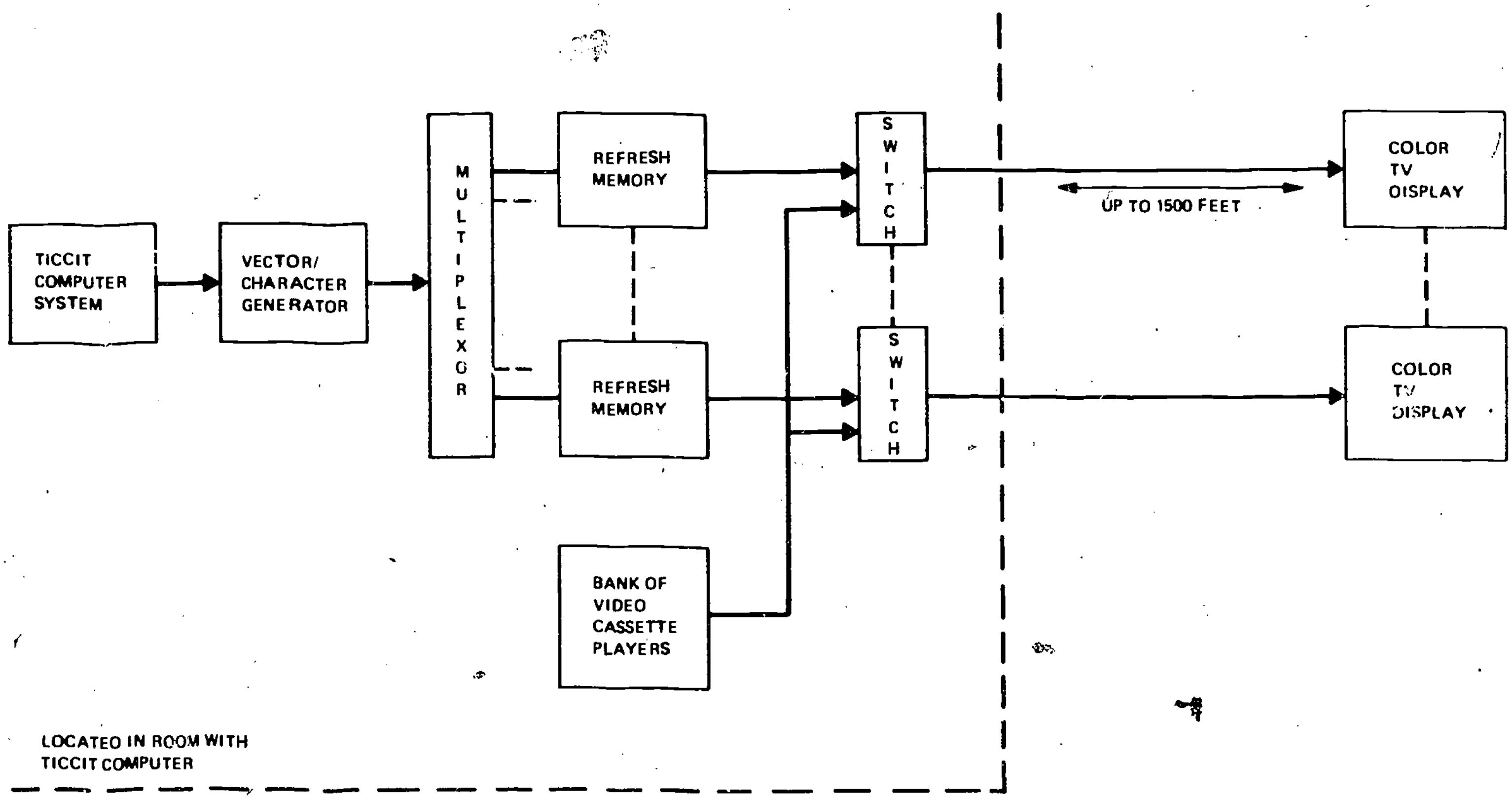


FIGURE 12
DIGICOLOR SYSTEM

This is an example of the kind of computer-generated picture MITRE's digital refresh memory can capture and display.

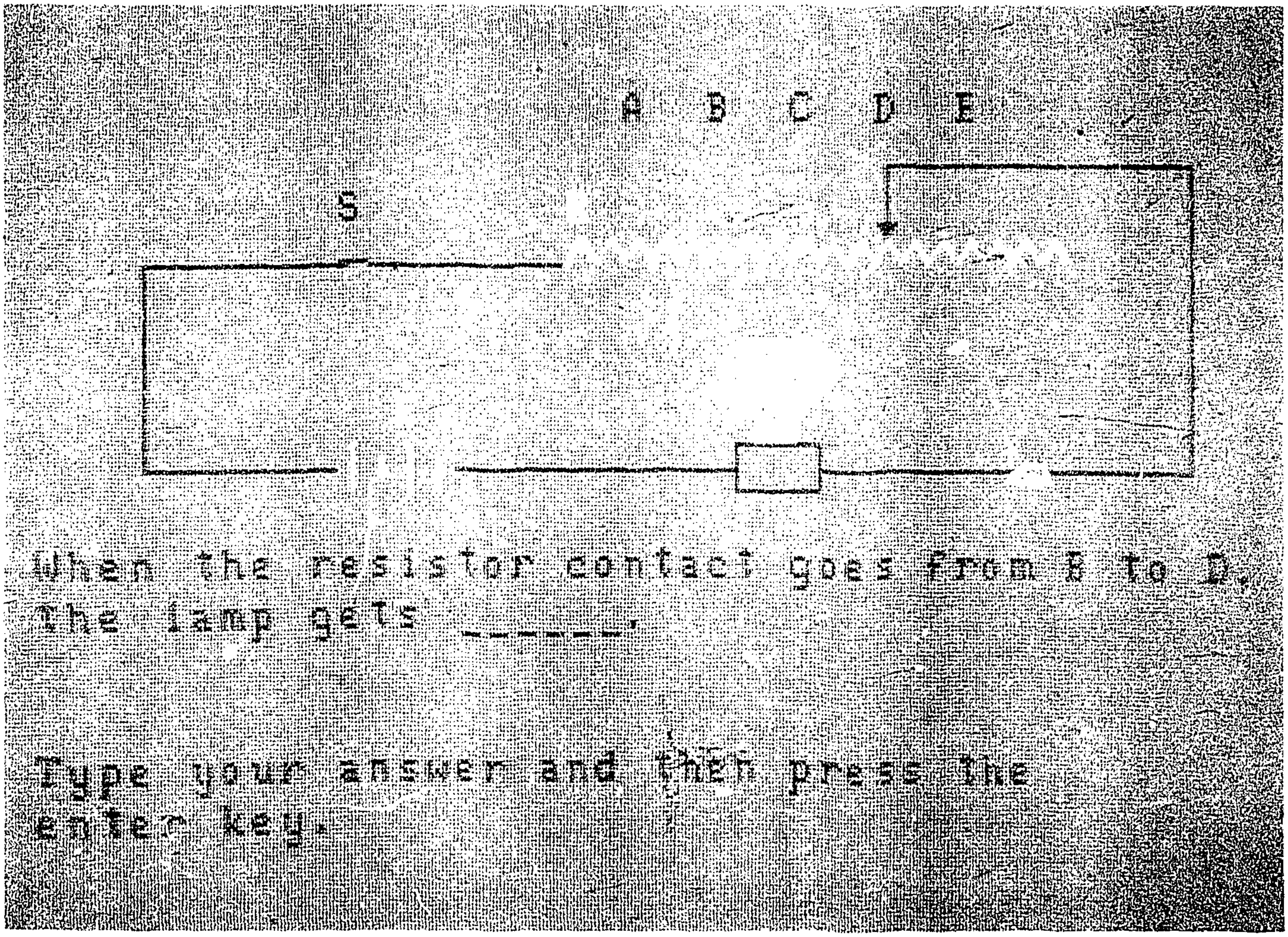


FIGURE 13
PHOTO OF MOS REFRESH MEMORY

The other half of the interactive television system is the communications link from the home back to the computer. As we envision interactive television development, we see two types of keyboards being used in the home, dependent upon how much and what kind of use the homeowner makes of the interactive television services. The casual user will more than likely use a small, low-cost (we anticipate the cost being about the same as the cost of pocket calculators) electronic keyboard with 12 to 16 keys. The more sophisticated user, or the person who wishes to add new information to the interactive television system data base, will have an electronic typewriter-like keyboard.

COMPUTER KEYBOARD FOR COMMUNICATION FROM HOME TO THE COMPUTER

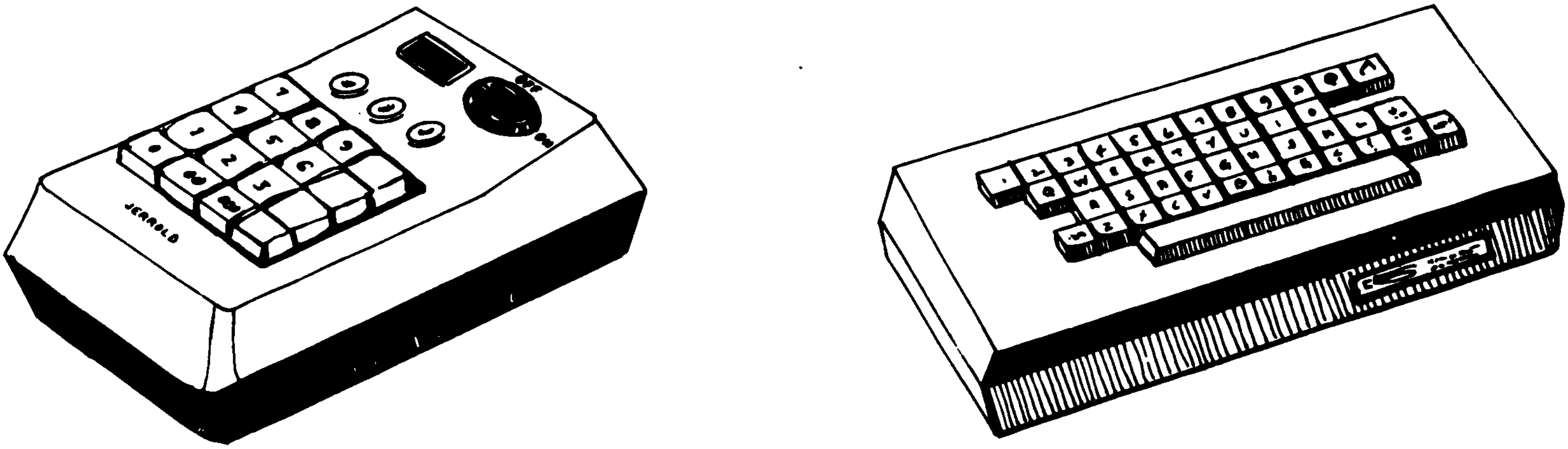


FIGURE 14
COMPUTER KEYBOARDS FOR COMMUNICATION
FROM HOME TO THE COMPUTER

ECONOMICS

The TICCIT system was originally conceived of as a cost-effective method of delivering computer-aided instruction. It is cost-effective due to three innovations: (1) one minicomputer and other equipment is time-shared among 128 users; (2) the display device used at the terminal is a conventional, inexpensive television set; and (3) effective use is made of bandwidth.

Impressed with the low cost of the TICCIT CAI system, many knowledgeable persons encouraged us to find a way of delivering TICCIT to the home. The most practical medium for home delivery of TICCIT is the cable television system. Coincidently, cable systems are now being brought into major urban areas, while the cable system operators, prodded by the FCC, are moving toward cable with a full two-way capacity.

Cable systems and TICCIT are complementary both in terms of technical requirements and economics. For cable to be successful in the major markets, which already possess good off-the-air TV reception, the system must offer additional services. One of these services could be TICCIT. The cable system would serve as the transmission medium for TICCIT, and TICCIT, by making cable service more attractive, would help make cable service in the major markets financially feasible.

It is an economic fact of life, of conventional cable systems, that the system must be built, and the capital investment committed, before market success can be ascertained. But cable operators have little experience with the major urban markets, which coincidentally contain 80% of the potential subscribers in the country. Additional innovative services, such as TICCIT, can help to assure market success and serve to reduce investment risk in these major markets.

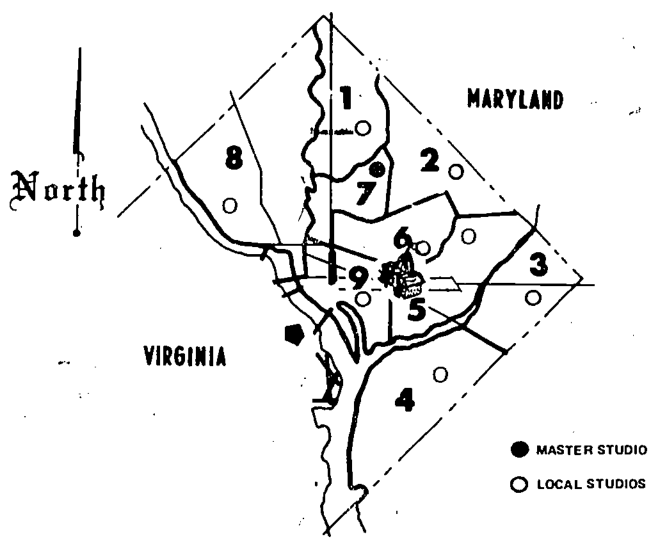
My comments thus far should have served to point up our concern with analyzing TICCIT within the financial and economic context of the cable television industry today, the services it provides, and its prospects for the future.

We have examined the economic feasibility of TICCIT within the context of a projected urban cable system. The area chosen is a section of Washington, D. C. This selection was made because our earlier work for the Markle Foundation, URBAN CABLE SYSTEMS, provided us with the necessary detailed information.

The area chosen consists of 26,680 households, or potential subscribers contained within an area of 5 square miles. This is a subscriber density of about 350 households per mile. We assumed that 20 percent of the cable system would require underground construction. In addition, 20 percent of the underground ducts would be filled to capacity and new construction would be required.

Although this area has a high subscriber density, the undergrounding required raises costs substantially. The system was assumed to have a 60-channel capacity achieved through a dual-cable with converters.

As an aside, the total capital cost of a system in Washington for 263,000 households is about $30 million. Capital costs for a subscriber-response system are about twice this cost and for a full two-way electronic information-handling system, including terminal equipment, the cost is about four times as great as for the basic system.



SERVICE AREA SIX CHARACTERISTICS

POPULATION	73,062
NUMBER OF HOUSEHOLDS	26,680
AREA	5 SQUARE MILES
NUMBER OF STREET MILES	76 MILES
SUBSCRIBER DENSITY	350 HOUSEHOLDS/MILE
PERCENT UTILITIES UNDERGROUND	20%
PERCENT UNDERGROUND DUCT CONSTRUCTION REQUIRED	20%

FIGURE 15
CONTEXT OF PROJECTED SYSTEM

Our economic and financial studies, including both TICCIT and conventional cable television systems, involved a thorough consideration of alternative cost/service/system combinations, in conjunction with trade-off studies of major variables. This major computational effort was facilitated by a MITRE computer program, which provides a complete report of system financial performance.

The program enables us to approach the analysis from two points of view: rate of return, and required revenue.

The first method, discounted cash flow rate of return, is at least in its basics known to almost all of us. Given central assumptions, such as costs, subscriber participation, and revenues, a rate of return over the project life can be calculated. But, by taking the required revenue point of view, we have added a new dimension to the analysis. Required revenue tells us how much we must earn, per subscriber, in order to achieve a target rate of return.

The target rates of return we chose were drawn directly from actual industry experience. They are 12.4 percent on total invested capital which, given appropriate financial leverage, would yield a 20 percent (after corporate tax is paid) rate of return on equity investment. Incidentally, ten thousand dollars, invested over 10 years, at a 20 percent rate of return, would have a terminal value of more than $61,900.

The analysis also tested sensitivity of required revenue per subscriber to market penetration for the basic one-way service and for TICCIT service. The results of this were used to assess investment risk.

RATE OF RETURN ON TOTAL INVESTED CAPITAL		–12.4%
RATE OF RETURN ON EQUITY AFTER CORPORATE TAXES (ASSUMES 80% FINANCIAL LEVERAGE WITH 8% COST OF DEBT AND 3% RATE OF INFLATION)		–20%
ONE WAY SERVICE AVERAGE PENETRATION		
	HIGH	–61%
	LOW	–31%
TICCIT SERVICE AVERAGE PENETRATION		
	HIGH	–38%
	LOW	–19%

FIGURE 16
ECONOMIC ASSUMPTIONS

Before showing you the results of our study, I want to point out the principle elements that we considered in undertaking this analysis. A computer program, developed specifically for this work permitted us to examine a variety of technological configurations for economic desirability.

The substance of the program is outlined in the following three figures. They serve to point out the complexity of the analysis and the sensitivity of the results to the basic assumptions. Throughout the study we chose the path of conservatism. Costs were based on near-term estimates in limited quantity production, rates of return on investment were set at the industry norm, and costs relating to cable systems were taken from actual industry estimates.

AREA CHARACTERISTICS

- SUBSCRIBER DENSITY
- PERCENT UNDERGROUND
- TRUNK TO FEEDER RATIO
- CABLE COST PER MILE
- EXISTING OVER-THE-AIR TV RECEPTION

SERVICE PARAMETERS

- LOCAL ORIGINATION
- PAY CABLE
- TICCIT

TECHNICAL PARAMETERS

- SYSTEM/EQUIPMENT FIRST COST
- MAINTENANCE AND ADMINISTRATION COSTS
- SYSTEM/EQUIPMENT PHYSICAL LIFE
- OBSOLESCENCE

MARKET PARAMETERS

- MARKET PENETRATION
- SYSTEM UTILIZATION
- PRICE OF SERVICES
- QUALITY OF SERVICES
- AVAILABILITY OF SERVICE – BUSY SIGNALS/QUEUING

FINANCIAL PARAMETERS

- RATE OF RETURN ON EQUITY – DISCOUNTED CASH FLOW
- COST OF DEBT CAPITAL
- FINANCIAL LEVERAGE
- TAXES

MEASURES OF ECONOMIC PERFORMANCE

- RATES OF RETURN ON EQUITY AND TOTAL INVESTED CAPITAL
- REQUIRED REVENUE – COST PER SUBSCRIBER
- PROFIT SENSITIVITY TO MARKET PENETRATION
- EXTENT OF FIXED INVESTMENT COSTS
- CAPITAL COSTS PER SUBSCRIBER
- YEARLY CASH FLOW

FIGURE 17
FINANCIAL ANALYSIS OF TICCIT
A COMPUTER AIDED APPROACH

Now, I would like to present the results of our study. Remember that our analysis is in the geographical context of an area of Washington, D. C. having a potential of 26,680 subscribers.

As our base, we analyzed a conventional one-way cable system which would meet current FCC requirements. The system has a capability of providing sixty television channels in conjunction with extensive local program origination. If an average of 61 percent of potential subscribers participated in the system, required monthly revenue would be $5.78 per subscriber. However, if only half of that number subscribed, the required revenue would rise to $9.33, an increase of 61 percent. The investment risk is obviously considerable, since actual experience suggests that the $9 charge is beyond the range of market acceptance--without the provision of additional services.

Next, we analyzed the TICCIT system. It uses the digital central refresh system which employs the hub concept. The hub provides us with the additional local channel capacity required in order to centrally place, and time-share, the comparatively expensive refresh devices. We are also investigating the new analog refresh units available at a cost of around $400 per equipped unit, which would be put in the home. The analog home refresh system has the advantage of using existing cable plant configurations. Comparative costs of both approaches are similar with the hubbed approach being cheaper for infrequent use and the home terminal superior for use on the order of more than one hour per day and in lower density high cable cost areas.

The results of our investigation are most interesting. We have found that TICCIT can be delivered at an additional charge of $13.73 per month, with an average subscriber participation of 38 percent but that the required revenue rises only 8.5 percent, to $14.90 if penetration is reduced to 19 percent. Unlike the basic cable system, the TICCIT add-on is relatively insensitive to the extent of market participation because of the phasing of TICCIT equipment with subscriber participation. At least at the hardware level, TICCIT financial risk is not great since even a minimal market success would provide the target rate of return on capital invested in TICCIT.

	HIGH PENETRATION	LOW PENETRATION
ONE WAY SERVICE	$ 5.78	$ 9.33
TICCIT	$13.73	$14.90
TOTAL MONTHLY CHARGE	$19.51	$24.23

SENSITIVITY ANALYSIS

INCREASE IN REQUIRED MONTHLY REVENUE

ONE WAY	61.4%
TICCIT	8.5%
TOTAL MONTHLY CHARGE	24.2%

FIGURE 18
REQUIRED MONTHLY REVENUE PER SUBSCRIBER

Two-way cable services are of interest inasmuch as there exists a market demand at costs that the public is willing to pay. I think that it is a simple matter of fact that we won't know the answer to this question until an actual market test, with real two-way services, has been conducted. This is what we plan to do in Reston, Virginia, the site of our present TICCIT demonstration.

However, we do have access to a market survey that was undertaken for the URBAN CABLE SYSTEMS report. The demand curve relates ultimate market penetration to monthly subscriber fee. As is apparent, a fee of around $20, which we have estimated would be required, is estimated to achieve a final penetration of 50 percent. Again, this is the result of a survey. The importance of TICCIT is that its profitability is rather insensitive to ultimate market penetration because most of the costs can be phased in response to actual market demand. This is not true for cable systems generally, which require almost all investment to be undertaken before market success is revealed in terms of actual subscribers.

I would be remiss in failing to point out that the costs and required revenues that we have been discussing are primarily hardware based. They do not include the cost of preparing actual program material such as computer-aided instruction (CAI). Some projected services, such as the community bulletin board, are subscriber provided. Others, such as emergency medical services, would probably be developed by the local medical society. I would expect that CAI would be funded by educational institutions. The costs of teleshopping would be borne by commercial establishments. My point is that the TICCIT system operator will not have to bear all the costs of courseware and TICCIT program development--especially after the proven success of the first full-scale interactive system.

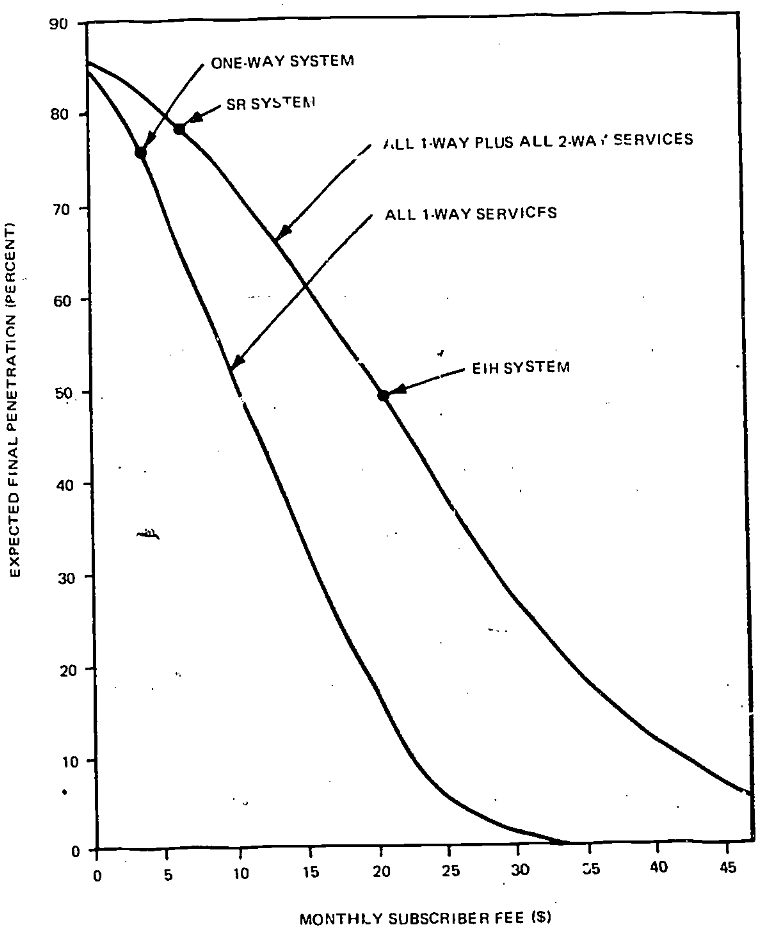


FIGURE 19
MARKET SURVEY

It might be worthwhile to examine the origins of systems costs. The first figure shows the investment cost components at the TICCIT headend. Perhaps it is a little surprising to find that the majority of costs are not computers--rather they come from the process of converting computer digital output to a standard television picture. However, the costs of this equipment are shared among 128 simultaneous users, or at the usage rate assumed, 2120 subscribers. This permits the use of the conventional home television set as a display device rather than requiring terminals that presently cost in excess of $1,000 per unit.

Using the hub configuration, the allocated TICCIT headend cost is reduced to $203 per subscriber. A continuation of this figure shows home terminal costs. The drop and converter are required for the 60-channel one-way system and the scrambler would be shared between TICCIT and limited access broadcast programming such as pay cable or special medical programs.

The only home terminal equipment required specifically for TICCIT is the keyboard/modem. This costs $200 per terminal, which added to the $203 cost at the TICCIT headend, results in an incremental cost, for TICCIT, of $428 per subscriber--if the entire $25 cost of the scrambler is charged against TICCIT. This might be compared to an incremental cost, per added telephone, of about $1,000 and to a fully switched cable system of about $12,000 per subscriber. Total cost per TICCIT-cable subscriber is $203 plus $292 = $495.

In terms of total costs, the basic Service Area #6 one-way system has a fixed cost of $1.53 million, with an additional investment of $67 per subscriber. The TICCIT system has a fixed investment of $2.39 million, $431,000 of which is for one TICCIT hub, for computers and associated equipment, and $420,000 which is the increased cost of cabling using the hub configuration. Thus, the hub costs about 28 percent more to build than the conventional cable layout. But even minimal market acceptance of TICCIT would provide a fair rate of return on this additional investment.

CIT LOCAL DISTRIBUTION CENTER (SERVES 2120 BSCRIBERS

COMM PROCESSOR	$ 21K
MAIN PROCESSOR	$ 26K
PERIPHERALS	$ 95K
KEYBOARD DATA MOD/DEMOD	$ 5K
REFRESH CONTROL ELECTRONICS	$ 10K
CHARACTER GENERATOR	$ 7K
CHARACTER SWITCHER	$ 3K
DIGITAL MEMORY	$620 x 116 = $ 72K
NTSC ENCORDER	$1000 x 116 = $116K
VIDEO MODULATOR	$ 500 x 116 = $ 58K
SIGNAL SCRAMBLER	$ 100 x 116 = $ 11.6K
COMBINER/SPLITTER	$ 500 x 12 = $ 6K
TOTAL	$430.6K
COST PER SUBSCRIBER	$203

HOME TERMINAL

DROP	$ 40
CONVERTER	$ 27
UNSCRAMBLER	$ 25
KEYBOARD, MODEMS ENCODER/DECODER	$200
	$292

FIGURE 20
INVESTMENT COST COMPONENTS

ECONOMIC CHARACTERISTICS OF TICCIT

- INVESTMENT PHASING IN RESPONSE TO CONSUMER DEMAND
- COST OF AN AVERAGE PHONE BILL - ABOUT $14/MO.
- LOW INVESTMENT RISK
- 20% RATE OF RETURN ON INVESTMENT AFTER TAXES
- INCREASES VIABILITY OF URBAN CABLE SYSTEMS

FIGURE 20A
ECONOMIC CHARACTERISTICS OF TICCIT

In summary, we have found that TICCIT can be provided for about $14 per month in addition to the costs of conventional one-way CATV services. Unlike the basic cable systems, TICCIT profitability is not strongly linked to ultimate market penetration because investment is phased in response to actual market demand.

It is widely maintained that urban cable systems are not economically viable without the inclusion of services not otherwise available. TICCIT could be one of those services. If TICCIT proves to have consumer acceptance, it will provide its own considerable capabilities and perform the additional service of improving the viability of cable systems in our major urban areas.

APPLICATIONS EXAMPLES

In addition to conventional one-way TV services such as off-the-air signals, new movies, sports events, local programs, etc., cable can provide interactive two-way services such as education, computer-assisted instruction, polling, catalog shopping, communications for alarms and utilities, and pay TV, health services, government and professional service channels, interactive entertainment, video libraries, banking service, and public and vocational information.

For example, interactive cable communications can eliminate the need to carry and use cash for most consumer transactions. Checks and credit cards would be eliminated by electronic banking via interactive cable.

Within the foreseeable future, we may rarely handle cash, checks, or even credit cards again. Through the use of interactive cable communications, the consumer will be able to order his bank to transfer funds from his bank account to a merchant's account, even in another bank, whether or not the consumer is at home or in his own city. Through the installation of several layers of protection into the system, the user is fully protected against unauthorized use of his account. Credit will be built into the system, and a bank will extend a predetermined line of credit on which the consumer may draw at his discretion.

Rather than paying a bill with a check, the consumer simply orders his own bank to transfer funds to the merchant's account. He does this by entering his own bank account number, the merchant's account number, the invoice number, and the payment into the computer in his own bank--all by entering digits on his home telephone. His bank reviews the consumer's account and authorizes the transfer. If the merchant's account is in another bank, the transaction will go through a clearinghouse computer. The merchant's bank enters the credit on his account. Besides saving the time and inconvenience of sending paper from one bank to another, electronic banking will save the cost of handling checks, which averages twenty-five cents for each check written.

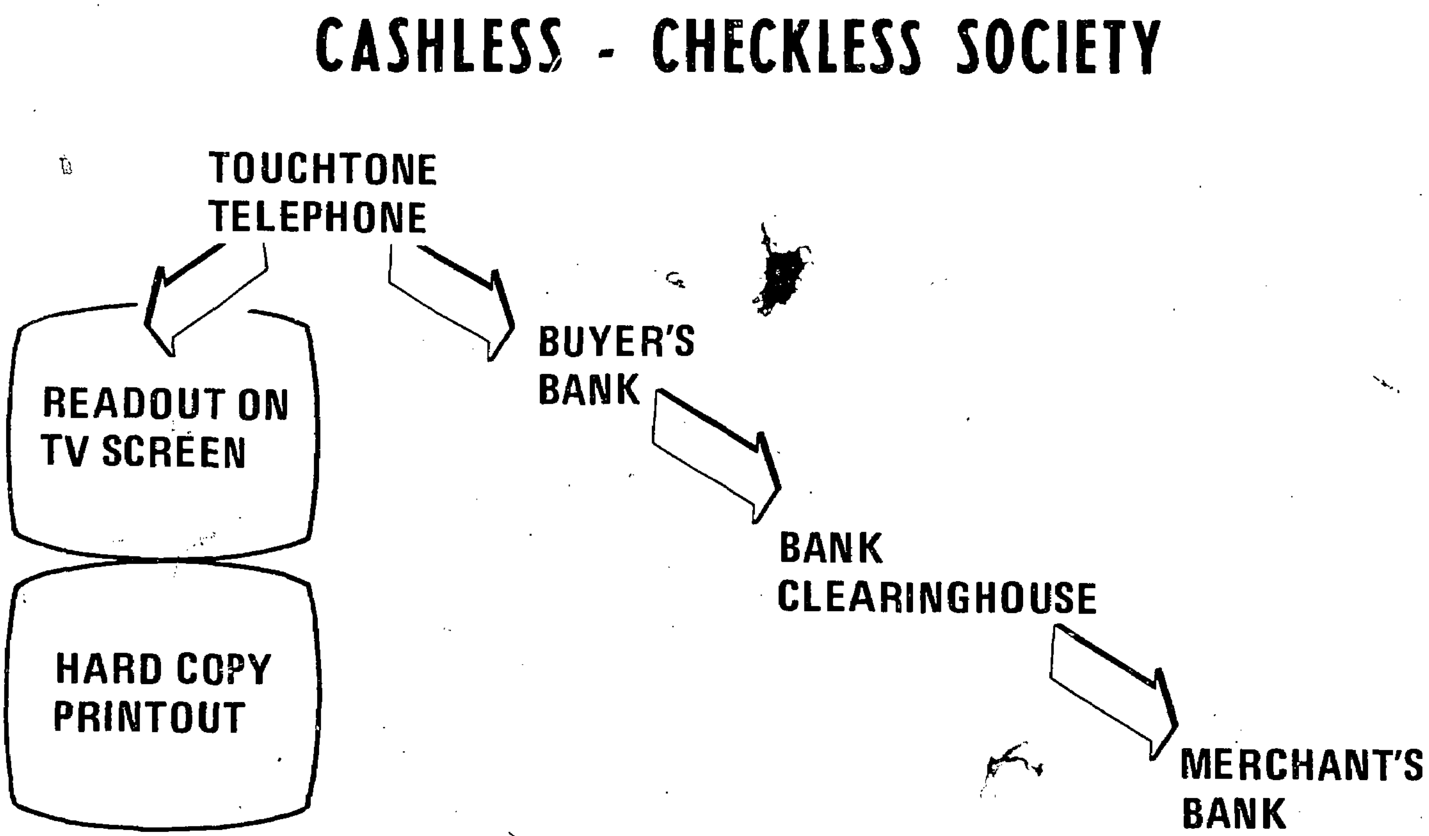


FIGURE 21
INTERACTIVE TV SERVICES FOR THE
CASHLESS-CHECKLESS SOCIETY

Interactive cable communications can be used as a teaching tool, gearing the presentation of material to the pupil's own pace and the teaching method which he can retain the best, thus maximizing the teacher's and student's time.

Computer-assisted instruction will allow the student to tailor his teaching to his own individual pace, needs, and learning capacity, and to use the teaching method which he finds the most comfortable. He may find that his retention is increased through example, through the learning of rules or theories, or by practice. Experiments which MITRE is now planning with the Fairfax County (Virginia) public elementary schools will test the use of computers connected to the schools via two-way cables. Education will be reinforced in the home through the use of interactive cable, all under the supervision of the student's teacher. A simplified computer language called "Mr. Computer" will allow the teachers to program the computers themselves, tailoring the programs to their own course materials. Mr. Computer is currently in use in the special education field in sixteen New York City public schools. The teachers were able to learn the language after only one or two hours of instruction and practice.

Also, vocational education and instruction is a potential big user of interactive cable systems.

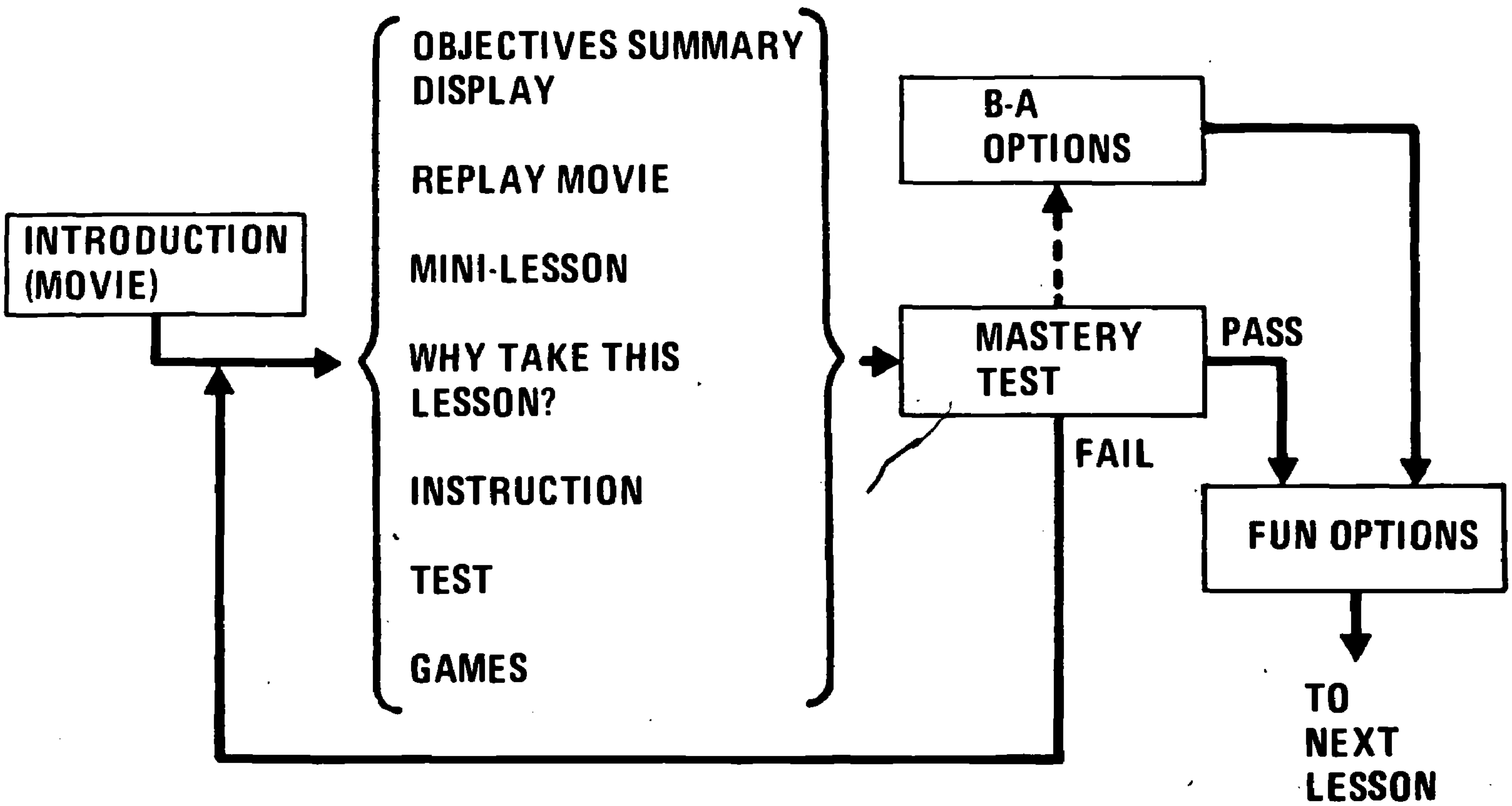


FIGURE 22
GENERAL LESSON FORMAT

One planned application of TICCIT is for the delivery of services to remote locations. A two-way video system is planned to link up the Reston Medical Center and Fellowship House, an apartment complex for senior citizens in Reston. The satellite clinic planned at Fellowship House will be staffed by paramedical personnel. The two-way interactive system will make physician services readily available upon demand. Once tested, this approach will be expanded to include patient-at-home medical video visits. This will incorporate the use of a patient's home television, a two-way video interactive system, a medical home visitor, a portable television camera and the on-line availability of any number of needed, remotely located, medical specialists.

A series of TICCIT applications are also planned within the clinic facility. In the clinic, TICCIT will be employed as a triage aid, a medical data collector, and as an educational tool. Future visiting patients will be screened upon arrival by paramedical personnel using a computer-based branching logic algorithm (one that is specifically being considered has just completed development under the U. S. Army AMOS Program). This routine will determine the service needed by the patient, collect the appropriate [illegible] data, and route the patient to the appropriate health team resource (which may or may [illegible] physician).

TICCIT will also be used in the clinic as the central focus of a Patient Self Education Center. This learning center will be used by patients (and staff) prior to their appointment time, while waiting, or upon completion of their visit. It will serve to impart, in a dynamic, multimedia, interactive manner, the knowledge necessary for the patient to begin to carry a greater portion of the burden for health maintenance.

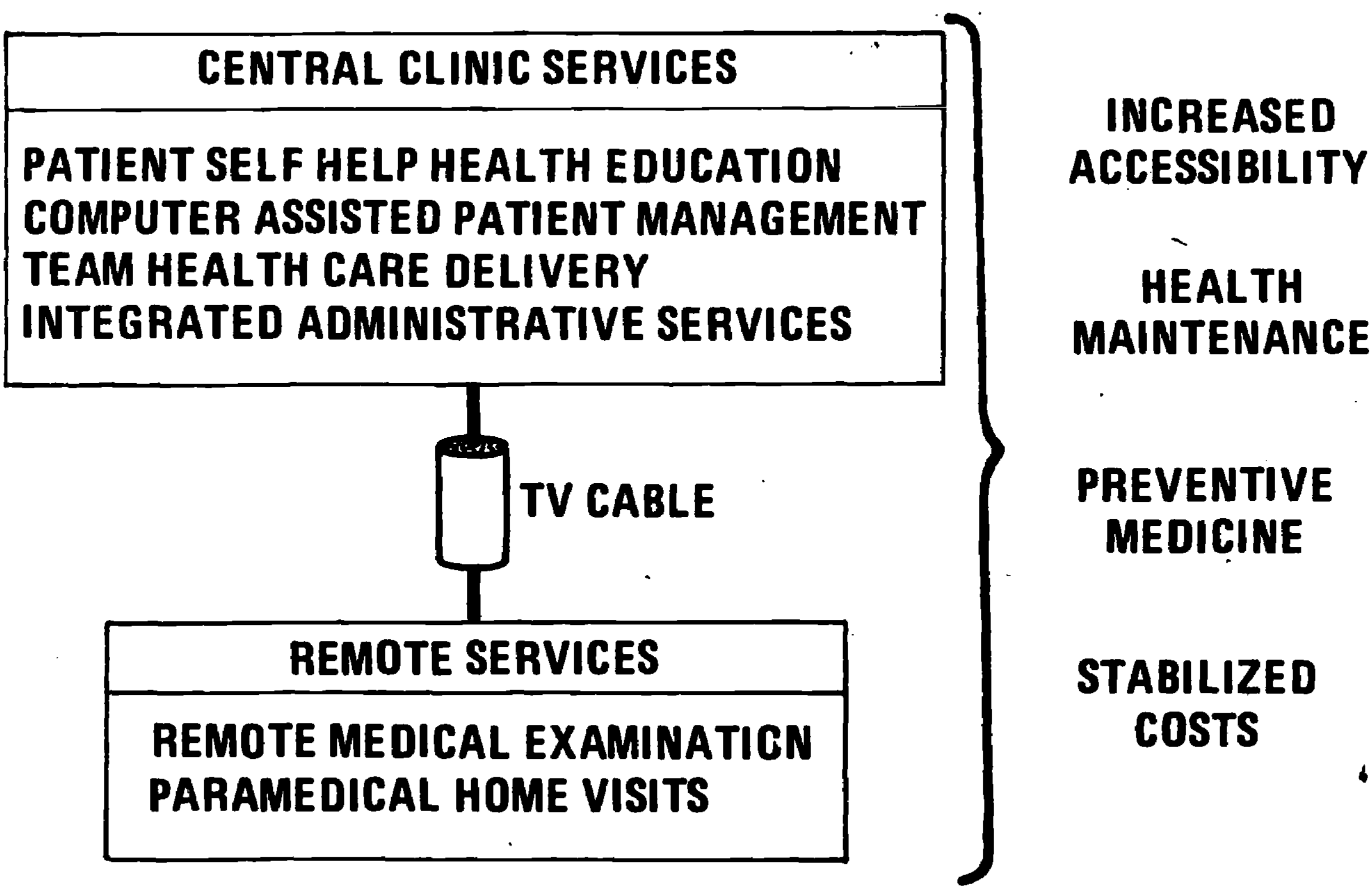


FIGURE 23
INTERACTIVE TV SERVICES FOR HEALTH MANAGEMENT ORGANIZATIONS

Our next step in Reston will be to move from our present experimental and demonstration mode to actual delivery of interactive services to the cable subscribers in Reston.

We see the big problems in interactive television today as being social, economic, and content-related, not bandwidth. We are, therefore, making considerable effort to select and implement an initial set of interactive services which will be useful socially and which will attract many users.

Specifically, we are working with the elementary schools in Reston to provide Dr. Pat Suppes' Drill and Practice computer-assisted instruction in math, reading, and language arts for grades 3 - 6. We envision that students will use this material at home in place of traditional homework. As mentioned earlier, we are planning to work closely with the new Health Maintenance Office in Reston to provide several innovative services. In addition, we will offer many communication services to the community--want-ads, a community bulletin board, a soapbox for users views, etc. On the lighter side, we will have a number of computerized games--some played between a pair of viewers with the computer mediating, and some where the viewer plays against the computer.

- AVAILABLE TO ALL 3500 CABLE SUBSCRIBERS
- UP TO 20 SUBSCRIBERS MAY USE THE COMPUTER SIMULTANEOUSLY—THIS IS AN ARBITRARY LIMIT BASED ON CHANNELS AVAILABLE FOR THE EXPERIMENT AND MONEY AVAILABLE FOR EQUIPMENT
- TOUCHTONE TELEPHONE OR ACOUSTICALLY COUPLED KEYBOARD USED FOR COMMUNICATION FROM HOME TO COMPUTER
- INITIALLY OPERATIONAL IN EARLY SUMMER 1973

FIGURE 24
NEW RESTON INTERACTIVE TV SYSTEM

Other interactive TV experiments are being planned in the U. S. Some are listed here.

TABLE I
SUMMARY OF TWO-WAY CABLE SYSTEMS & DEMONSTRATION PROJECTS

LOCATION	POPULATION	NUMBER OF TERMINALS	STARTING DATE	DESCRIPTION	SYSTEMS OWNER	EQUIPMENT SUPPLIER	STATUS
AKRON, OHIO	275,425	----	1971	LARGE TWO-WAY CABLE INSTALLATION, TO DATE, NO FORMAL EXPERIMENTAL PLANS.	TVC	JERROLD-KAISER	NO FORMAL PLANS
CARPENTERVILLE, ILL.	24,059	5	MID-1972	FIRE & BURGLAR ALARMS, POLLING SUBSCRIBER, VIEWER HABITS, REMOTE CONNECT AND DISCONNECT-PHASE II PAY TV.	LVO	SCIENTIFIC-ATLANTA	LIMITED TESTS
DALY CITY, CA.	66,922	----	1971	SORT OF R&D PROJECT TO TEST THE DISCADE SYSTEM.	VISTA GRANDE CABLE VISION	AMECO	NO FORMAL PLANS
D[illegible]PORT, MA[illegible]	SMALL	----	1970	TEST BED FOR THE REDIFFUSION LTD HARDWARE.	LEGHORN CORP.	REDIFFUSION LTD	INACTIVE
EL SEGUNDO, CALIF.	15,620	30 INITIAL 1000 LATER	1972	MAJOR TWO-WAY DEMO FOR EVALUATING SRS SERVICES.	TELEPROMPTER-HUGHES TOOL CO.	THETA-COM	MAJOR DEMO.
IRVING, TEXAS	97,260	UP TO 1800	LATE 1973	TWO-WAY TERMINALS FOR SRS SERVICES SUCH AS: ALARMS, PAY-TV, HOME PURCHASES.	LEAVELL	TOCOM	MAJOR DEMO.
JONATHAN, MINN.	5,300	PROJECTED 50-100	1972	HUD FUNDED, THREE-PHASE PROGRAM TO EXAMINE A WIDE RANGE OF BROADBAND SERVICES IN A PLANNED CITY.	COMMUNITY INFORMATION SERVICES, INC.	GE	SIMULATION
MONROE, GA.	8,071	100	1973	CENTRAL STATION SECURITY SYSTEM FOR FIRE AND BURGLAR ALARMS TO BE FUNDED BY LEAA.	CITY OF MONROE	SCIENTIFIC-ATLANTA	OPERATIONAL
NEW YORK CITY (MANHATTAN)	7,867,760	----	1971	LIMITED TWO-WAY VIDEO OVER A RETROFITTED PORTION OF THE ONE-WAY PLANT.	TIME-LIFE TELEPROMPTER	VIDEO INFORMATION SYSTEMS	LIMITED FORMAL PLANS
ORLANDO, FLA.	99,006	25 INITIAL 500 IN 1973	1972	MAJOR TWO-WAY DEMO OF PAY TV, SECURITY SYSTEMS, MERCHANDISING, OPINION POLLING, AND CREDIT CARD VERIFICATION.	ATC	EIE (RCA)	MAJOR DEMO.
OVERLAND PARK, KANSAS	76,623	16	1971	TWO-WAY EXPERIMENT FOR HOME INSTRUCTION OF HANDICAPPED STUDENTS. HAS BEEN EXPANDED TO INCLUDE RESPONSE POLLING, HOME SHOPPING AND ALARMS.	TELE CABLE, INC. TIME-LIFE	VICOM ANACONDA	WORK NEARLY COMPLETED
RESTON, VA.	17,000	1 - PRESENT 400 TO 1000 LATE 1973	1971	MAJOR TWO-WAY DEMO OF COMMERCIAL, EDUCATIONAL & INFORMATION SERVICES USING FRAME-STOPPING TECHNIQUES.	WARNER	MITRE	MAJOR DEMO.
SOUTH ORANGE, N. J.	16,971	PROJECTED-4000	LATE 1973	TWO-WAY SHOPPING, VOTING, POLLING, ALARM SYSTEMS BOTH FIRE AND BURGLAR.	CABLE INFORMATION SYSTEM	VIDEO INFORMATION SYSTEM	IN PLANNING STAGE
SPARTANSBURG, S. C.	53,546	----	1973	SAME AS OVERLAND PARK, KANSAS.	TELE CABLE, INC.	VICOM	IN PLANNING STAGE
SUNNYVALE & OCEANSIDE, CALIF.	96,000 41,000	---- ----	1972	TWO-WAY SYSTEM, TO DATE NO FORMAL EXPERIMENTAL PLANS.	FCB CABLE VISION	EIE (RCA)	NO FORMAL PLANS