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ABSTRACT

The MITRE Corporation has been experimenting with a system called Time-Shared Interactive Computer-Controlled Information Television (TICCIT) to show that standard TV receivers, cable television (CATV), and computers can be used to provide low-cost in-the-home information services. In the experiments computer generated pictures were delivered to customers over CATV. The users communicated with the computer through 12-button push-button telephones, and received individualized messages on their TV screens by means of at-home videotape recorders (VTR). If a transmitted picture carried an address that matched the customer's address, the VTR recorded the message. Some of the services offered included a home calculator, tax filing assistance, library services, electronic mail, personalized job-finding and investment advice. Experiments indicated that TICCIT services may enable communications to reduce need for transportation. Barriers to introduction of the system include problems of privacy, marketability, and costs of programs. (MG)

MARCH 1972

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REVOLUTIONIZING HOME COMMUNICATIONS

New Techniques for Using Computers with Cable Television

The MITRE Corporation

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THE MITRE CORPORATION
WASHINGTON OPERATIONS

ABSTRACT

It is widely recognized that we face an opportunity to make revolutionary changes in our entire life style using cable TV systems. Not only will cable provide tremendous bandwidths, clean from noise, into every home, but we will have a new generation of TV related equipment technology. Low cost minicomputers will be used to organize information of special interest for distribution to individual homes or small communities-of-interest. TV channels will be assigned for both general and special purpose digital communication and, with the advent of home video recorders and a new generation of TV "frame grabbers," some channels will deliver on the order of 600 different types of information and service using time-division multiplex of individually addressed TV frames which can be selected by decoders in the home. Two-way voice and video can also be provided.

Some examples of how such capabilities will reduce travel and other transportation requirements in the future include electronic mail delivery (for some classes of mail), electronic shopping, more efficient use of police, fire, taxi and other mobile services, remote medical diagnosis, computer-aided education in the home and, of course, new forms of home entertainment. The MITRE Corporation has been demonstrating the distribution of a few hundred such services into a few homes and schools, using a single TV channel of the Reston, Virginia, cable system and a computerized program delivery system remotely operated over a microwave link. This paper describes the system and the services.

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INTRODUCTION

Throughout history communications systems have been used as a substitute for transportation. Primitive man's smoke signals, drum beats and reflected lights were forerunners of telephone, radio, television, and newspapers, reducing the need for direct personal contact. This paper will discuss new communications capabilities that cable technology will soon bring to the home, and describe a demonstration of these capabilities in Reston, Virginia.

MITRE has been working on a variety of systems involving the use of cable and ordinary television sets as display devices. The work has included the design of home terminals for use in urban area cable systems and the use of conventional TV terminals to replace the expensive terminals now needed for computer-aided instruction. Over a million dollars has been invested in MITRE studies of TV-related hardware, software and systems development and the related demonstrations of new home TV terminal capabilities in Reston, Virginia, during the last eight months. A number of the services being demonstrated at Reston illustrate how communication can be substituted for travel.

THE RESTON EXPERIMENT[1]

The interactive television system conceived and developed by The MITRE Corporation is called TICCIT for Time-Shared Interactive Computer-Controlled Information Television. TICCIT combines computer capabilities with low-cost standard television receivers as a display. As shown

in Figure 1 computer generated information emanates from our facility in McLean, Virginia, is transmitted over a microwave link to Reston (over 10 miles away) where the signal is picked up and transmitted throughout the Reston cable television system. Users communicate with the computer through 12-button push-button phones. The Reston Transmission Company is cooperating in the demonstration and providing various facilities and the use of its cable television system.

The goals of the Reston test are threefold: (1) to demonstrate operation of low-cost computer-interactive TV in the home; (2) to catalyze the development of this type of hardware by the cable television systems operators and equipment manufacturers; (3) to interest city, state, and federal planners in the tremendous educational, informational, and cultural potential of this type of hardware, and the impact it can and will have on the lives of people, when coupled with strong supporting software.

A number of services being demonstrated at Reston could reduce the need for travel, including a home calculator, tax filing assistance, library services, electronic mail, personalized job finding, investment advice and numerous home entertainment games. New and supplemental services are being added each week. The full range of potential services is limited only by one's imagination.

A more detailed discussion of the Reston demonstration system follows the next section on various types of systems needed to deliver various types of services.

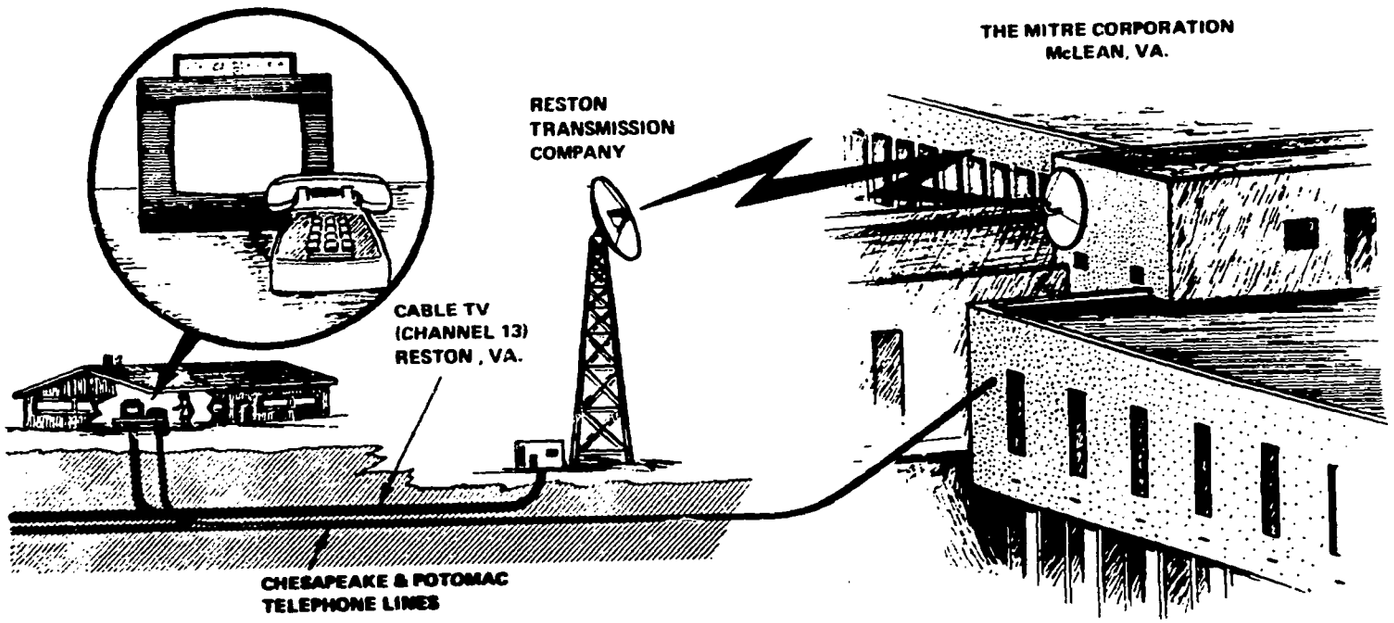


FIGURE 1
DISTRIBUTION SYSTEM FOR COMPUTER INTERACTIVE TV AT RESTON

SERVICES

When large urban areas are implemented with cable, it will be possible to deliver a great many new types of services using home TV sets. The Electronics Industry Association has listed over a hundred services (Ref. 2) and a Canadian Government Study has listed even more (Ref. 3). Since we are primarily interested here in the technologies involved, it will be sufficient to discuss a few types and examples that are representative. The types of terminals listed in this paper are sufficient to provide practically every service that has been mentioned in the cable television trade literature.

The fundamental classes of service as shown in Figure 2 are:

- Conventional One-Way Broadcasting
- Special One-Way Broadcasting
- Dynamic Addressing
- Limited Two-Way
- Full Two-Way

Conventional One-Way Broadcasting: This class is important because many more channels than we now have will soon be available to provide greater entertainment to a greater extent. Several means are used to allow current TV sets to select more channels. Two cables into the home will allow use of an inexpensive "A-B" switch to choose either of two sets (an "A" set and a "B" set) of 12 channels for input to the regular TV tuner. A set top converter allows many channels to be selected from a single cable by translating them into a single channel

CLASS OF SERVICE	SPECIAL TERMINAL HARDWARE	SERVICES
CONVENTIONAL ONE-WAY	• TWELVE CHANNEL CABLE • A-B SWITCH • CONVERTER • SWITCHED HUBS	• MORE CHANNELS • SPECIAL INTEREST PROGRAMS
SPECIAL ONE-WAY	• DEDICATED NETS • SCRAMBLERS/UNSCRAMBLERS • WIDEBAND DISPLAYS	• PAY TV
DYNAMIC ADDRESSING	• FRAME GRABBER/DECODER • HARD COPY	• *ELECTRONIC MAIL • *LIBRARY SERVICE
LIMITED TWO-WAY (100 BIT RESPONSE)	• TRANSPONDER • MULTIPLE CHOICE TERMINAL • TELEPHONE/TWELVE BUTTON TERMINAL • FRAME GRABBER/DECODER • GENERAL PURPOSE DIGITAL COMMUNICATIONS TERMINAL	• POLLING • *HOME CALCULATOR • COMPUTER FILES • REMOTE HEALTH DIAGNOSIS • HOME SHOPPING • *TAX FILING • CAI
FULL TWO-WAY	• VIDEO-PHONE • FACSIMILE	• FACE-TO-FACE CONVERSATION • ELECTRONIC MAIL

*AT RESTON

FIGURE 2
BASIC (TECHNOLOGICAL) CLASSES OF CABLE SERVICE

channel for input to the regular TV tuner. Or, the trunk system can carry several channels on separate cables and use switches at hubs (or local distribution points) to select the channel any particular viewer wants to see.[4,5]

•Special One-Way Broadcast Services to Special Groups of Receivers: This class includes either dedicated full time nets where some subscribers pay for an extra cable into their homes, or special channels which only certain terminals can decode or demodulate. Pay-TV is in this class. This class also includes the distribution by cable of signals requiring more than conventional television bandwidth for use at terminals that have special receivers and display systems designed to take advantage of the wider bandwidth broadcasting systems, e.g., large screen displays.

•Dynamic Addressing: This class of service enables distribution of individualized television frames of information to specifically addressed receivers. An address decoder is needed in the participating homes. The kind of addressing being used in the Reston demonstration uses a digital code structured in the vertical blanking interval. The discrete addressing capability is key to many of the other classes of service discussed below, but here is considered in conjunction with the use of some form of "frame stopper", "frame grabber" or "frame catcher" at the home terminal. Assuming the TV set is to be used as the display device, the frame grabber will "catch" a frame addressed to the particular terminal and will "refresh" the television screen at

that terminal while other terminals are being addressed by the central system. In other words, to provide the sixty fields per second needed for normal television, some kind of home refresh device is needed so that the central broadcasting system need only be tied up one-sixtieth of a second to service each customer.

Home terminals that use hard copy printers are also in this class, but, assuming regular TV formatting is used to distribute information, a storage or buffer capability is needed to hold the wideband TV signal while the narrowband printer reacts. Electronic mail and library services are provided by this class of service.

•Limited Two-Way Service: When a device is provided in the home to allow the subscriber to enter information into the system in the form of either a multiple-choice selection based on what he sees on this television screen or allows him to enter information using a full typewriter-like keyboard, we have another class of service. Generally speaking, if the subscriber response is limited to approximately 100 bits or less, the service is classed as limited or 'basic' two-way. Included in this class, for technical reasons, are the services which require that other kinds of information collected in the home situation be forwarded to the central computer. For example, burglar, fire, and other kinds of emergency alarm or monitoring systems. These services are clustered in one class because they all involve a home transponder function wherein the central computer, in order to manage the inputs from many terminals, uses a polling technique. Information of any type

can be collected from some kind of a storage buffer at the home terminal. The information so collected can be generated manually with a keyboard or by various sensor systems in the home. The two-way frame grabber services demonstrated at Reston use the frame freezing technique described earlier in conjunction with a keyboard. Shopping at home, a simple home calculator, tax filing and some aspects of computer aided instruction (CAI) can be provided by this class of service. An informative discussion of two-way is provided by Reference 6.

Services that can utilize more than 100 bits of information but less than video in response from the subscriber are still classed as limited two-way in this paper. These services can utilize a full typewriter keyboard. A complete home calculator, remote health diagnosis, and full computer-aided instruction can be implemented in two-way. General purpose digital communications with all of its ramification as a substitute for travel fits into this category. In MITRE's laboratories,[7] we are now demonstrating a very flexible scheme for transmitting data under computer control from any terminal to any other terminal or to many terminals in a standard cable television system. The technique is based on the transponder approach whereby messages are picked up by the polling computer and delivered with the polling query to whatever terminal is identified by the sender.

• Full Two-Way: "Full" two-way involves two-way video and would permit face-to-face conversation. If switched, this service would be very much

like Bell's Picturephone® service and needs no further explanation. MITRE is demonstrating a similar capability in conjunction with a frame grabber capability, so that time sharing of a channel can provide 180 "jerky video" conversations per channel. Facsimile is another means (other than the frame catcher) to obtaining electronic mail service.[8,9]

EQUIPMENT AVAILABILITY

Much of the equipment required for the services described above is available today. Approximate costs for this equipment are shown in Figure 3.

The cost range for a twelve channel one-way system is approximately $100 per subscriber[6,8] for the entire complement of equipment required to service an individual subscriber. A twenty channel cable has similarly been estimated at approximately $150 per subscriber. This capital cost may be compared to an average $500-$750[6] per subscriber cost for telephone plant.

The frame grabber costs today from $60 to $800. The cost is dependent upon the type of storage device that is used, the quantity purchased, and the projected date that the frame grabber is to be purchased. The frame grabber refresh device could be a video tape recorder with a 1972 targeted cost of $400-$800, an image storage tube-scan converter unit is available today for about $500 with good prospects for under $100 for large orders. A single frame alpha-numeric (chip) storage and refresh device is projected at $60 for very large quantities, down from today's $200-$300.

®Registered trademark of the Bell System

CLASS OF SERVICE	SPECIAL TERMINAL HARDWARE	COSTS
ONE-WAY	• TWELVE CHANNEL/CABLE	$75 - $100/SUBSCRIBER
	• A-B SWITCH	$5
	• CONVERTER	$30
	• SWITCHED HUBS	$50 - $100 (INCREMENTAL)
SPECIAL ONE-WAY	• DEDICATED NETS	- - -
	• SCRAMBLERS/UNSCRAMBLERS	$25 - $50/SUBSCRIBER
	• WIDEBAND DISPLAYS	$1000 ON UP
DYNAMIC ADDRESSING	• FRAME GRABBER/DECODER	$60 (CHIP) - $800 (VTR)
	• HARD COPY (STRIP PRINTER)	$50
LIMITED TWO-WAY	• TRANSPONDER	$10 - $20
	• MULTIPLE CHOICE TERMINAL	$50 - $100
	• TELEPHONE/TWELVE BUTTON TERMINAL	$100 - $250
	• FRAME GRABBER/DECODER	$60 (CHIP) - $800 (VTR)
	• GENERAL PURPOSE DIGITAL COMMUNICATIONS TERMINAL	$500 (CHIP) PLUS TERMINAL
FULL TWO-WAY	• VIDEO PHONE	$4000/SUBSCRIBER
	• FACSIMILE	$200 ON UP

FIGURE 3
TYPICAL COSTS OF CABLE TECHNOLOGY

The most controversial items with respect to costs are the multiple choice and twelve button terminals.[6,8] A variety of manufacturers have prototype terminals available. A few are now testing terminals in Overland Park, Kansas, and El Segundo, California. The controversity centers around the production costs of these terminals; the costs listed in Figure 3 are production cost estimates. A functional block diagram[8] of a home terminal is shown in Figure 4.

The Sloan Commission[4] has estimated that 6 MHz videophone service within a 10,000 subscriber cable exchange would cost at least $4,000 per subscriber. Facsimile costs depend upon the speed and the size of machine. A Sloan Commission report[10] has placed a $200 per terminal cost on a 1980 facsimile machine. Today's low speed facsimile machines rent for $100 per month plus communications costs.

RESTON DEMONSTRATION HARDWARE

An overall diagram of the MITRE Reston demonstration hardware is shown in Figure 5. The basic TICCIT computer facility is designed to support about 128 on-line terminals. The computer subsystem separates foreground (terminal processing) from background (algorithmic frame processing) tasks and devotes a minicomputer to each task. Tasks of the main processer are complex and diverse. Tasks of the terminal processer involve the rapid, efficient organization and management of data from the main processer and from many terminals.

The demonstration terminal uses a standard television receiver, a video tape recorder (VTR), keyboard and control electronics as shown

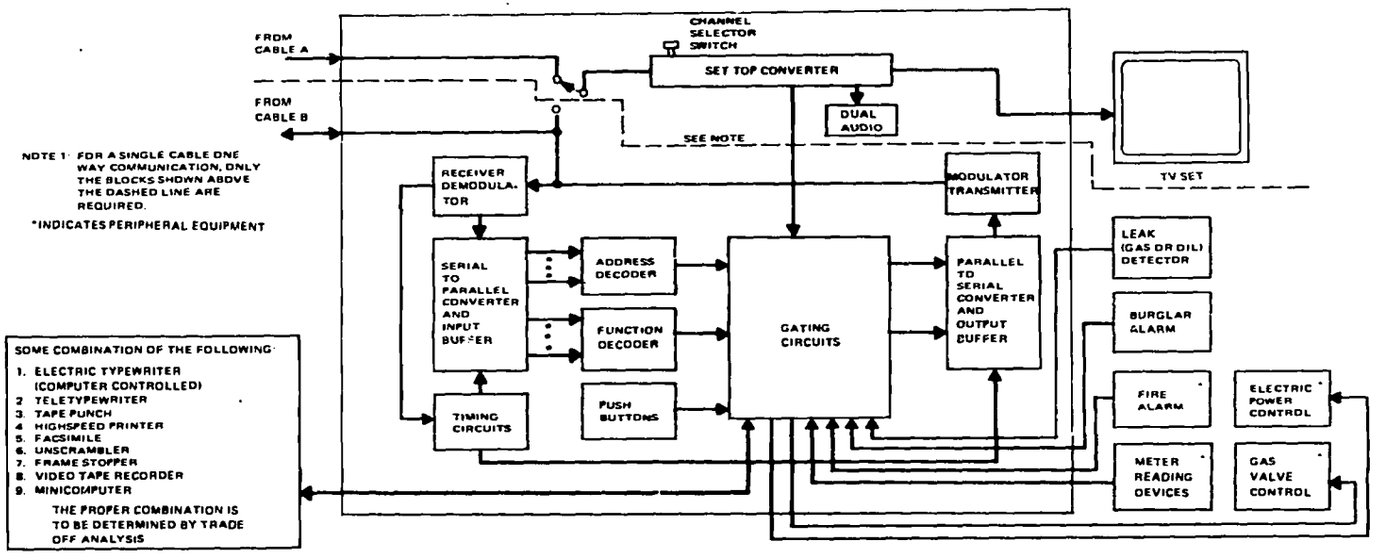
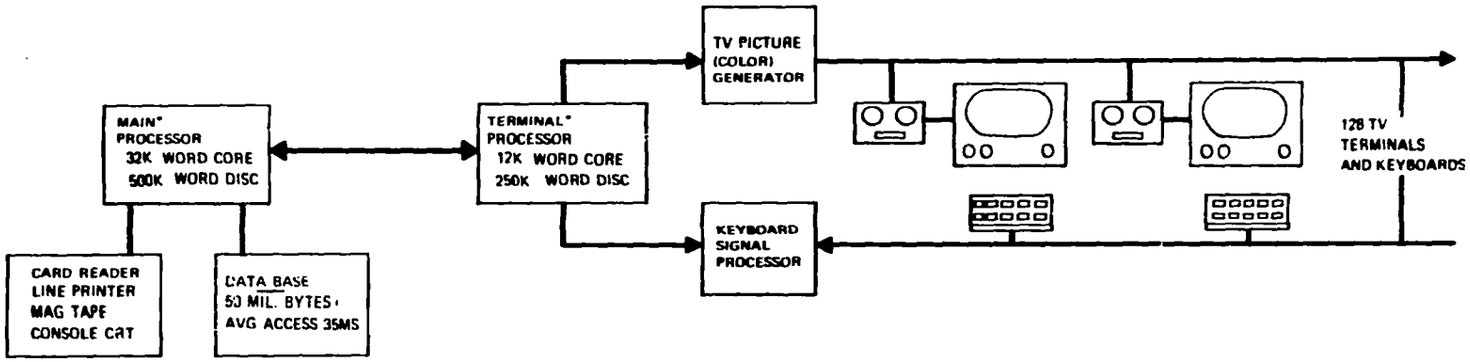


FIGURE 4
HOME TERMINAL



*TWO 16 BIT MINICOMPUTERS
800 NS MEMORY CYCLE
EACH WITH TWO INDEPENDENT FIXED HEAD DISCS
FAST ACCESS (2MS AVG LATENCY, 100,000 BYTES/SEC TRANSFER RATE)

FIGURE 5
DEMONSTRATION SYSTEM DIAGRAM

in Figure 6. The VTR which serves as the TV refresh memory is driven by a video signal coming from the television receiver. The VTR, in turn, provides video to the television receiver for display. The control electronics examines the data encoded into the vertical blanking interval of each received picture field and compares the data with the distinct address pattern set in the terminal. If the transmitted picture's address matches the decoder's address, the control electronics will place the VTR in the record mode for the next field.

The control electronics are housed in the coupler/decoder shown schematically in Figure 6 and pictorially in Figure 7. The coupler/decoder has a TV tuner, an IF strip and a detector in addition to the address decoder. At the completion of the frame, the recorder is placed back into the playback mode. Keyboard signals are time division multiplexed by the control electronics onto the same cable that carried RF signals to the terminal. Figure 8 is a photograph of the terminal installed in a home.

WHAT WOULD SUBSCRIBERS PAY?

We believe, based on our Reston experience, that cable television and TICCIT like services will soon enable communications to reduce the need for transportation. To test this belief in a quantitative manner, MITRE is beginning a study of the technical and economic considerations attendant to the home delivery of instruction and other socially related services via interactive cable TV, a technology assessment of interactive cable television, for the National Science Foundation.

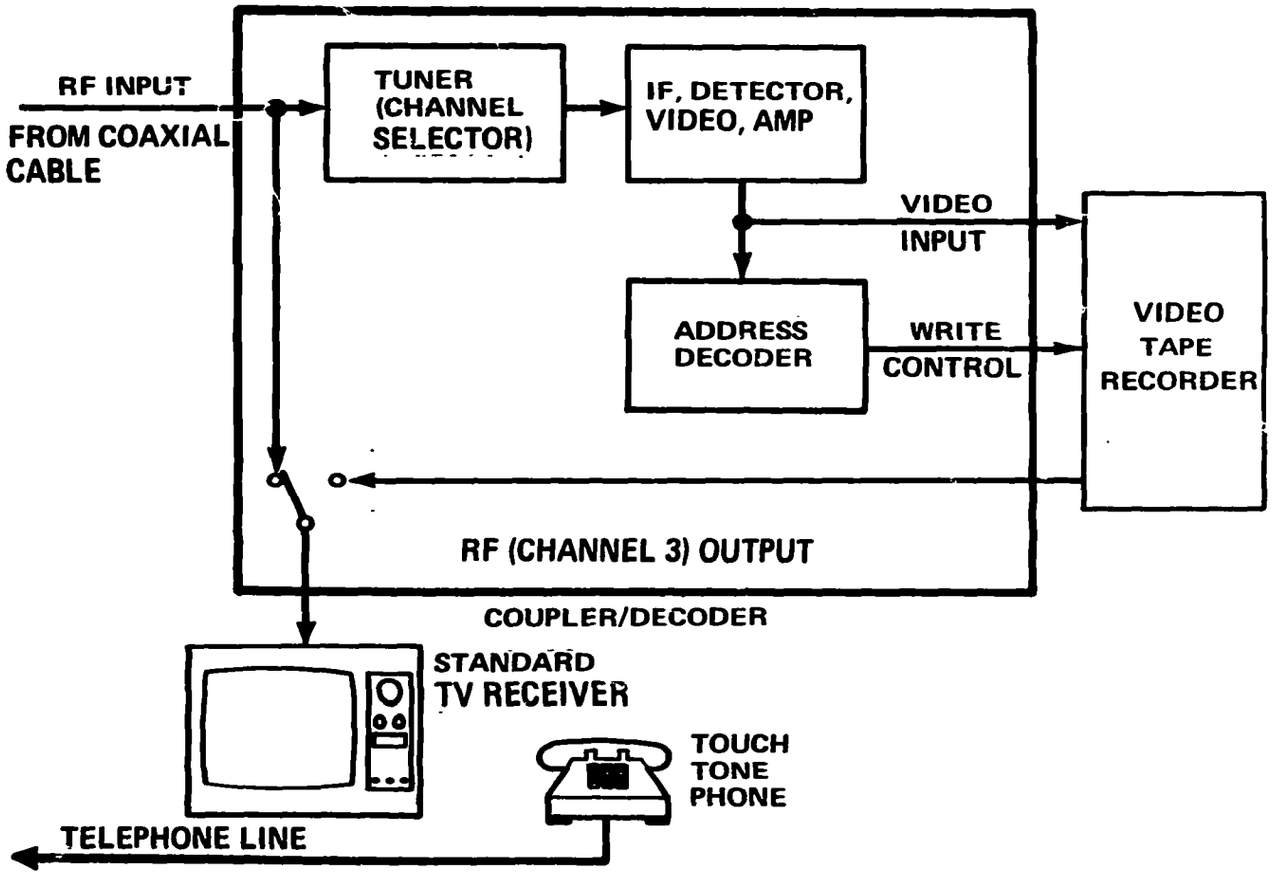


FIGURE 6
DEMONSTRATION SYSTEM HOME TERMINAL

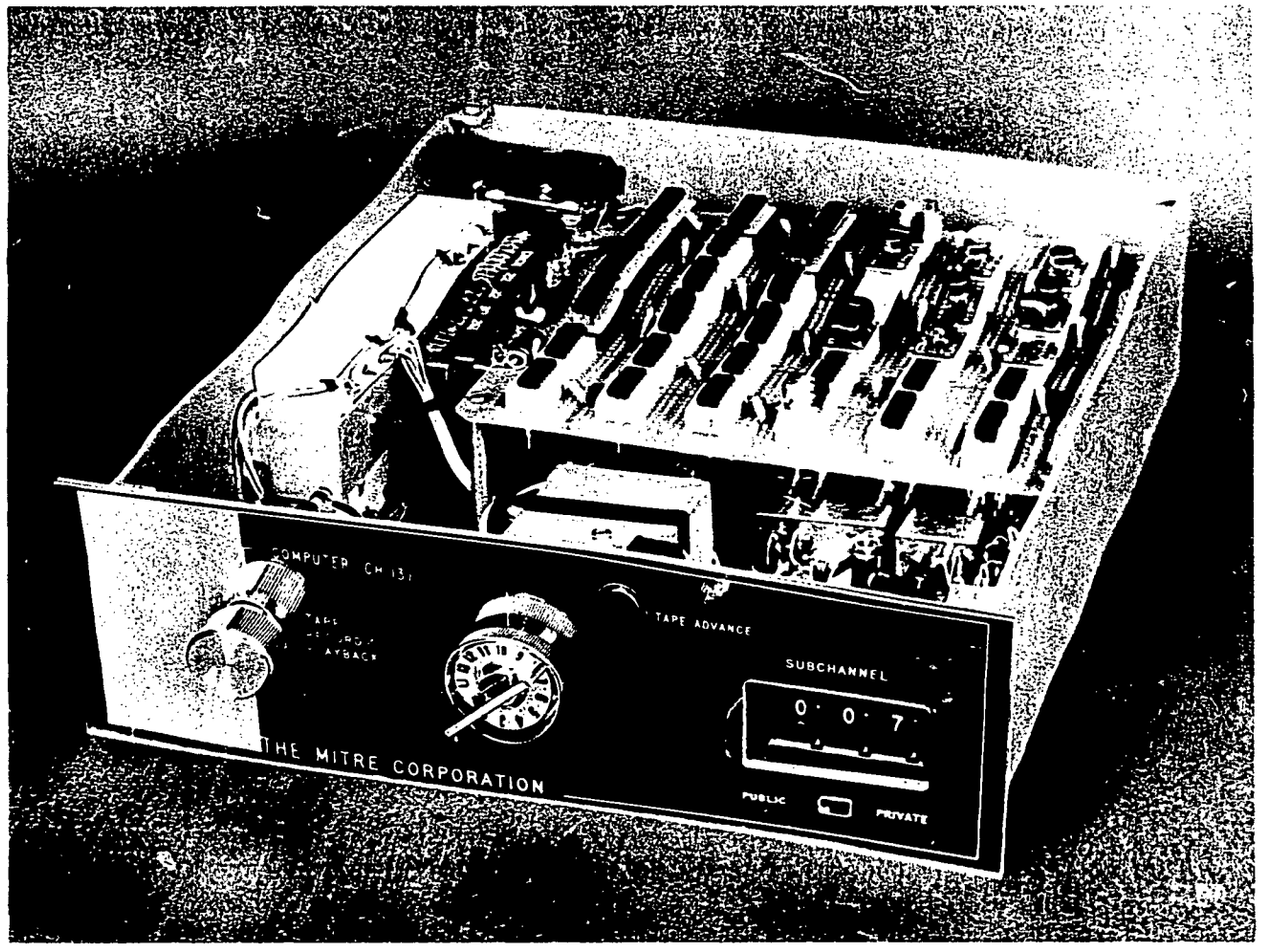


FIGURE 7
MITRE COUPLER/DECODER

FIGURE 8

TERMINAL INSTALLED IN HOME

A survey of visitors who have seen the TICCIT demonstration[11] has revealed that for the home calculator capability 2/3 of them would pay an average of approximately $3.00 extra per month. Library services such as those shown in Figure 9 were desired by about 50% of the visitors who would pay an average of $.50 per month extra for this service. Shopping at home was deemed desirable by about 50% of the visitors at an average of $1.00 extra. Computer-aided instruction was deemed desirable by over 3/4 of the people who experienced it in the TICCIT demonstration.

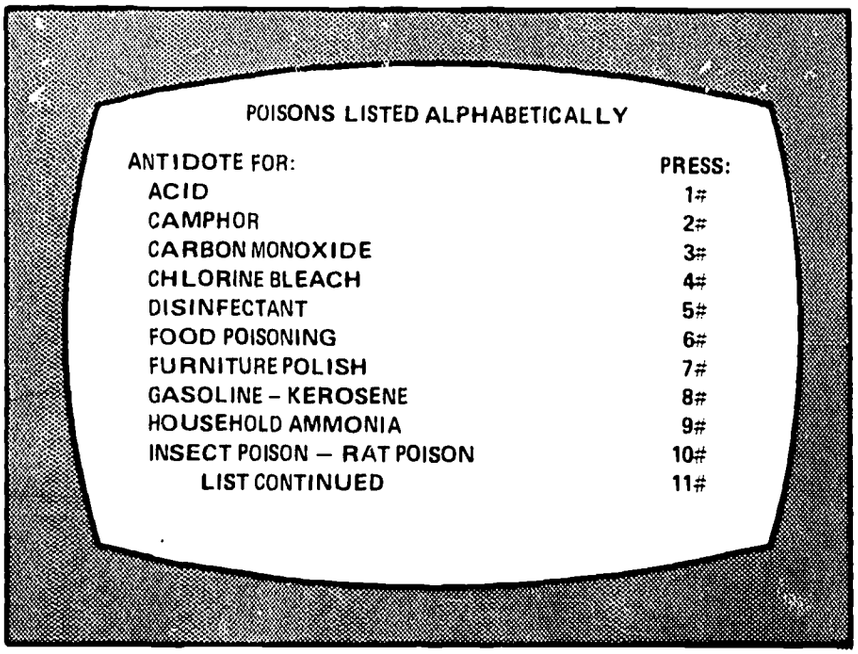
We realize that the population surveyed is not typical of urban populations. Nevertheless, this survey can be used as a guide of what to expect. This informal survey indicates great initial acceptance to interactive cable television and its implications as a substitute for travel.

BARRIERS

The primary barriers that we see to the rapid introduction and wide spread usage of cable television and its attendant benefits are:

1) problems in privacy
2) uncertainty in the marketplace and
3) costs of two-way services (programming).

We believe that in time these barriers will be surmounted and with the widespread usage of cable technology, communications will increasingly become a substitute for transportation.



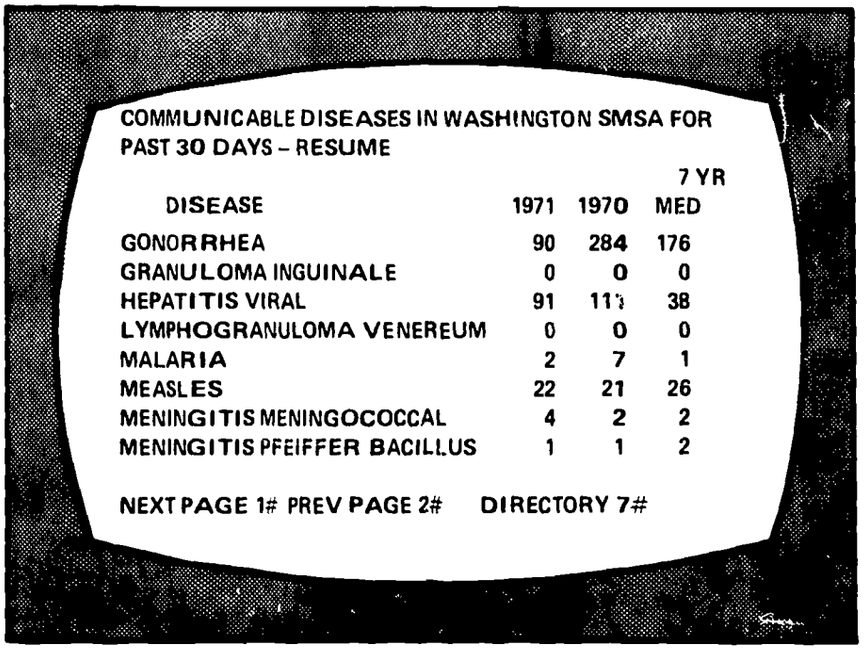


FIGURE 9
LIBRARY SERVICES

SUMMARY

The Reston demonstration has achieved our three objectives. It has contributed to widespread interest in two-way interactive TV by the industry and the operators. Government planning groups are extremely interested in the social impacts and public service possibilities, and last but not least, the technology has been shown to be here and ready.

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