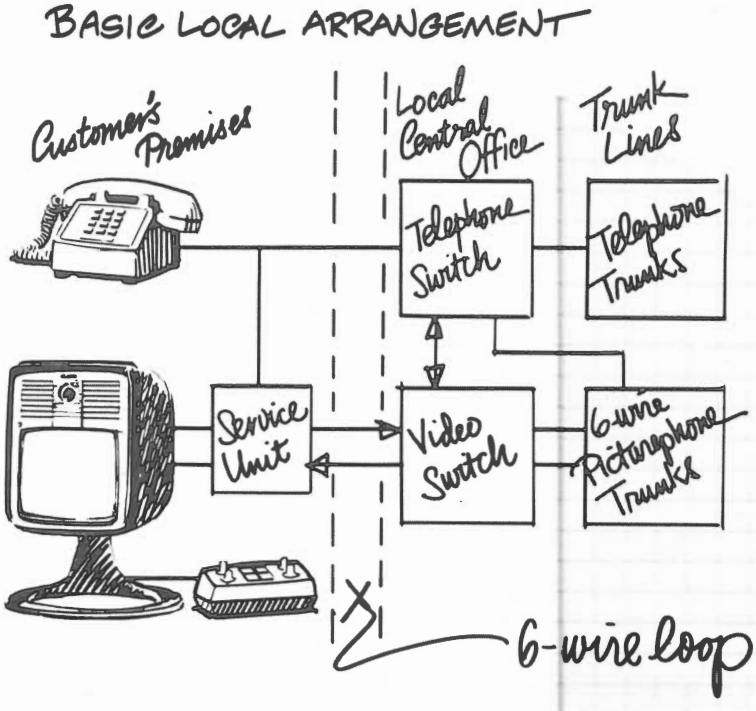
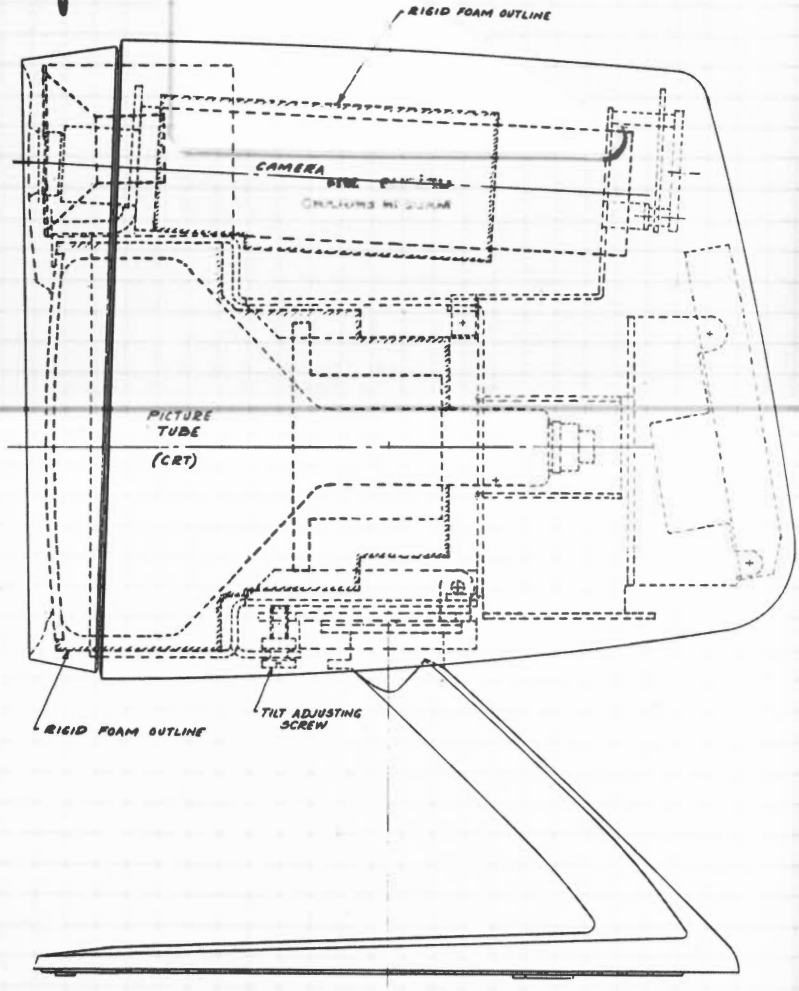
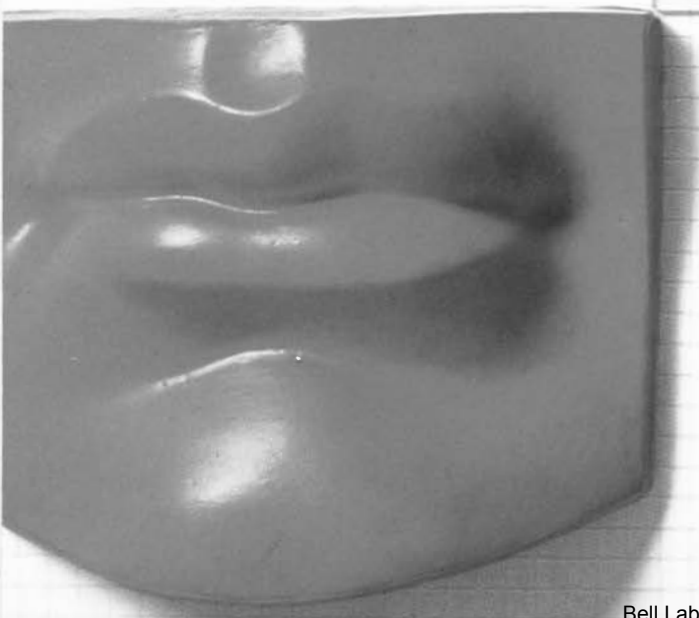

BASIC LOCAL ARRANGEMENT
Customer's Premises
Local Central Office
Trunk Lines
Telephone Switch
Telephone Trunks
Service Unit
Video Switch
6-wire Picturephone Trunks
6-wire loop

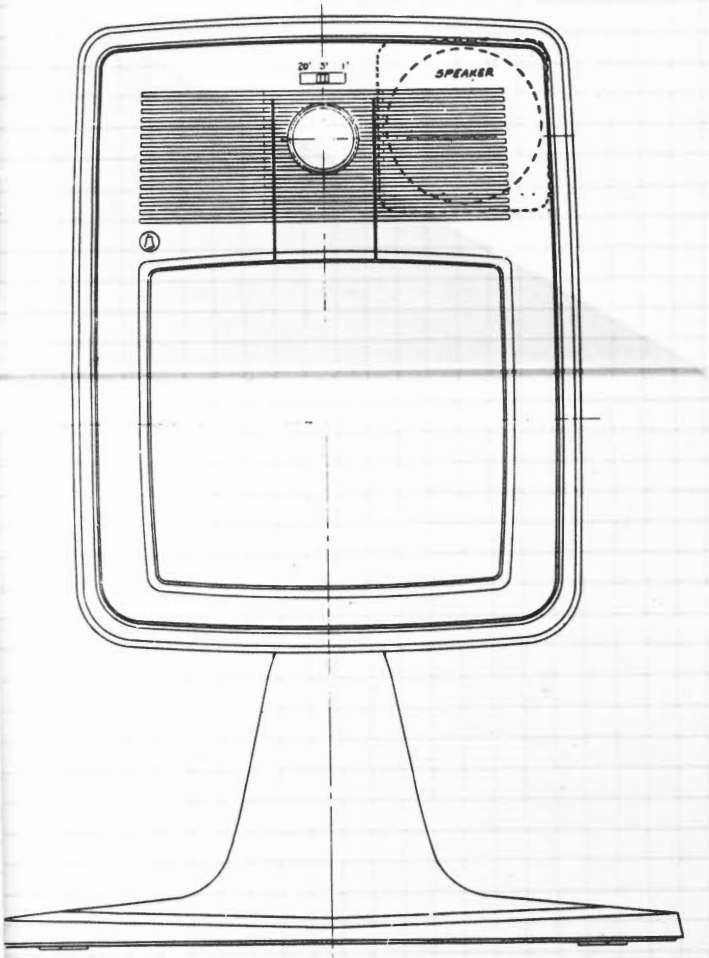

RIGID FOAM OUTLINE
CAMERA
PICTURE TUBE (CRT)
RIGID FOAM OUTLINE
TILT ADJUSTING SCREW

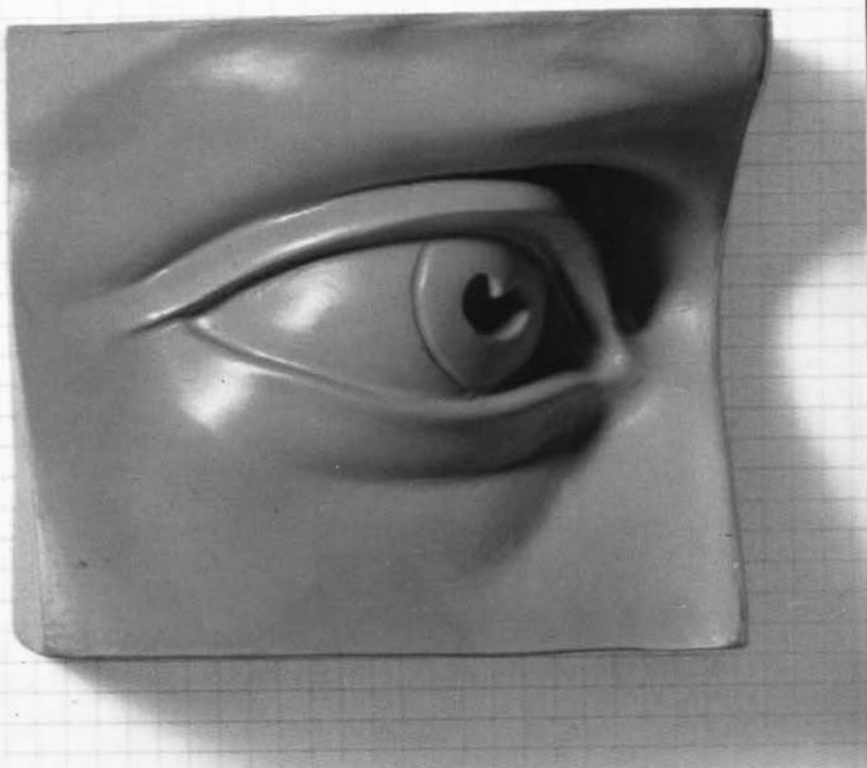


Irwin Dorros

Picturephone®

Picturephone service, a product of Bell System research and development, adds a new dimension to telephone communication — that of sight. Here is a discussion of the system that has evolved to make the telephone conform more perfectly to the communication needs of people.





THE TELEPHONE brought a new dimension to human communications. Where previously men had been able to send written messages over wires as electrical signals, the telephone made it possible for the human voice to span the miles. Now, almost a hundred years later, the telephone is commonplace and another dimension is being added—that of sight. And just as the telephone has revolutionized human habits of communicating and made a major contribution to the quality of modern life, many of us at Bell Labs believe that PICTUREPHONE® service, the service that lets people see as well as hear each other, offers potential benefits to mankind of the same magnitude. It is a tribute to the flexibility and versatility of the existing telephone network that Picturephone service, now being readied for introduction as a regular Bell System offering, can be added as an integral part of telephone service.

What is Picturephone service like? Most important, of course, the user sees the person with whom he is talking. People today are so accustomed to using the telephone and to its usefulness as an instrument of communication, that they sometimes overlook the importance of vision in communication. But think, do you telephone the person in the next office or go to see him? Most people sense a more complete and satisfying exchange when they can both see and talk to each other. Thus, the advantage of more complete communication with Picturephone service is readily apparent.

Picturephone service is useful in other ways too. Graphic material, such as drawings, photographs, and physical objects, can be viewed with the Picturephone set. The equipment can also be used to communicate with a computer. The customer "talks" to the computer via TOUCH-TONE® dialing buttons, and the computer's responses are displayed on the picture tube (see *Picturephone Sets Put a Computer on Executive Desks,* RECORD, *June 1968).*

When Picturephone service becomes available commercially (in the early 1970's), it will probably be accepted most readily by businesses—particularly by large corporations. The executives of a corporation with offices in different locations form a natural "community" with a need for the utmost in communication facilities. Trials already conducted and now in progress have demonstrated the usefulness of Picturephone service in the corporate environment (see *The Evolution of Picturephone Service,* RECORD, *October 1968).* As Picturephone service becomes widely available and a public awareness of it develops, it will spread gradually into the residential market.

The equipment at the Picturephone customer's location consists of four parts: a 12-button Touch-Tone telephone; a display unit, with picture tube, camera tube, and a loudspeaker built in; a control unit, which contains a microphone; and a service unit containing power supply, logic circuits, and transmission equalizing circuits, which is installed out of sight.

Picture standards have been chosen for the best possible picture, subject to the limits imposed by cost and transmission capabilities (see the table on page 139). The picture signal is composed of about 250 active lines, displayed 30 times per second on a 5½-inch by 5-inch screen. Resolution is the same in the vertical and horizontal directions. The quality of the picture equals that of a typical television set in the home. Transmitting the picture signal requires a 1-MHz bandwidth.

Normally, a person using the Picturephone set will be about 36 inches away from the screen. The field of view at that distance is adjustable from 17½-by-16 inches to 28½-by-26 inches. This range of sizes is designed to give the user freedom to move from side to side during his conversation, and to permit one or two other persons to be "on camera" at the same time. The camera iris automatically adjusts the lens for changes in room lighting.

The Picturephone system is designed to take maximum advantage of the existing telephone network and add as little new equipment as possible. Picturephone customers will make voice-only telephone calls from their regular telephones, with all extra features, such as speakerphone, card dialers, and key telephone options, in place.

A 12-button Touch-Tone telephone set will be required for Picturephone service (all Touch-Tone phones are now being manufactured with 12 buttons). The Picturephone customer initiates a video call by pressing the lower right-hand, or 12th button, labeled #, and then, in most cases, dials the regular telephone number of the person he is calling.

A distinctive ring, created by a new tone ringer, identifies an incoming Picturephone call. In key telephones, such as a six-button set, the key corresponding to the called line lights red to identify a Picturephone call; the key lights white to identify a voice-only telephone call.

Lines equipped for Picturephone service can also have voice-only extensions—a secretary's pickup, for example. Video calls can be answered on such extensions; the caller sees a blank screen until the call is answered on a Picturephone set. An attendant at a PBX, for example, may or may not be equipped for picture service, as the cus-

tomer wishes. In addition, at the customer's option a fixed image, such as a company trademark, can be transmitted to the caller while the attendant handles the call.

Communication services available to the business community today range from simple direct lines to PBX and centrex arrangements for business customers. Individual service features include dial intercommunication, attendant service, and, in the case of centrex, direct inward dialing to telephones and identified outward dialing, as well as a variety of sophisticated services tailored to meet specific needs.

Picturephone service will be a valuable addition to the telephone services already available to business. To assure continuation of these services, new Picturephone key telephone units offering pickup, hold, and intercom service will be furnished. Customers served by the 701 and 757 PBX's, the No. 101 ESS, and the No. 5 crossbar centrex-CO (switched in the central office) systems will be able to add Picturephone service and retain all of their major PBX and centrex features. Picturephone service with the No. 1 ESS centrex-CO system and other new PBX systems will be introduced later.

Thus far, our discussion has related primarily to Picturephone service as it will affect the user. What about the rest of the system? Here too the philosophy of taking maximum advantage of existing telephone facilities prevails. The upper diagram on page 140 shows the basic local equipment arrangement.

Picturephone service requires no modifications to existing two-wire loops (the wires that connect a customer's telephone to the local switching office); voice-only calls and the voice portion of Picturephone calls use these wires. Two more pairs of wires in standard telephone cables are assigned for the picture signals, one pair for transmission in each direction. Equalizers are inserted at about one-mile intervals along the additional pairs. The ON-OFF switch-hook signals and Touch-Tone dialing signals, as well as the voice portion of Picturephone calls, are transmitted over the voice pair.

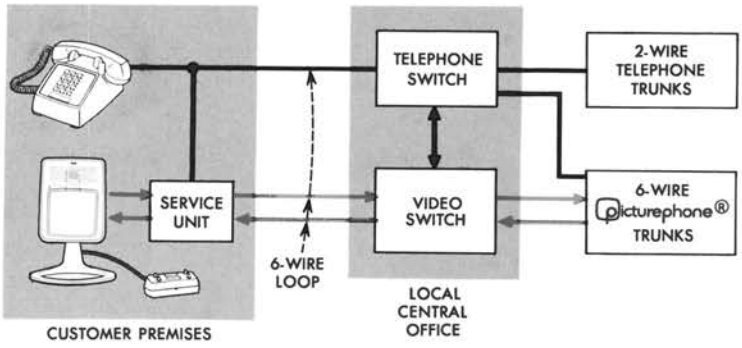
At the local central office, the voice pair is connected to the existing telephone switch in the conventional way. The video pairs, however, are connected to a separate four-wire video switch under the control of the existing telephone switching machine.

As Picturephone service is first offered, No. 5 crossbar switching machines will be modified to switch video calls; the capability will be added to No. 1 ESS later. Picturephone service for customers served from step-by-step, panel, or No. 1 crossbar offices will be routed to a nearby No. 5 crossbar or, later, a No. 1 ESS office.

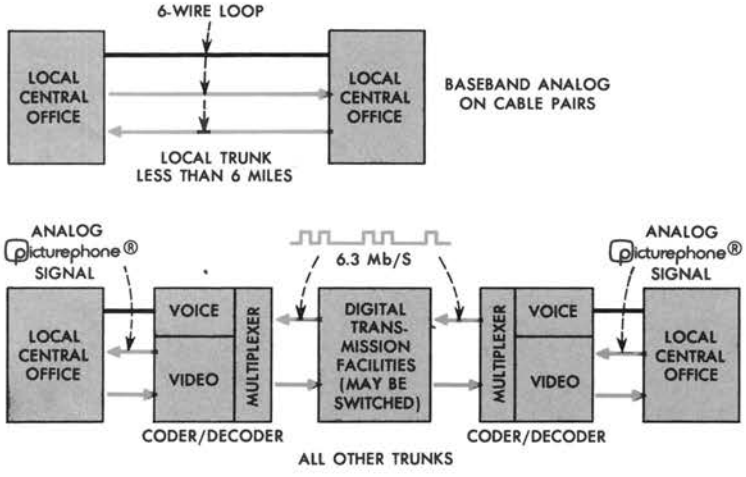
PICTURE STANDARDS	
Bandwidth	1 MHz
Active Lines Per Frame	≈ 250
Frames Per Second	30
Fields Per Frame	2 Interlaced
Screen Size	5-½" x 5"
Viewing Distance	36"
Field of View (Normal)	17-½" x 16"
Field of View (Expanded)	28-½" x 26"

Whenever a customer dials a call, the common control equipment in the switching machine recognizes the digits and causes a talking path to be established. For voice-only calls, the existing two-wire telephone switch will make the connection. When the special prefix, #, is dialed, indicating a Picturephone call, the talking path is established by the two-wire telephone switch, and a path is established simultaneously by the four-wire video switch to the trunk side of the switching machine. There, the audio and video paths form a composite six-wire appearance. For intra-office calls, the six-wire Picturephone signal returns through the switches to another line. For calls to a distant central office, however, the path is established over a six-wire Picturephone trunk. The audio portion of the six-wire trunk is never used for voice-only telephone traffic.

The Picturephone signal discussed thus far is a line-by-line electrical representation of the scanned shades of gray in the picture material. Short synchronizing pulses, between scan lines and fields, tell the receivers how to line up the parts of images. This kind of signal is called "analog." Between central offices, up to about six miles apart, the picture signal is transmitted over the



The customer's Picturephone set is connected to the local central office over a six-wire loop. As in today's telephone service, one pair of wires carries the voice signal. Two other pairs with equalizers are used for the two directions of video transmission. The audio pair is switched in the central office in the conventional way, while the video portion is switched by a newly designed four-wire video switch controlled by the switching machine. The entire Picturephone signal is switched to other central offices over a special six-wire trunk; voice-only calls continue to be switched over conventional two-wire trunks.



The Picturephone signal is transmitted between nearby central offices (less than six miles) in analog form (top). For transmission beyond six miles, the picture signal and the audio and signaling information are digitally encoded into a composite 6.3-Mb/s signal and decoded again at the distant office.

Picturephone trunk in analog form. The Picturephone trunk in this case consists of three separate wire pairs in exchange cables, with equalizers placed at about one-mile spacing in the two video pairs, as in loops.

For transmission beyond six miles, the picture, voice, and interoffice signal information is digitally encoded into a composite pulse stream of 6.3 megabits per second (Mb/s). This is called a "digital" signal. Once encoded, a signal usually is not decoded until it is within six miles of the distant local central office. Limitation to a single encoding in a connection is required to prevent an accumulation of the picture degradation that occurs each time the signal is coded and decoded. While some impairment is caused by the single coding and decoding, digital transmission is highly desirable because virtually no further impairment occurs during the transmission of the digital pulse streams.

Picturephone signals remain in digital form for switching in toll offices. No. 5 crossbar switching offices will be the first to perform the toll switching function. Later electronic toll centers now being planned will switch Picturephone calls.

The application of analog and digital transmission is shown below left. The T-2 digital carrier system, expected to be introduced in the near future, transmits at 6.3 Mb/s and is, in fact, the reason for selecting this particular signal encoding rate for Picturephone signals. The T-2 system operates over wire pairs for distances up to several hundred miles.

Digital transmission systems now being developed will ultimately take over the long-haul transmission of Picturephone signals. Until then, two existing facilities will be used: the TD-2 microwave radio relay system and the L-4 carrier system. In TD-2, a 20-Mb/s pulse stream, carrying three coded Picturephone signals, is transmitted on a single radio channel. In the L-4 system, a 13-Mb/s pulse stream, carrying two coded Picturephone signals, is transmitted in place of one of the six mastergroups on a coaxial tube. No additional transmission facilities, other than the designs now existing or contemplated for regular telephone service, will be necessary to transmit Picturephone signals. A single transmission network will transmit all services.

The picture that is finally viewed at a Picturephone receiver contains impairments introduced by each part of the built-up connection. Just as in today's telephone network, the end-to-end impairments are controlled by holding each part of the connection within specified limits. Based on analytical calculations and subjective tests, each of these has been assigned a numerical end-to-end maximum value with a specified limit allocated to stations, loops, trunks, etc. Dealing with these impairments requires techniques that are, in many cases, different from those used for audio transmission systems. The necessary new techniques are being developed.

The switched network arrangements for Picturephone service will be useful for services in

addition to Picturephone calling. Equipment will be developed that, to the network, looks like a Picturephone set, but is actually a data set. A customer will be able to dial the data set, using a regular Picturephone number, and reach a computer. The Touch-Tone dial will then be the means of communicating with the computer to retrieve data or interact in a computation. (One kind of computer response is shown in the upper photograph on this page.)

The network will also be equipped to handle machine-to-machine data traffic at a rate of about one Mb/s, much as DATA-PHONE® service handles voice-band data. Such service will require an appropriate data set at each end of a connection.

To verify the practicality of the Picturephone system plan, to make refinements in it, and to test customer acceptance of the features, a product trial was begun in February of this year and is still in progress. A total of 41 sets have been placed in offices of the Westinghouse Electric Corporation in Pittsburgh and New York with toll links between cities. Each set can be dialed from any other set, and computer access facilities are included in this trial. Acceptance by the users has been enthusiastic.

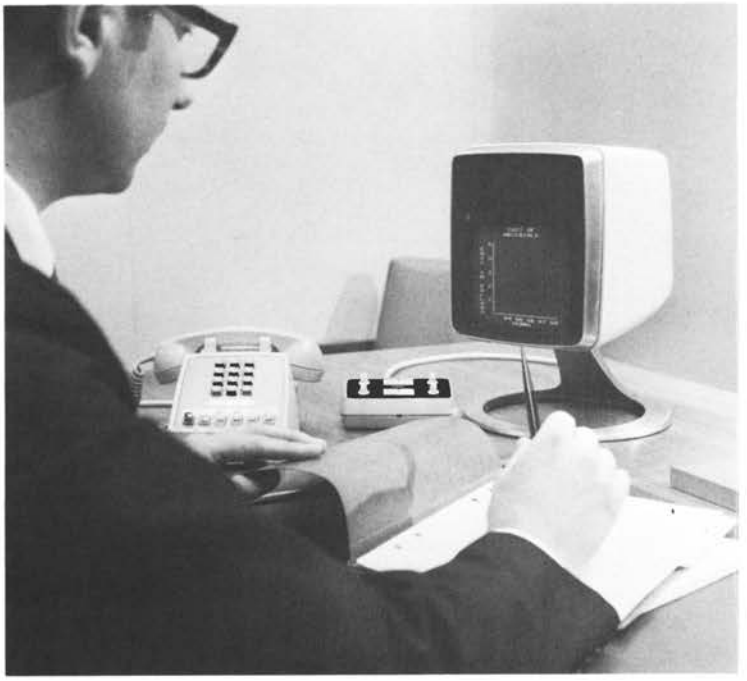
Many readers will be led to speculate about possibilities for future improvements. Among the items currently receiving attention are higher resolution for transmitting detailed documents, color, capability for making conferences calls, and reducing the transmission band by taking advantage of inherent redundancy in video images.

Satisfactory transmission of a stationary image, such as a drawing resting on a table, does not require 30 frames per second. In theory an image may be slowly scanned a few times per second with many lines, resulting in higher-resolution transmission within the same 1-MHz channel. Optional equipment arrangements to achieve this are now being investigated.

A sizable fundamental research effort is now in progress to gain enough understanding to propose a compatible color system for future phases of the service.

For Picturephone conference calling, an experiment is now in progress in which a voice-actuated switch causes the picture of the person talking to appear on the screens of all other conferees. Finally, a number of signal-processing approaches which may reduce the 6.3-Mb/s rate of transmission are in the research stages.

A practical beginning has been made. Development of Picturephone service to its present stage brings the goal of better, more natural, and more nearly complete communications nearer to reality.



Besides the "see-as-you-talk" capability of the Picturephone set, man can communicate with a computer as well. A data set, which appears to the switched network as a regular Picturephone set, permits the set to be connected to a commercial computer. In this case, the Touch-Tone dial is used to communicate with the computer and the information retrieved or the results of a computation can be displayed on the Picturephone screen. The variety of characters available to display information on the Picturephone screen is shown in the bottom photo.