





The Evolution of PICTUREPHONE Service

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A new 'see-as-you-talk' telephone, long a dream of telephone people, is nearing the day when it will be a standard service. The successful evolution of PICTUREPHONE[®] service is due both to the knowledge gained in extensive trials and to technological advances.



The first public demonstration of television as an adjunct to the telephone took place on April 7, 1927 when Herbert Hoover, then Secretary of Commerce, and other officials in Washington, D. C., spoke "face-to-face" with Walter S. Gifford, President of AT&T, and other Bell System officials at Bell Laboratories in New York City. Since then the concept of a video telephone system has progressed through several evolutionary stages, represented by the models in the foreground.

THE TELEPHONE, one of the world's most revolutionary inventions, has influenced the lives of people all over the world. It extended man's natural way of communicating—by instant two-way talking. Today, we're approaching an even more natural way of communicating by providing visual as well as aural contact through the introduction of standard PICTUREPHONE® service.

The concept of face-to-face talking—of seeing the other person as well as hearing him in a distant conversation—remained a dream for many years. As early as 1927, experiments in transmitting a picture as an adjunct to the telephone took place at Bell Laboratories. It wasn't until the mid-1950's, however, that serious studies aimed at providing commercial video telephone service could begin. The time was right—technology was beginning to catch up with the concept. The transistor had been invented, and inexpensive and reliable camera and display tubes were becoming available. Only then did video telephone service seem possible as an economic venture. The years as a laboratory curiosity were near an end.

How does a laboratory curiosity evolve into a commercially feasible system? Historically, the Bell System has used a system of field trials to evaluate both the service and the technical aspects of new advances in communications. Some trials, such as a product trial of a new telephone set, are apparent to the user and are aimed at his reactions. In others, such as a technical trial of a new carrier or switching system, the customer is seldom aware that a trial is in progress, even though extensive changes may have been made in equipment. The evolution of PICTUREPHONE service has included both types of trial.

In October 1959, final plans were made to develop a video telephone station set, now informally called "Mod I," specifically for trial use. By early 1964, a complete experimental system had been developed (see *Experiments with PICTUREPHONE Service*, RECORD, April 1964). The system had a nominal 500-kHz bandwidth and could be connected for video transmission by ordinary pairs of wires in cables to switching centers. The cable pairs needed no electrical shielding.

The equipment used by customers consisted of three packages: a display unit, a special telephone, and a power supply. The display unit contained a cathode-ray picture tube, a vidicon camera tube, the scanning, synchronization and other video circuits, and a loudspeaker. The telephone unit contained a conventional telephone handset, a microphone (to permit "hands-free"

operation), a set of TOUCH-TONE® pushbuttons, and other pushbuttons for video control.

A few of the experimental sets were installed at Bell Laboratories locations at Murray Hill and Holmdel, New Jersey. After a brief "shake-down" trial, the sets were installed in the Bell System exhibits at the New York World's Fair and at Disneyland.

The World's Fair exhibit, which was a joint effort of Bell Laboratories, the New York Telephone Company, and the American Telephone and Telegraph Company (AT&T), marked the general public's first exposure to this new service. For this reason we studied 1) how users reacted to the design, features, and operation of the PICTUREPHONE system, 2) whether users could stay "on camera," and 3) whether there was a market for video telephone service.

Physically, the World's Fair exhibit consisted of a row of six individual booths and one group booth, constructed about a central demonstration stage. The equipment in each of the individual booths was fastened in place. In three of these booths, the combination telephone set and video control unit was placed to the right of the picture display unit, while in the remaining three it was placed on the left. These alternative arrangements were designed to test the effect of equipment placement on the user.

Visitors, selected at random, were asked to try the video telephone for about ten minutes. They were asked to try both the speakerphone and the handset and to sit approximately opposite the center of the screen. They were given special operating instructions. Picture brightness and speakerphone volume were adjusted to suit each user.

During the ten-minute trial period, each participant in the individual booths was observed to see how successful he was in staying properly centered on the screen. At the conclusion of each trial, a professional market research agency conducted interviews. Some 700 visitors were interviewed during the test period from August 10 to September 10, 1964.

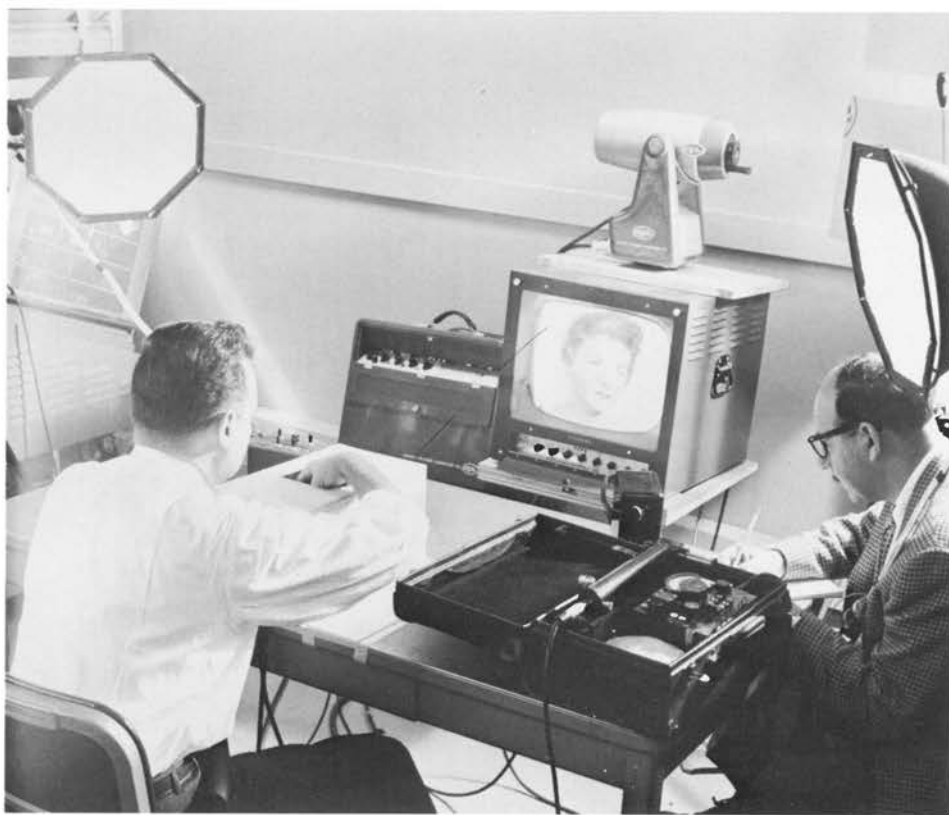
More than 80 percent of the World's Fair visitors rated picture quality as "good" or better. They liked the added personal touch of face-to-face communication, especially for enhancement of future long-distance service. Moreover, the potential for other visual services was readily recognized. Other features such as TOUCH-TONE dialing, tone ringing, speakerphone, and the "view-self" and "one-way" controls were all well received.

The equipment, as opposed to the service con-

1956 By this time, scientists in the research department of Bell Laboratories had developed several experimental "video telephone" systems of varying size and appearance which offered commercial possibilities. The one shown here was used in a public demonstration before the Institute of Radio Engineers on August 23. This was the first such system to transmit and receive recognizable pictures over ordinary telephone wires. It achieved this by transmitting a new picture every two seconds.



1957 Studies and experiments continued at Bell Laboratories to develop an economically feasible video telephone system. Experiments such as the one shown here helped Bell Labs engineers establish picture standards. As the parameters of the picture are changed, the man seated in front of the screen judges picture quality, contrast, resolution, and other features. By 1959, plans were made to develop a video telephone system specifically for trial use.



cept, was the object of some critical comments. For example, those interviewed felt the display unit was too deep. They also thought the control unit and display unit should be combined and that housings of different colors should be available, and they wanted the controls nearer the user. More than one-fifth of the study group stated that the area covered by the camera (field of view) should be increased and that the display tube screen should be larger.

Observations indicated that users had more trouble staying "on camera" than they thought they did. About two-thirds of the participants had trouble staying in the center of the camera field of view. In the interviews, however, only one-fifth of the subjects reported the same difficulty. We found from supporting data that including the video controls as part of the special telephone set was a major cause of off-center pictures.

Marketing information from the World's Fair study gave only a hint of the potential video telephone market. Service was only hypothetically available, and people were not really facing a decision whether to put up hard cash for the real thing. Under these circumstances, 60 percent of the study group said it was "very important" or "important" to see the other person during a telephone conversation. About 45 percent of this group indicated a need for home service, while 59 percent of the businessmen in the group expressed a need for PICTUREPHONE service in their offices. When one of three specific price ranges was quoted to these same people, however, home need dropped to between 9 and 34 percent, while business need only dropped to between 38 and 51 percent.

The World's Fair study established that there was indeed substantial public interest and acceptance of the concept of PICTUREPHONE service. Both business and residential needs were expressed strongly, but potential use in the home was quite sensitive to cost.

Important equipment deficiencies were identified in this study. Controls would have to be more accessible to the user, and the centering problem would have to be solved. Before changes could be made, however, additional data were needed from groups more widely representative of future customers and under more realistic operating conditions. At this early date, it was clear that an extensive trial program was needed to establish final technical and service requirements.

Exploratory commercial service was inaugurated in 1964. This venture tested the idea of a

major-city booth network as a means of establishing service. Public booths were installed at the Prudential Building in Chicago, the National Geographic Society Building in Washington, and Grand Central Station in New York. A telephone attendant made the necessary arrangements to place PICTUREPHONE calls by appointment. Official opening of service in June of that year began with a conversation between Mrs. Lyndon B. Johnson and Dr. Elizabeth Wood of Bell Laboratories. Although the booth service is still being offered, it is not used very much, nor is it being vigorously promoted. The attractiveness of this service is limited since both parties must go to a public booth to converse. It is apparent that this type of offering does not meet the needs of our customers.

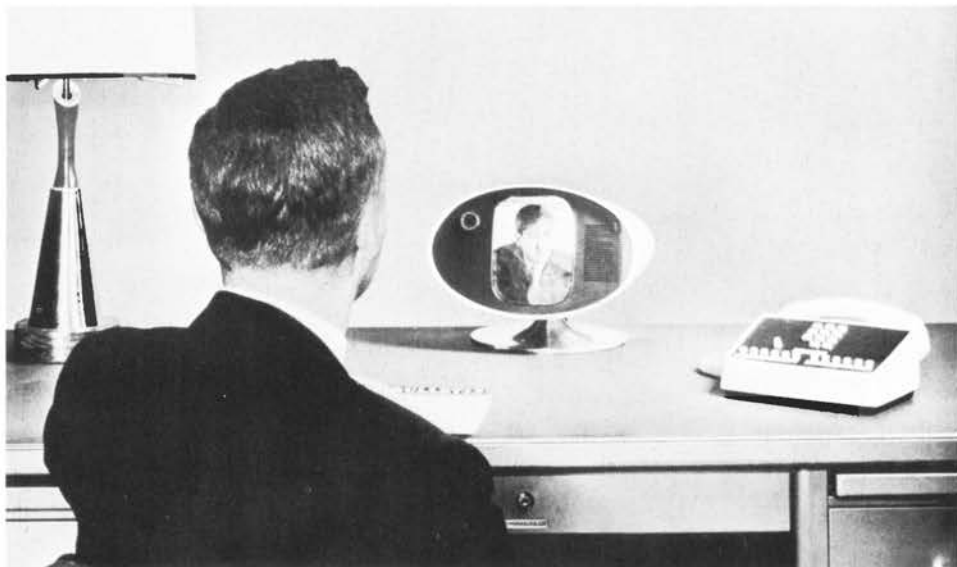
Another trial between Bell Labs locations at Murray Hill and Holmdel was begun in April, 1965. The transmission and switching equipment originally installed for the "shakedown" trial was again used in this trial. Modified Western Electric 400A switching systems were used for audio switching and control of the video switches. The video signals were transmitted over two pairs of regular telephone cable wire, one pair for each direction of transmission. Equalizing amplifiers were installed to extend the frequency response to 500 kHz. Two trunks were provided in each direction between the Murray Hill and Holmdel laboratories over combined wire and microwave radio facilities.

Twenty-eight members of the Bell Laboratories management staff were asked to participate in this trial so that both the service and equipment would be exposed to a group with a keen critical interest in innovations such as PICTUREPHONE service. This afforded greater freedom for experimentation than would have been possible in a trial conducted in cooperation with outside customers. Traffic, video control operation, and speakerphone usage were automatically recorded for the 26-week trial period.

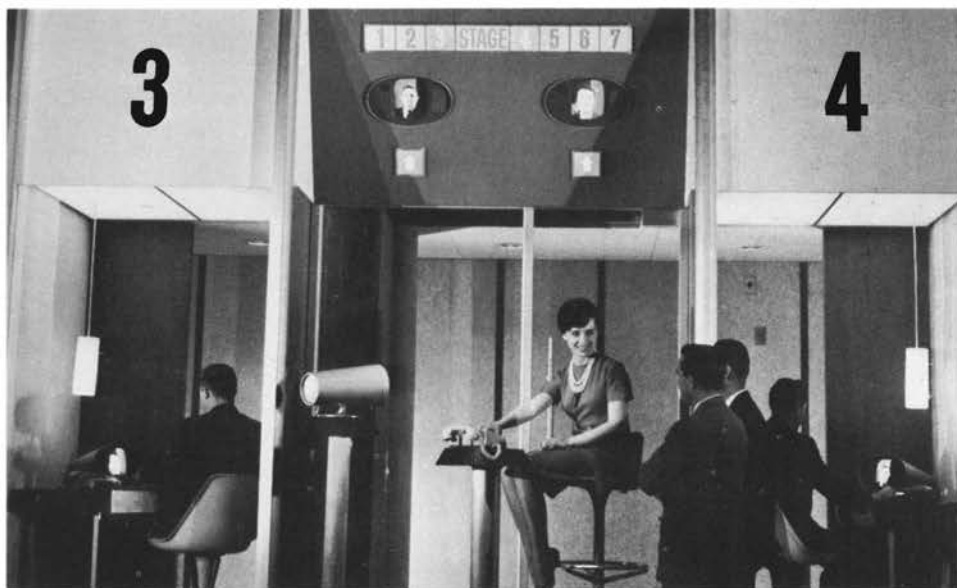
The participants in this trial were interviewed at the end of 6 weeks and again at 15 weeks. The network was left in operation following the trial period to give Bell Labs people experience with the service and to allow continuing experiments with hardware and service features.

The interview results showed that this group was indeed more critical than those participating in the World's Fair study. In this case, only 65 percent rated picture quality as "good" or better, compared with 80 percent at the World's Fair. When asked what other features or changes were needed, nearly 70 percent of those at Bell

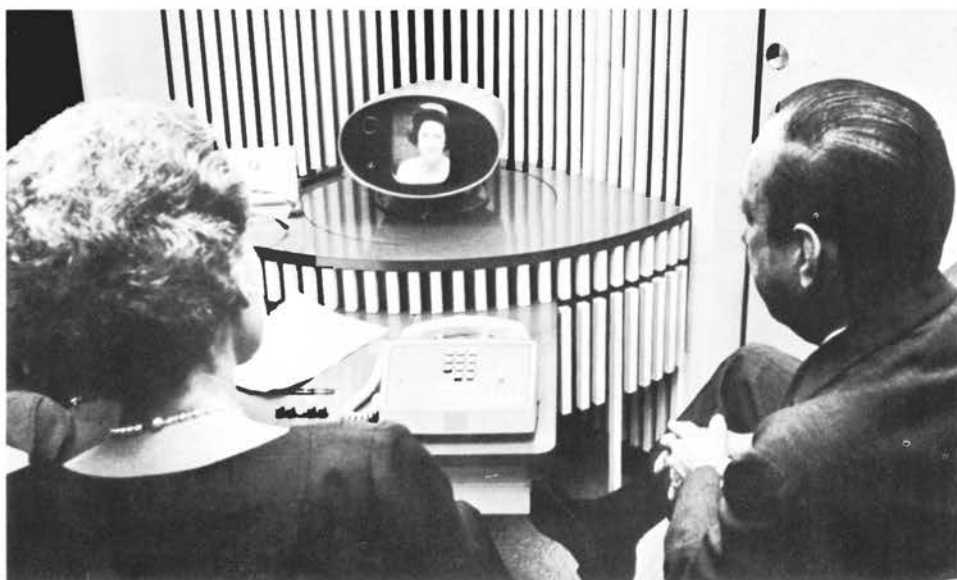
1963 A complete experimental PICTUREPHONE system had been developed. This station set included the camera-receiver-loudspeaker unit and the separate combination telephone set-video control unit.

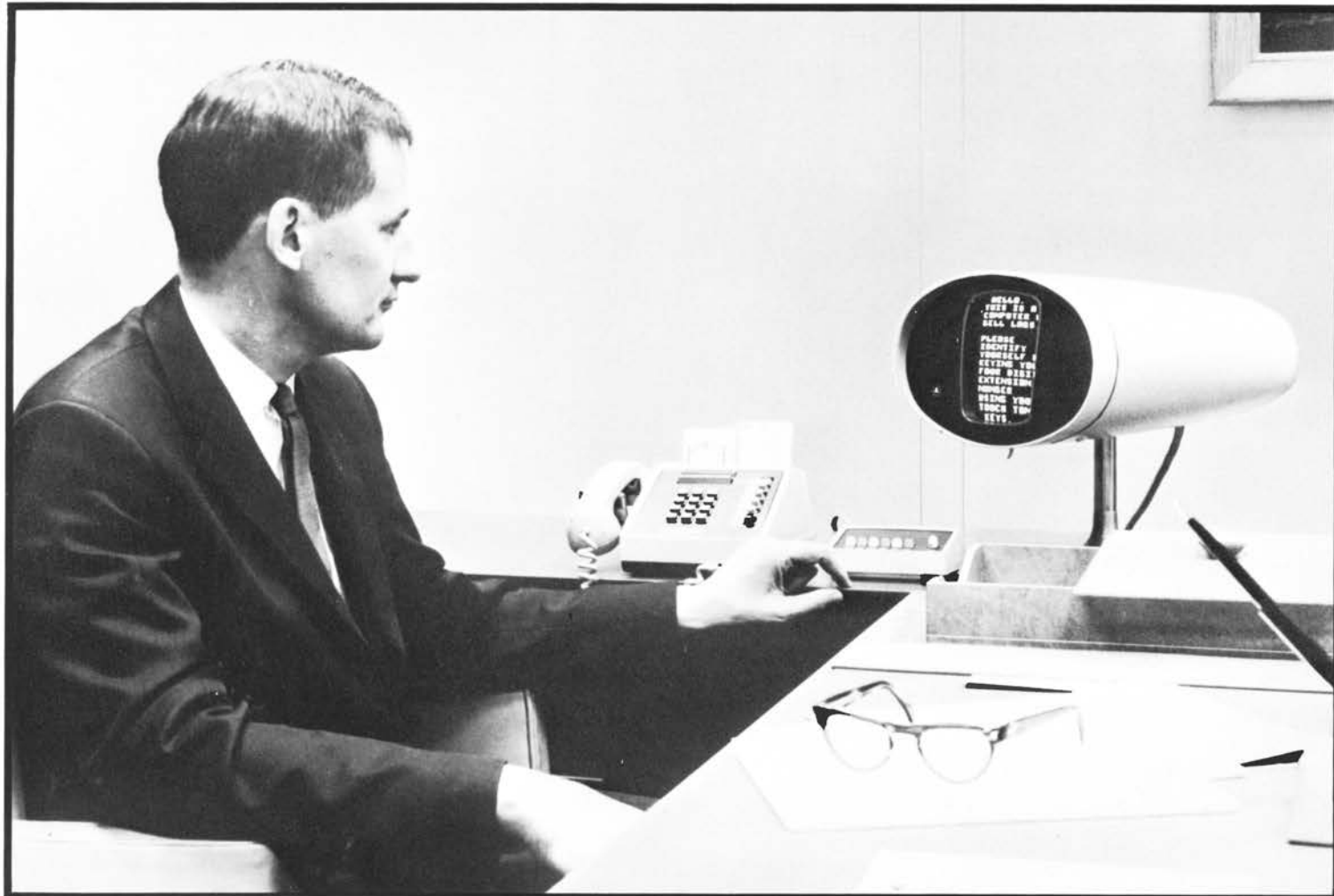


1964 The first mass public exposure of PICTUREPHONE service was made at the New York World's Fair. The exhibit consisted of six individual booths and one group booth constructed about a central demonstration stage. Visitors, selected at random, tried the service for about 10 minutes each. Results of interviews conducted at the conclusion of each trial provided information on early public reactions.



1964 Limited commercial PICTUREPHONE service between public locations in three cities—New York, Chicago, and Washington, D.C.—began on June 25. The service was inaugurated with a call from Mrs. Lyndon B. Johnson in Washington to Bell Laboratories scientist Dr. Elizabeth A. Wood, at the PICTUREPHONE center in Grand Central Terminal, New York. Robert F. Wagner, at that time Mayor of New York City, is seated at the right. Although service is still offered, public acceptance is quite limited since both parties must go to a public booth at a prearranged time.





1965 As a result of earlier trials, significant equipment and operational changes were made in the PICTUREPHONE system. A separate video control-microphone unit, for example, and a standard TOUCH-TONE telephone set could be used in place of the special combination unit used earlier. The modified equipment was used in an experimental trial at AT&T headquarters in New York City. In June, 1967, the trial was

expanded to include three Bell Laboratories locations. This trial integrated video telephone service with normal telephone service. This "corporate network" offered an opportunity to explore additional uses for the system, such as the feasibility of using the PICTUREPHONE set as an interface between man and computer (shown here). The computer is interrogated from the TOUCH-TONE dial; results are displayed on the screen.

Laboratories requested items requiring improved reproduction of detail (better resolution). The opinions of the World's Fair group were substantiated in other areas. For example, more than 60 percent of the comments on objectionable features were related to the camera's restricted field of view and the associated centering problem. The need for locating the control buttons within easy reach was also recognized. At least one new problem area was defined—the sensitivity of the station set to background and lighting conditions. More work was needed to make the set's performance less dependent upon the lighting in a room.

Traffic data obtained during the Bell Labs study indicated the service was widely used. Of the total traffic among the participants who

had PICTUREPHONE sets, 83 percent was video. However, since the number of people who could be reached with video telephone was very small compared to the number of people who could be reached by conventional telephone, the average calling rate (calls per station day) was substantially less for PICTUREPHONE service than for voice-only telephone. The average holding time (minutes per call) on video calls was about 1.3 times the average of all other telephone calls originating from or terminating to persons on the trial network. Between the first and second halves of the 26-week test period, video traffic increased by 30 percent, while voice-only telephone traffic decreased by 13 percent.

The speakerphone was used six times more often on video calls than on regular telephone

calls. This indicated that speakerphone was a necessary and natural adjunct to the face-to-face communication provided by PICTUREPHONE service. The "view-self" and "one-way" buttons were used less frequently as the trial progressed. Nevertheless, users felt these buttons were essential to maintain control over the transmitted image.

The next milestone was a product trial of the Mod I equipment, begun in July 1965, in cooperation with Union Carbide Corporation, New York Telephone Company, Illinois Bell Telephone Company, and AT&T. The trial offered an opportunity to obtain additional customer reaction in a business environment. Furthermore, valuable installation and maintenance experience could be gained by using regular operating telephone company personnel.

The equipment for this trial was essentially the same as that used in the Bell Laboratories trial. Local calls were dialed directly; intercity calls were made person-to-person via the same transmission facilities used for the booth service.

The trial, divided into two parts, involved Union Carbide employees at New York and Chicago. During the first part, from July to October, 23 sets were in service in New York and 12 in Chicago. The sets were distributed among several Union Carbide divisions to provide as broad a range of usage as possible. The second part of the trial, from October to December, used 22 sets in New York and 2 in Chicago. This final segment involved only Union Carbide executives.

As in the Bell Laboratories trial, objective data was gathered from traffic measurements. Subjective data was obtained from a series of three personal interviews with each of the trial participants. The first two interviews were designed to determine early reactions to the service. The third interview, conducted after about three months' experience, was designed to discover any changes in opinions occurring since the initial interview. This final interview was also used to gather information about the user's need for visual communications. Altogether, 66 interviews were conducted.

The results of the Union Carbide interviews showed, once again, that the concept of video telephone service was well received. Face-to-face contact and the speakerphone features were again very popular. A prism accessory, designed to fit over the camera lens, permitted written material and small objects at desk level to be displayed. This device was judged inadequate by both Union Carbide and Bell Laboratories users. Union Carbide participants agreed

with Bell Labs participants on other dislikes as well. For example, they had difficulty staying in the center of the screen. Participants in both tests felt a wider camera field of view and improved resolution were needed. Some agreement was found with the World's Fair results as well, with some participants feeling that a larger display screen was needed. It became evident from the results that the Mod I graphic capabilities were inadequate, and there was a definite customer need for greater capabilities.

Some rather interesting results were obtained from the traffic data, especially when compared with data from the Bell Laboratories trial. The average calling rates for video telephone and voice-only telephone were very similar at Bell Laboratories and at the Chicago Union Carbide location. In New York, however, the average calling rates were nearly double those at Bell Laboratories. The average holding time for video calls was nearly equal at both Union Carbide locations and was one-half to one-third less than the time at Bell Laboratories. The average holding time for voice telephone calls was shortest at Union Carbide in New York, but differed only slightly from the Chicago and Bell Labs locations. Thus, no clear pattern emerged when video telephone traffic was compared with voice-only telephone traffic.

Although the Union Carbide trial was scheduled to terminate in December, 1965, so much enthusiasm for the service was generated that a portion of the New York network was left in operation. Later, a single station was added in Chicago. The experimental service is still in operation.

Close on the heels of the Union Carbide trial, experimental PICTUREPHONE service was introduced in December, 1965, at AT&T headquarters in New York City, to serve about 20 executives. As a result of the earlier trials, significant equipment and operational changes were made for this trial. For example, a separate unit containing video controls and the microphone part of a speakerphone was provided to bring the video controls within easy reach of the user. A video switch slaved to a No. 5 crossbar switching machine was substituted for the 400A switching system used in previous trials.

Both service and economic aspects of video telephone were significantly affected by this new equipment. Video calls that were previously switched over a separate network required special numbers for PICTUREPHONE service. Video switching under control of the conventional telephone switched network allowed uniform tele-



1968 The Bell System's PICTUREPHONE "see-while-you-talk" set has been redesigned to incorporate additional features as a result of the extensive trials. The improved "Mod II" set shown here will itself be the subject of further trials during the continuing evolution of PICTUREPHONE service.

phone and PICTUREPHONE numbering. Furthermore, standard telephone sets with 12-button TOUCH-TONE dials could be used in place of the special telephone set-video control unit. By using the lower right-hand, or "12th," button of the TOUCH-TONE dial as a special prefix designating video service, users could be reached by dialing their regular telephone numbers. Thus, the service could be more fully integrated with regular telephone service.

During this period, additional public exposure to the concept of PICTUREPHONE service was gained through permanent exhibits at Disneyland

in California, the Museum of Science and Industry in Chicago, and the Franklin Institute in Philadelphia. Both local and switched intercity service demonstrations were provided by this network. Many more people were introduced to the video telephone system through exhibits at fairs, such as Expo '67, and through traveling Bell System exhibits at other public functions. These exhibits contributed to the evolution by creating an increased public awareness of the new service and by directly involving telephone companies in installing and maintaining the equipment.

The most extensive trial to date began in June, 1967, when improved versions of the No. 5 crossbar slaved video switch replaced the earlier No. 5 crossbar arrangement in New York City and the 400A switching system that had been in service since 1964 at the two Bell Laboratories locations. At the same time, microwave radio equipment was added to tie the Bell Laboratories and AT&T networks together. This expanded trial, known as the "corporate network," now serves 57 users plus a number of laboratory lines. The 57 sets are in service at the Bell Laboratories locations at Murray Hill, Holmdel, and Crawford Hill (a laboratory location close to Holmdel), New Jersey, and at AT&T locations at 195 Broadway and 32 Avenue of the Americas in New York.

At Bell Laboratories, nearly all participants have video telephone service with essentially the same features as their regular telephone service. The video telephone and regular telephone numbers are the same, except for the video-call prefix. A distinctive ring (bell plus tone ringer), together with special red lamps on CALL-DIRECTOR® and main-station line buttons, notifies the user of an incoming video call. Two-line hunting is provided, along with pick-up and hold features on each line. Secretaries can pick up on an audio-only basis. Add-on conferencing can be used on both video and audio calls for those stations so equipped. In general, the intent is to provide video telephone service integrated with and as much like normal telephone service as possible. This approach allows the customer to make effective use of video telephone service without learning a complete new set of operating rules.

The same features are not available to AT&T users because their regular telephone service is provided through a step-by-step PBX system which has no video switching adjunct. Therefore, the No. 5 crossbar machine serving Western Electric at 222 Broadway was equipped with a video switch to provide single-line service to

AT&T users. This experience is valuable since it is one of the ways service could be offered to early commercial customers not served from a No. 5 crossbar office.

The corporate network has provided a wealth of information about face-to-face video service. Moreover, this system has served as a vehicle for implementing exploratory projects to investigate new uses for the entire system and the associated switched transmission network. Changes in the existing service can be easily incorporated and their effects studied. For example, the feasibility of using the video station as an interface between man and computer has already been demonstrated. The PICTUREPHONE station set displays characters generated by a data set connected to a standard commercial digital computer. Access to the computer is obtained in the same way a call is made to another video telephone. Once the connection is established, the computer is interrogated by depressing buttons on the TOUCH-TONE dial of the telephone set. Simple instructions for use of the computer are included as part of the visual display. Weather reports, stock market quotations, and simple calculation routines are some of the other uses that have been demonstrated.

A number of maintenance features have been incorporated in the network to allow one man to align trunks and isolate trunk trouble. One man working at Holmdel, for example, can adjust the Murray Hill-Holmdel trunks for zero loss at 1 kHz in both directions. Remote-controlled loopback switches connect the transmit path to the receive path at the Murray Hill and Holmdel (Crawford Hill) microwave locations. In conjunction with other loopbacks that can be dialed up through the video switches, a maintenance man at Holmdel can isolate trunk troubles to 1) the wire facilities between the Holmdel main building and Crawford Hill, 2) the Crawford Hill to Murray Hill microwave system, 3) the wire facilities between the Murray Hill microwave tower and the laboratories building, or 4) the Murray Hill to New York microwave system.

In the near future, voice-switched video con-

ferencing and simulated satellite delay experiments will be implemented. The first experiment is designed to test a new idea for video conferencing service where the picture of the participant who is talking at the time will be automatically displayed on the other PICTUREPHONE sets of the conference. The second looks forward to the era of international video calling and long-distance domestic use of communication satellites. Subjective effects of delays equivalent to those that would be experienced on a video telephone connection via synchronous satellite (about 0.6 second, round trip) will be explored by inserting audio and video delay in selected calls made over the Bell Laboratories-AT&T network.

More than four years of trials with the Mod I equipment have been completed. During this period, nearly 800 persons have had their feelings probed concerning their reaction to PICTUREPHONE service. In addition, a considerable amount of objective data has been obtained on the use of controls, the difficulty of staying on camera, and how the service is used. A great deal has been learned; a great deal remains to be learned.

Examination of the Mod I trial results reveals one clear conclusion—general reaction to both service and equipment is very favorable. However, if we apply the traditional yardstick that 95 percent of the people must judge the service as “good” or better, improvements to Mod I are clearly necessary.

As a result of these trials, a completely new station set, known as “Mod II,” has been designed. Together with a new supporting system, this set will also be the subject of a series of evaluative trials. One such trial is scheduled in cooperation with the Westinghouse Electric Corporation at their offices in New York and Pittsburgh for a period of about three months. Just as results of the Mod I trials were used to formulate requirements for Mod II, so will the results of the Mod II trials be used to further the evolution of PICTUREPHONE service. The successful performance of Mod II in these trials marks a major step toward the introduction of PICTUREPHONE service on a standard basis in the early 1970's.