Switching

The *Picturephone*® System:

Switching Plan

By J. F. URICH

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This paper develops the switching plan for Picturephone® *service from a statement of the service operating procedures. The signaling plan is presented in detail. The switching plan provides the framework for the detailed switching papers which follow.*

I. INTRODUCTION

A prime objective of *Picturephone* service is to make it a natural extension of present telephone service. The switching plan gives explicit definition to this objective while permitting extensive use of the portion of the switching plant that performs functions common to both services. Where economies dictate that the *Picturephone* network depart from the telephone network, the switching plan provides the means.

The technical aspects of switching and transmitting a video signal are treated in other articles in this issue. This paper deals primarily with the service as seen by the customer, and about those engineering factors which then follow from the service definition.

II. OPERATING PROCEDURES

The operating procedures for *Picturephone* service form a set of self-consistent rules which define it as a vertical extension of telephone service. From these procedures, requirements are generated for the switching hardware to provide the customer, local, and toll switching for the service. These procedures are as follows:

(*i*) *Picturephone* and telephone calls are placed and received on common station equipment.
(*ii*) The telephone loop carries *Picturephone* audio.
(*iii*) The telephone line is busy when a *Picturephone* call is in progress and vice versa.
(*iv*) *Picturephone* and telephone numbers are the same.

(*v*) *Picturephone* service will only be provided with *Touch-Tone*® calling.

(*vi*) *Picturephone* calls are placed by keying a *Picturephone* service indicator followed by the telephone number.

(*vii*) The *Picturephone* service indicator is the twelfth *Touch-Tone* combination (# button).

(*viii*) *Picturephone* calls placed to non-*Picturephone* numbers will not be allowed to complete on any basis. Such calls will be routed to a suitable announcement.

(*ix*) A *Picturephone* call can be originated on any standard *Touch-Tone* telephone set having access to the audio portion of a *Picturephone* loop.

(*x*) A *Picturephone* call can be answered on any telephone having access to the audio portion of a *Picturephone* loop, e.g., bridged telephone.

(*xi*) A *Picturephone* station can always pick up (with video) a *Picturephone* call previously answered on a telephone.

(*xii*) Switchhook supervision on *Picturephone* calls is maintained over the audio connection.

(*xiii*) The switched video and audio *Picturephone* service connection is provided at called party answer and throughout the duration of the call.

(*xiv*) Charge timing for customer dialed *Picturephone* calls is based upon audio supervision, beginning at called party answer and terminating upon disconnect.

(*xv*) A distinctive alerting signal is provided during ringing to distinguish incoming *Picturephone* calls from telephone calls.

(*xvi*) The associated switching equipment will provide signaling to energize the video circuits in a *Picturephone* station. On outgoing calls the station is energized in response to the *Picturephone* indicator (#) keyed by the caller; on incoming calls the station is energized when the customer answers at the *Picturephone* station.

(*xvii*) *Picturephone* service should not restrict any telephone service available to the associated telephone line.

2.1 *Discussion*

These 17 operating procedures determine the numbering, dialing, and charging plans for the service. Procedures (*i*) through (*iv*) say that the customer has one line and one number used in common for both telephone and *Picturephone* calling. For telephone calls only the audio portion of the loop is used; for *Picturephone* calls, both

audio and video portions are used. The normal telephone numbering, based upon a three-digit area code followed by a three-digit office code and four-digit station number, uniquely identifies each customer. Destination routing can be employed within the *Picturephone* hierarchy just as it is used in the telephone hierarchy.

Procedures (*v*) through (*vii*) describe the customer dialing plan. Prefixing any telephone call with the # indicator signifies a *Picturephone* call. Item (*xvi*) further adds that the switching system will respond by turning on the video circuitry in the caller's station as a visual attending function. When the station is energized, a gray raster appears on the screen. With key telephone services a red lamp is lighted as well.

Procedures (*ix*) through (*xii*) recognize the boss-secretary relationship in a business communications environment. The boss may have *Picturephone* service while the secretary has only a telephone. She may still place and answer *Picturephone* calls on his line.

Procedures (*xii*) through (*xiv*) cover the supervision and charge timing of *Picturephone* calls. The plan calls for "immediate video." That is, the caller declares his intention during the dialing of the call. If the # prefix is dialed, *Picturephone* trunks, composed of audio and video transmission facilities, are selected for routing the call to the terminating office. If the call is answered, be it from a *Picturephone* station or from a bridged telephone-only instrument, *Picturephone* charging commences immediately. Under the "immediate video" discipline, standard telephone signaling and charge recording systems can be employed on the audio portion of the network with little modification. As a safeguard against erroneously dialed *Picturephone* calls resulting in improper charges, item (*viii*) requires that the switching systems block *Picturephone* calls which cannot, per se, provide the visual capability. In the *Picturephone* network, this screening function will be performed as close to the originating office as the routing plan will allow. In addition, the terminating *Picturephone* office will screen the terminating line for *Picturephone* service capability before ringing. If the call cannot be completed, a recorded audio announcement will inform the caller and suggest that the call be placed again without the # prefix—a subtle benefit of the "one number" procedure.

Procedures (*xv*) and (*xvi*) recognize that in integrating *Picturephone* service and telephone service, some additional customer line signaling is required. A single additional signal, Video Supervisory Signal (VSS), is sufficient to perform these functions. This will be described in more detail in Section IV.

Finally, procedure (*xvii*) recognizes that *Picturephone* is an adjunct to telephone service, not a replacement for it. A single exception has been made to this rule. *Picturephone* service will not be provided on multiparty telephone lines, an exception not deemed to be a serious restriction to the usefulness of the new service.

III. THE ANALOG SWITCHING HIERARCHY

The *Picturephone* system description discusses the reasons for employing both baseband analog and digitally-encoded video transmission in the network.[1] The allocation of video impairments allows for a five-level switching hierarchy, excluding customer switching systems.[2] The top three levels of this hierarchy will always switch the *Picturephone* signal in its digitally encoded form.

Figure 1 depicts the switching hierarchy from the Class 4 office down to the *Picturephone* station.[3] As a rule, the machines in this portion of the hierarchy switch the video signal in its baseband analog form. Class 5, or local *Picturephone* switching offices are selected telephone central offices in key business wire centers throughout the country. Initially only No. 5 crossbar switching entities can be modified to function as *Picturephone* central offices.[1] The capability to use No. 1

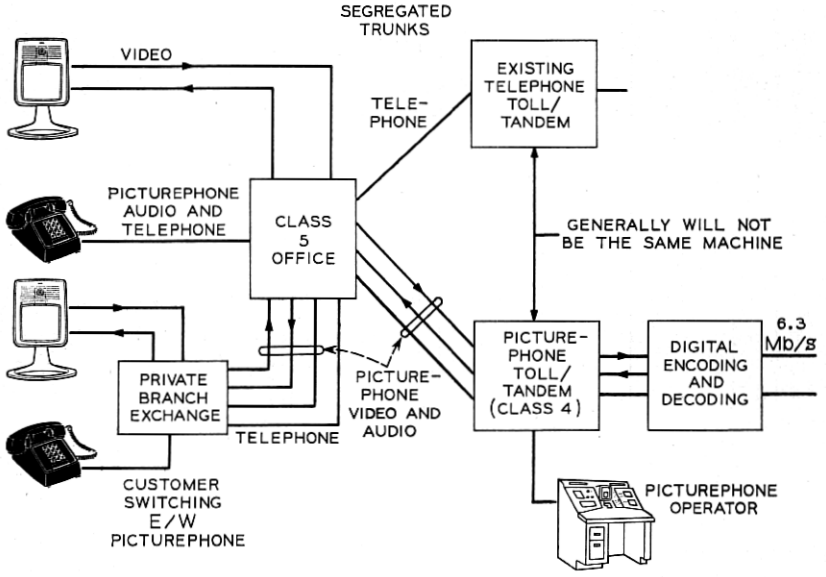

Fig. 1—The lower two levels of the *Picturephone* hierarchy illustrate the switching-trunking plan.

ESS as a local *Picturephone* switching entity will be included as the service develops.

The Class 5 *Picturephone* office terminates the audio and video pairs of individual *Picturephone* lines, *Picturephone* trunks from PBXs, and two-way *Picturephone* trunks to the Class 4 *Picturephone* office. All *Picturephone* lines and trunks require three appearances on the switching machine—one for audio and one for each direction of video. The two-wire audio appearance of a *Picturephone* line is used in common for *Picturephone* and telephone calls from the customer. All *Picturephone* trunks, however, are dedicated to *Picturephone* service only. The audio part of a six-wire *Picturephone* trunk is never used for a telephone call. Thus, for individual line customers, the Class 5 office serves as a point of departure between the telephone and the *Picturephone* networks. To the customer the two services are closely integrated. Beyond the Class 5 office the *Picturephone* transmission-switching network is engineered independent of the telephone hierarchy. *Picturephone* tandem/toll offices are physically located in telephone switching offices, but there is not 1:1 correspondence between the function of the switching machine in the *Picturephone* and telephone hierarchies. Because of the different ratio of switching and transmission costs between the two services, and the large disparity in traffic volume in the early years, it is expected that the *Picturephone* network will employ more final routing and fewer direct trunk groups than the telephone network. In essence, above the Class 5 office the *Picturephone* network is a wideband communication network overlayed on the nationwide telephone network. Routes, right of way, transmission facilities, switching control, and buildings are shared; but network engineering is different.

3.1 *Customer Switching Consideration*[4]

Just as the Class 5 *Picturephone* office splits *Picturephone* and telephone traffic into two networks for its customers, the customer switching systems (PBX and Centrex CU) accomplish the same split for their customers. Trunks leaving a *Picturephone* equipped PBX are segregated into a *Picturephone* group and the normal telephone groups. These separate trunk groups can even home on two different Class 5 offices (one being *Picturephone* service equipped of course) without numbering plan ambiguity. In many cases, large business customers with *Picturephone* service will be able to retain their listed telephone directory number even though their local Class 5 office is not equipped for *Picturephone* switching.

3.2 *Operator Services*[5]

Picturephone service operator services are directly analogous to operator services provided on telephone. The *Picturephone* service assistance operator, however, must control the video as well as the audio part of the contact. *Picturephone* service customers request assistance by dialing #0. The call is routed using *Picturephone* trunks to *Picturephone* operator trunk circuits which are generally terminated on a Class 4 *Picturephone* switching office. Audio-only facilities link the switching machine to operator positions on standard No. 3 switchboards. On the switchboards, each *Picturephone* answering jack is paired with an outgoing *Picturephone* jack over which the operator can extend the call by dialing back into the class 4 machine. The video portion of the call is not extended from the switching machine to the switchboard although the operator can control it by means of a key on her cord circuit.

In lieu of the customer seeing the assistance operator during the contact, a fixed video image is transmitted to the customer from the switching machine.

The other service and assistance codes applicable to telephone service, e.g., 411 for Directory Assistance and 611 for Repair Service, do not have specific *Picturephone* service counterparts. Calls to obtain these services will follow regular telephone procedures in order to allow calls *about Picturephone* service to be placed from non-*Picturephone* stations. So, for example, customer dialed calls to #411 are blocked and the customer is instructed to dial the call without the # prefix. The intention in blocking such calls is to avoid having the customer expect to receive a video response and then provide him audio only. If, in the future, *Picturephone* counterparts to these services become desirable, they can be provided.

IV. THE SIGNALING PLAN

4.1 *General Considerations*

As described in the Operating Procedures in Section I, all call control supervision and address signaling for both lines and trunks is carried on the audio portion of the *Picturephone* facilities. Standard telephone supervision and addressing systems can therefore be used for *Picturephone* service without modification. The opportunity was taken, however, to reduce to a minimum the number of different systems employed for signaling in the *Picturephone* system, in order to save development effort. For example, *Touch-Tone* calling is stan-

dard for all *Picturephone* customers. All interoffice trunks employ E&M lead supervision and multifrequency address signaling on the audio path.[6] Because *Picturephone* trunks are never used for non-*Picturephone* calls, there is no necessity to carry the *Picturephone* service indicator past the originating office. The trunk class of service conveys this information.

4.2 *Video Continuity Testing*[7]

Charge recording in the *Picturephone* network is based entirely upon supervisory signals on the audio path. In order to verify that a usable video transmission path is provided on every billed call, an integrity test is made of the entire video connection from station to station on every network call.

This video continuity test is performed link-by-link as the call is set up. Every analog loop and trunk, when it is idle, has its video transmit path connected to its video receive path through a "loop around." When the circuit is to be used in a *Picturephone* call, the switching office selecting or controlling the circuit connects a 12 kilohertz sine wave oscillator to the video transmit pair and a tuned receiver to the receiver pair. The continuity test tone is looped back at the distant end of the circuit, and the receiver checks the returned tone level. Satisfactory completion of this test is required before the call set up procedure can proceed. Failure of the test on a *Picturephone* trunk results in the switching office selecting another trunk and trying again to complete the call. Because all *Picturephone* trunks are two-way—that is, they can be seized from the switching office at either end—loop arounds are required at each end. To prevent singing on idle trunks, 3 dB of attenuation is contained in each loop around circuit. The customer end of video loops do not require attenuation in their loop around circuit, so the test tone is returned at nominally the same level as transmitted.

On *Picturephone* interoffice trunks, the loop around at the outgoing end of the trunk is removed upon seizure of the circuit. At the incoming end the loop around is removed when multifrequency addressing commences on the audio path, which will only happen if the continuity test is satisfied. Thus, no additional control signaling is required for loop-around control on analog *Picturephone* trunks. Loop-around control on *Picturephone* loops does however impose some additional customer line signaling requirements over and above that employed in telephone service.

4.3 *Customer Line Signaling for* Picturephone *Service*

Operating Procedures (*xv*) and (*xvi*) refer to the requirements that *Picturephone* switching offices provide a means for distinctively alerting a *Picturephone* station to an incoming *Picturephone* call (alerting function) and control the video turn-on of both calling and called *Picturephone* sets (attending function). Section 4.2 described the necessity for loop-around control on *Picturephone* loops. Accomplishing these three functions requires a degree of interaction between the switching office and the loop terminating equipment at the station not necessary in telephone service.[8] One additional customer line signal applied at the switching office is sufficient to provide this interaction. This signal is called Video Supervisory Signal (VSS).

4.3.1 *Additional Signaling Constraints*

The signaling plan required to accomplish alerting, attending, and loop around control must also satisfy the following operational requirements:

(*i*) It should be possible for maintenance personnel at a switching machine location to perform tests on the video portion of a *Picturephone* loop (i.e. through a distant loop around) without alerting the customer.

(*ii*) A *Picturephone* customer should never be allowed to inadvertently see himself through a continuity test loop around.

(*iii*) First-order failures—that is, a single signal-generator failure in a switching office—should not result in an unsatisfactory call.

4.3.2 *The Signaling Logic Design*

The new customer line signal required is VSS. This is a video signal composed of vertical and horizontal sync pulses with a fixed brightness level instead of picture information. VSS generators are provided at all switching offices. Notice, however, that a *Picturephone* set transmitting video also generates VSS; e.g., VSS is a subset of the set of all video signals.

At the *Picturephone* loop terminating equipment (a *Picturephone* service unit or a Key Telephone System line circuit) the following binary information is available:

L = Audio loop off hook. Voltage present and current flowing.*

* In general the logic circuitry in the *Picturephone* station has metallic access only to the switchhook of the main telephone. The on hook-off hook state of bridged telephone extensions on the audio loop must be deduced from the state of the loop.

L' = Audio loop on hook. Voltage present and no current flowing. *All* telephones are on hook.
M = Main station off hook. Derived from switchhook contacts of the main telephone set.*
M' = Main station on hook.
V = VSS present on the *incoming* video pair.
V' = VSS not present.
R = 20-Hz ringing present on the audio loop.
R' = 20-Hz ringing not present.

Figure 2 shows the sequential state diagram of the *Picturephone* loop terminating logic package.

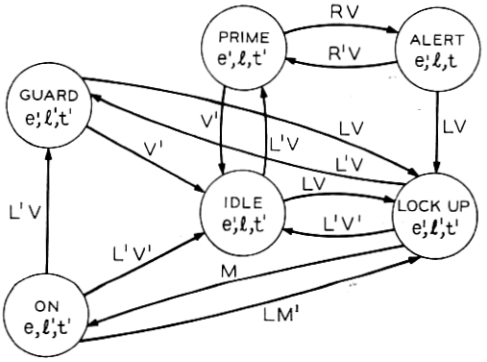

Fig. 2—The sequential state diagram of the *Picturephone* station logic illustrates the switching-station interaction.

Five logic states are defined in order to control three binary outputs. The outputs to be controlled are:

e = video circuitry energized, camera and receiver on;
e' = video circuitry off;
ℓ = video loop around in;
ℓ' = video loop around out;
t = tone ringer sounded; and
t' = tone ringer silent.

In the IDLE state the video circuitry is off (e'), the loop around in (ℓ), and the tone ringer silent (t'). On an originating call the main station or an extension goes off hook, receives dial tone, and dials. The set remains IDLE. The switching equipment performs a con-

* Note that the L and M variables are not independent. State $L'M$ is impossible.

tinuity test, and then returns a burst of VSS. The combination *LV* causes a transition to LOCK UP. If the call is being originated by the main station, a transition to ON occurs immediately. In LOCK UP and ON the loop around is out, and the set is energized or not energized respectively. Notice that as long as any telephone is off hook, the main station can go on and off hook repeatedly and the video circuitry will turn off and on. The set will not return to IDLE until all stations on loop are on hook. The transition to IDLE takes place directly if *L'V'* occurs, or via GUARD if *L'V* occurs first. The GUARD state prevents the distant party from seeing himself through a loop around in this station in the case of a called party disconnect.

On an incoming *Picturephone* call, the set is necessarily in the IDLE state. This switching equipment tests video continuity and then applies VSS prior to starting 20-Hz ringing. This causes a transition to PRIME. Note that a test man at the switching machine can perform loop-around transmission tests of frequency versus gain, or can apply and view video test patterns without alerting the customer. The video circuitry in the station cannot be energized, however, unless the station is off hook. When 20-Hz ringing is applied by the switching machine, the tone ringer is sounded (ALERT) keyed on and off by the 20 Hz as long as VSS is present. When the called party answers and VSS is present, the set goes to LOCK UP and then to ON as in the previous example. On terminating *Picturephone* calls, the switching machines apply VSS towards the station prior to ringing and continuously until an answer signal is received over the audio path. Notice the fail-safe feature that even if one VSS generator fails to operate on a call, the calling station (if transmitting video) will turn on the called station or vice versa.

Figure 3 shows the entire sequence of an interoffice *Picturephone* call between two individual stations. This serves to illustrate the entire switching process, and summarize the switching system plan.[9]

V. CONCLUSIONS

The switching plan for *Picturephone* service is the definition of a numbering, dialing, charging, and hierarchical plan for the new videotelephone service. It provides a service well integrated with telephone communications from an operational viewpoint, while allowing the incremental use of that sizeable portion of switching systems logical hardware not particularly sensitive to the communications medium. With this plan, switching development effort was minimized, focusing on those aspects of the service which make it different from telephone service.

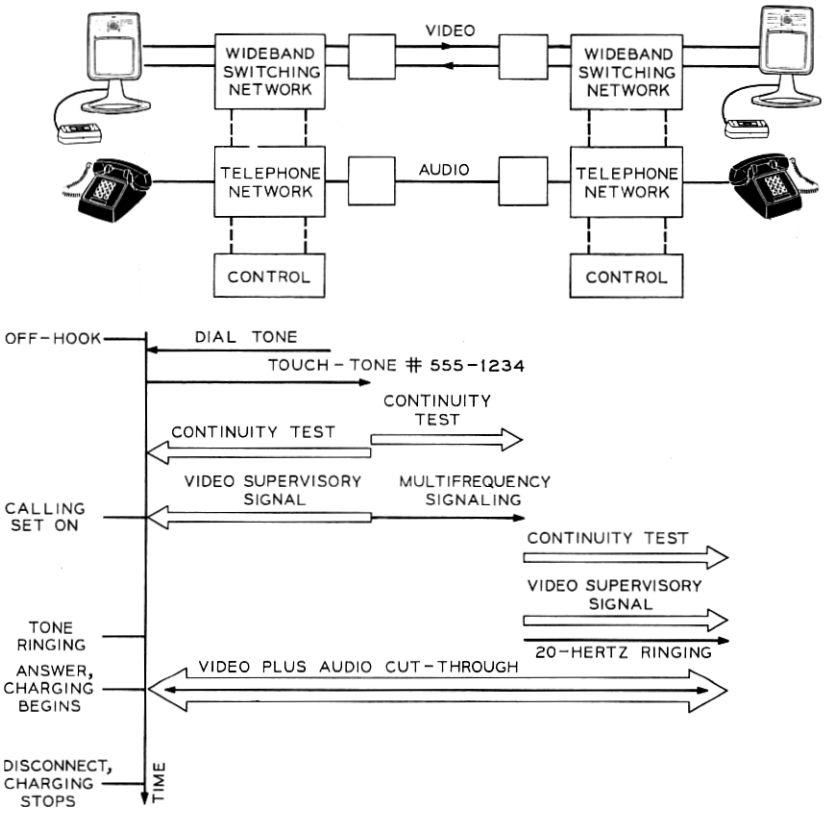

Fig. 3—The complete sequence of events in an interoffice *Picturephone* call.

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