

## The *Picturephone*<sup>®</sup> System:

# Key Telephone Systems

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*Initially, Picturephone<sup>®</sup> service will consist to a large extent of key telephone systems (KTS) that will permit subscribers to have multiline access to Picturephone Central Office or Private Branch Exchange (PBX) lines as well as to Picturephone intercoms. Add-on-conference capability will also be available. In this paper, Picturephone KTS operation, logic and control, and physical characteristics are described.*

### I. INTRODUCTION

A key telephone system (KTS) is a customer-controlled switching system which permits use of a station set for more than one Central Office, Private Branch Exchange (PBX) or intercom line by switching from one line to another. Generally speaking, customers can signal from one station to another, transfer calls between stations, hold a call on one line while talking on another, and converse between stations without making use of a Central Office (CO) or PBX line.<sup>1</sup> *Picturephone* service adds a new dimension to key systems in that now video as well as audio switching must take place to connect one *Picturephone* station set to a number of *Picturephone* CO or PBX lines or intercoms.

Five key system services will be offered for *Picturephone* service:<sup>2</sup> two Central Office or PBX line services, two intercom services and one add-on-conference service. The line services will permit (i) boss/secretary access to one *Picturephone* CO or PBX line,\* and (ii) shared access of one line by a number of boss/secretary groups. The first of these services is referred to as single-group line service while the second is referred to as multigroup line service. The intercom services will consist of (i) a single-link *Picturephone* intercom that

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\* Hereafter referred to as "Line."

will provide dial service for up to ten stations on one audio/video link and (ii) a multilink *Picturephone* intercom that will provide service for a maximum of 27 stations on three audio/video links. Add-on-conferencing will be available between two lines or one line and one intercom station.

A *Touch-Tone*® telephone set and a speakerphone are an inherent part of the *Picturephone* station<sup>3</sup> and these may be used for normal telephone calling. *Picturephone* service is provided as an adjunct to regular telephone service, the only restriction being the provision for *Touch-Tone* signaling. Key system line services interface with the serving Central Office or PBX over three cable pairs: one pair for audio communications and two pairs for video.

From a subscriber's point of view, calls can be placed either on a video or audio basis in all of the key services mentioned simply by preceding (or not) the called number with the # digit. Incoming *Picturephone* calls are distinguished by a tone ringer (bell for telephone) and a red line lamp (white for telephone). Normal key system lamp flashing rates are used to indicate hold, ringing and busy. A single red and white lamp assembly is used under each line button for visual alerting.

## II. KEY TELEPHONE LINE SERVICES

### 2.1 General

Single Group service is intended to serve boss/secretary arrangements and permits simultaneous audio access to both stations. However, video access is provided on a hierarchical basis and if both boss and secretary are off-hook on the same line, only the boss will have a video connection. Multigroup line service allows a number of boss/secretary groups to share one *Picturephone* line. The first station within a group to seize the line will lock out all other groups.

### 2.2 Single Group Service

The block diagram in Fig. 1 shows a typical key system line installation. A single line picked up by a boss and a secretary is shown; however, additional lines may be connected to a station by adding a line circuit, a video switch and a video cable equalizer<sup>4</sup> per line.

To illustrate the operation of this service, incoming and outgoing video calls will be described. Telephone calls follow standard KTS practice and will therefore not be discussed. On an incoming *Picturephone* call, the CO or PBX applies the Video Supervisory Signal

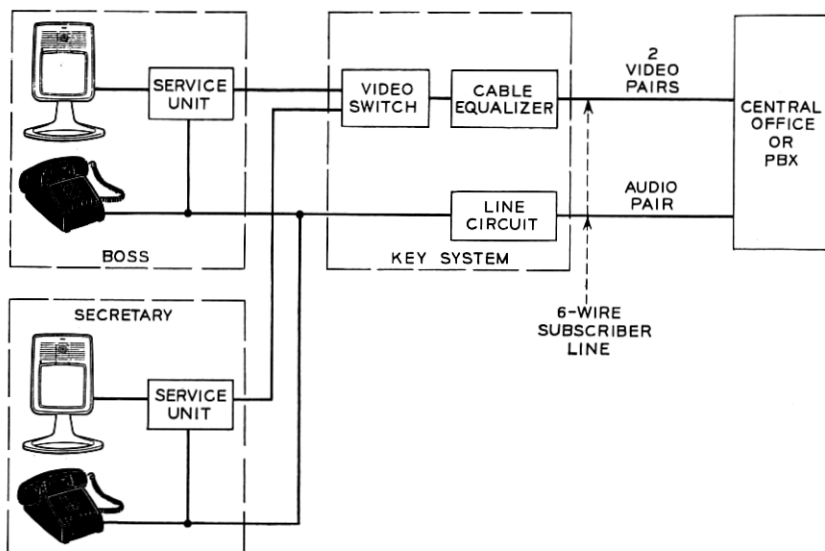


Fig. 1—Single-group *Picturephone* line service.

(VSS) to the incoming video pair at least 100 ms before applying ringing to the audio pair. After detecting VSS and within the 100-ms interval, the cable equalizer switches the line circuit into the video mode. When ringing is detected by the line circuit, a distinctive ring (tone ringer) and a flashing red lamp alert the station user. When the call is answered, ringing is retired, the red lamp goes steady and the video switch extends the video and turn-on-set signal to the called *Picturephone* station. If the call is placed on hold, the line circuit provides a winking red lamp to the telephone set. The video switch is released in the hold state resulting in a blank screen to both parties. Upon re-entering the connection, video as well as audio communications may be continued.

When a station is placed off-hook to originate a *Picturephone* call, the line circuit lights the corresponding white lamp in the set. The # button is depressed followed by the telephone number of the called station. When the CO or PBX detects that a video call has been dialed, a burst of VSS is sent to the video cable equalizer. The equalizer commands the line circuit into the video mode; the line circuit in turn switches the lamp in the telephone set from steady white to steady red. The system goes idle when all stations are on-hook.

A video loopback<sup>5</sup> is provided between the transmit and receive

pairs of the line at the cable equalizer circuit. This loopback is connected when the system is idle and is removed when the line circuit is in the video mode and a station is off-hook. Once removed, the loopback will not be reconnected until the system is idle, i.e., VSS not being received and all stations on-hook. This logic allows a video signal to be transmitted through the customer loop for transmission testing.<sup>6, 7</sup> It also prevents a person from seeing himself if the person to whom he is talking goes on-hook. In the event of a power failure, either at the line circuit, the cable equalizer, or the station set, loopback is removed to prevent the CO or PBX from completing video calls to that line.

### 2.3 Multigroup Service

Multigroup *Picturephone* line service was designed to provide shared-line service to a number of boss/secretary groups. The multigroup system as shown in Fig. 2 utilizes a line circuit, a cable equalizer, and a common control and lockout circuit. It shows boss/secretary groups one through nine sharing one *Picturephone* line. In this illustration, secretaries have video access; however, audio-only service may be provided for secretaries. When any one group (station) is using the line, access is denied to all other groups (stations). Any *Picturephone* group that inadvertently goes off-hook on a line that is in use will receive a busy tone. Possession of the line can be transferred to another group by placing the line on hold and through external signaling means, directing another group to pick up the line. Multigroup equipment arrangements will allow up to nine *Picturephone* groups to share a single line.

If the secretary within a group is equipped with a *Picturephone* station, single-group rules apply. That is, the customer must choose a hierarchical video order for the two *Picturephone* stations but both stations within the group have audio access.

Incoming and outgoing calls, insofar as distinctive audible and visual signaling and call completion are concerned, are handled the same way as in single-group *Picturephone* service with one exception. That is, on incoming calls one group (station) will usually be designated as the attendant group and all incoming calls will ring and flash at the attendant location. During ringing, the lamp associated with each line is lighted steady at all nonattendant stations. If a nonattendant station goes off-hook during ringing, it will receive a busy tone. When the attendant determines the station to which the calling party wishes to be connected, she may place the incoming call on hold and, through external signaling means, advise the proper station to



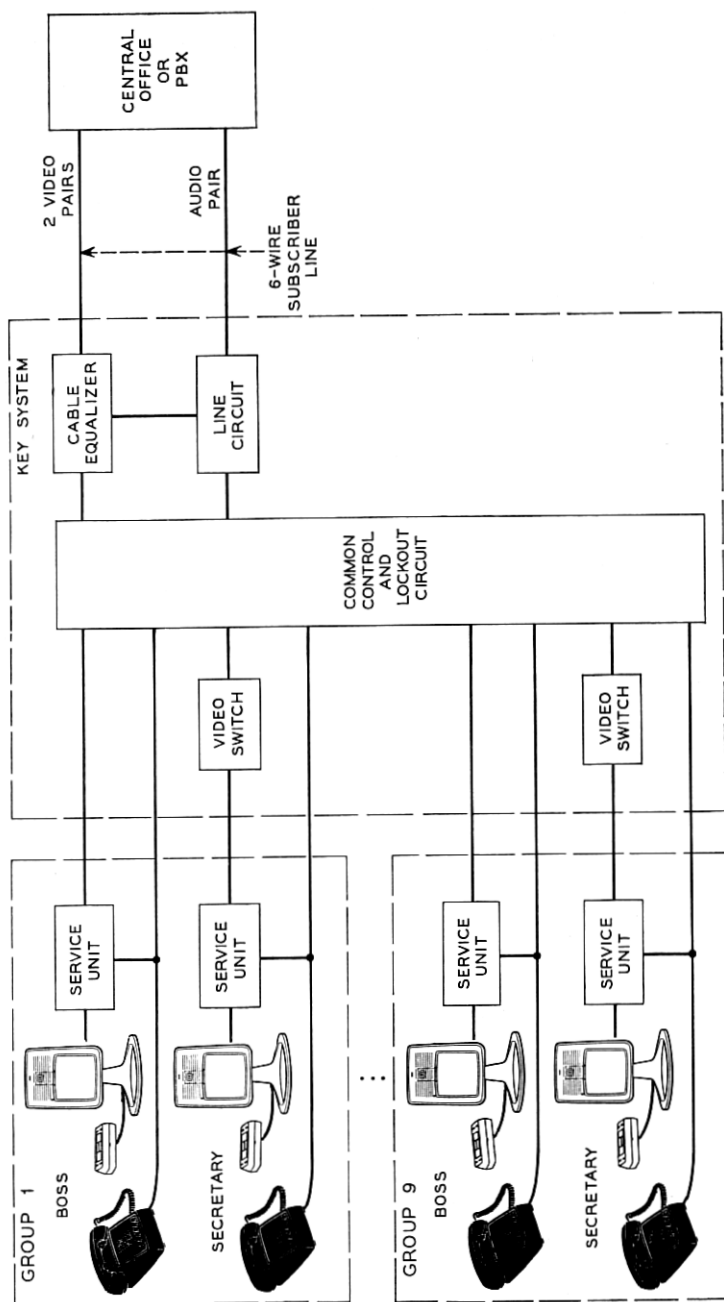


Fig. 2—Multigroup Picturephone line service.

pick up the line. When the alerted station picks up, the call will be transferred to that station and the attendant as well as all other groups will be locked out.

An optional Direct Station Selection (DSS) arrangement can be provided for the attendant to advise a station of an incoming *Picturephone* call. With this arrangement, the attendant operates the proper DSS button which activates a flashing red lamp and audible tone ringer signal associated with the *Picturephone* line to be picked up by that station. As above, when the station picks up, the call will be transferred and the attendant will be locked out.

An application of Multigroup service is given in Fig. 3. It shows three boss/secretary groups sharing two *Picturephone* lines (secretaries are audio only). A button appearance per line is required at each station. If the principal user of group 1 is off-hook on a line, the lamp associated with the line in use will light steady at each station appearance in all three groups. If either a group 2 or group 3 station goes off-hook on the same line, that station will receive a busy tone. If the secretary in group 1 goes off-hook, she will get audio access to that *Picturephone* line.

### III. KEY TELEPHONE INTERCOM SERVICES

#### 3.1 General

Two types of *Picturephone* intercom services will be offered to handle customer switching needs: single link and multilink service. Single link service is intended for the small user and will accommodate a maximum of ten stations. Multilink intercom service is aimed at the larger user and will serve a maximum of 27 stations on a maximum of three links. All basic key telephone features are provided on each of the two systems; i.e., pickup, hold, lamps, audible signals, add-on-conference, etc.

Intercom service is entirely separate from the type of line service chosen. For example, stations having access to the single link intercom can have either single-group or multigroup *Picturephone* line service or telephone-only line service. A button appearance is required at each station that has access to an intercom.

#### 3.2 Single-Link Intercom Service

This service provides private intercommunicating on a # plus one-digit dialing basis among a group of ten or less stations, some or all of which are equipped for *Picturephone* service. Single-link intercom

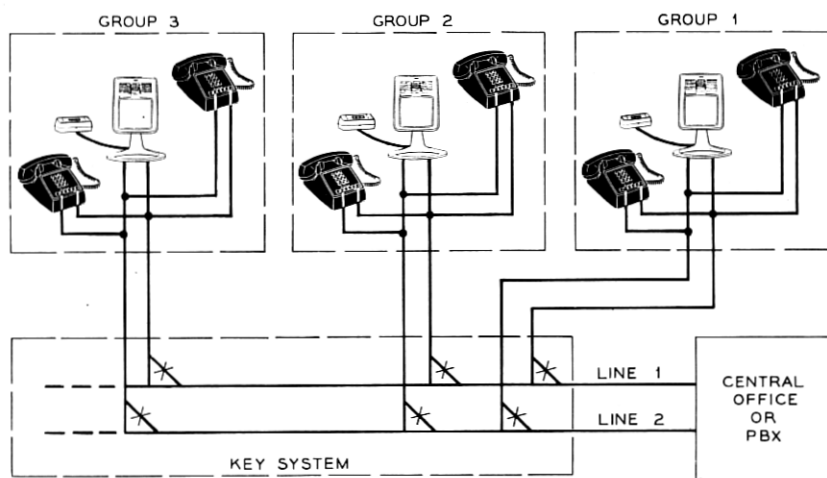


Fig. 3—Multigroup *Picturephone* line service—application.

service is provided by the units shown in Fig. 4, consisting of a station circuit per station, common control to allow access to one station and exclude all others, tone and lamp control and *Touch-Tone* dial receiving equipment.

The origination and termination of calls follow the procedures described for line services insofar as dialing and station alerting are concerned. If a call is in progress, the intercom line lamp will light steady at all stations having intercom access. If a station goes off-hook while a call is in progress, that station will receive busy tone.

The basic core of the single-link *Picturephone* intercom is the 1A2 dial selective intercom (audio only) presently available to the field. Video switching, lockout, and other video features have been added to result in a complete *Picturephone* intercom system. The features of the single-link intercom are privacy, system busy tone, hold, boss/secretary bridging of one intercom line appearance, station hunting from a primary to a secondary when the primary is busy on another line, and add-on conferencing. Rotary dial sets for audio-only stations are permitted.

When a station is placed off-hook to originate a call, the station and common control circuits are seized, preventing other stations from originating a call on the intercom. The station is connected to a battery feed circuit and to the terminated video path. The calling station receives dial tone and all stations receive a steady white lamp signal. If

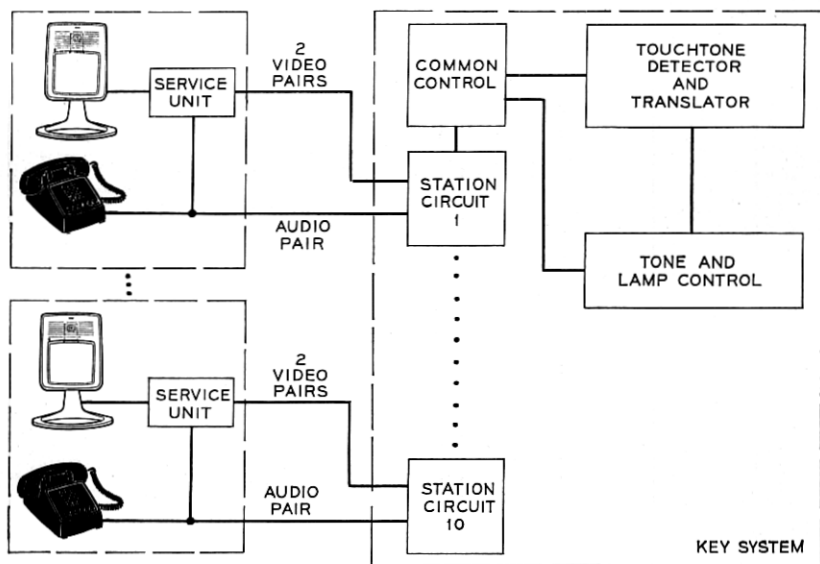


Fig. 4—Single-link *Picturephone* intercom.

the # digit is dialed, indicating a *Picturephone* call is being placed, the lamps change to steady red.

Upon completion of dialing, the common control circuit makes a busy test of the called party. If the called party is busy on another line, busy tone is returned to the calling station; if the called party is idle, ringing is applied. When the called station answers, the called display unit is turned ON, the video paths are connected together in proper transmitter-to-receiver fashion, and the ringer is retired. The system remains in the busy state until the last station is placed on-hook.

On an established intercom call, one of the talking parties may choose to answer an incoming call on a line while the other intercom party remains off-hook. After answering the incoming call, he may then return to the intercom as long as the other party remains off-hook. Therefore, intercom users are provided a means for holding an intercom call.

Boss/secretary bridging of one intercom line appearance and station hunting from a primary to a secondary when the primary is busy on another line are audio key system features and will not be covered here. The optional feature of add-on-conference, which is

available with the single-link *Picturephone* intercom, is discussed in Section IV.

### 3.3 Multilink Intercom Service

This system is intended to fill the intercommunication needs of customers who range in size from those who can be served by the ten-station single-link *Picturephone* intercom to those who require a *Picturephone* PBX but do not require full PBX features.<sup>8</sup> The multi-link intercom is a common control system designed to provide communications to a maximum of 27 stations. It features complete privacy, serves telephone as well as *Picturephone* equipped stations, and can be equipped for either two or three intercommunicating links. Standard key system features such as hold, boss/secretary bridging of one intercom line, and station hunting from a primary to a secondary when the primary is busy on another line are provided on an optional basis. CO or PBX lines can be connected to provide audio add-on and video transfer into the intercom.

#### 3.3.1 System Organization

Figure 5 is a block diagram of the multilink system. It consists of a system control and register, up to three link circuits, a switch matrix, and a station circuit for each station.

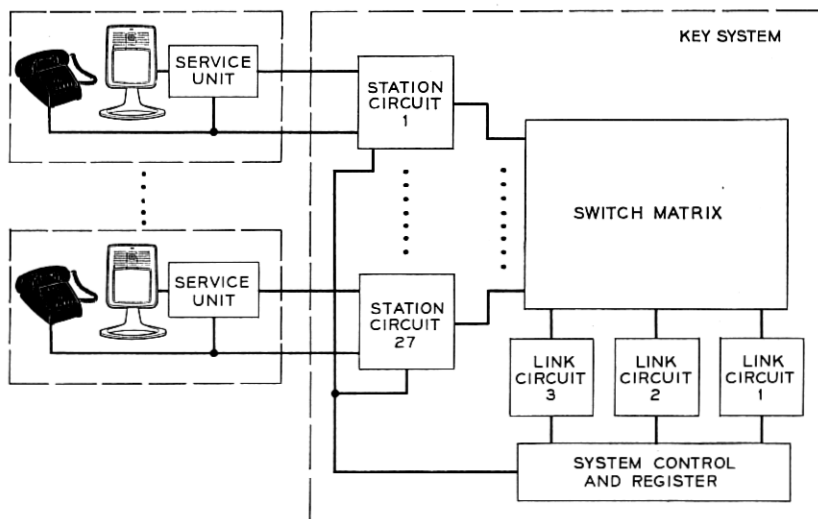


Fig. 5—Multilink *Picturephone* intercom.

The register contains the bulk of the system logic and consists of a *Touch-Tone* receiver, a selector circuit and a logic circuit for controlling the system. The link circuit performs the functions of call supervision and selective signaling. The station circuit connects the stations to the system and controls the functions of video, lamp and ringer switching. The switch matrix connects selected stations to a link circuit and locks out all other stations.

### 3.3.2 System Operation

**3.3.2.1 Telephone Calls.** Referring to Fig. 5, when a station goes off-hook, the register is seized and prevents other stations from originating a call at this time. The register identifies the calling station and also enables an idle link. The enabled link causes the operation of the matrix crosspoint associated with the calling party. At this point, the calling party's tip and ring leads are connected to the enabled link circuit through the matrix circuit. Tones (dial tone, ringback, station busy and permanent signal) are transmitted by the link to the connected station. The link circuit supplies loop current, detects rotary dial pulses and repeats dial pulses to the register. If *Touch-Tone* dialing is involved, as is required to originate *Picturephone* calls, the tones are capacitively coupled to the register.

Upon completion of dialing, the register makes a busy test of the called party. If the called party is busy, busy tone will be returned to the calling party. If the called party is idle, the crosspoint associated with the called station and the enabled link will be operated. The register will be released from the enabled link making it available to handle another call. Ringing and ringback tone will now be applied by the link circuit. After the called station answers, the link will remain in the busy state until the last station is placed on-hook.

**3.3.2.2 Picturephone Calls.** *Picturephone* calls are originated in the same fashion as telephone calls with the additional requirement of preceding the called number with the # digit. The register detects the digit and signals the link which in turn sets the station circuit into the *Picturephone* mode (i.e., red lamp, tone ringer). The viewing path through the switch matrix is controlled by each station circuit in such a way as to connect the transmitters and receivers of the calling and called parties in a transmitter-receiver combination in both directions. When both the calling and called parties have been connected to the switch matrix, the link circuit must prevent additional stations from being added in a *Picturephone* mode to the existing two-party call. Third and fourth parties can be added, audio only, to an existing call

by two methods to be discussed: i.e., DSS and register recall. The intercom call can be placed on hold which results in a distinctive winking red lamp to the user.

3.3.2.3 *Direct Station Selection (DSS)*. The DSS feature may be used to call a *Picturephone* intercom station by going off-hook, dialing the # digit followed by a depression of the DSS key associated with the called party. In addition, after a two-party call has been set up, either party may add stations to the call using the DSS feature (up to four parties total because of audio transmission restrictions). The third and fourth parties will be added as audio-only participants as previously noted. A DSS key is required for each specific station that a user wishes to signal directly.

When a user depresses a DSS key, the link involved is re-enabled thereby connecting it to the register for the called party busy test. If the called party is idle, its crosspoint becomes operated, the station circuit is switched into the ringing mode and ringback tone is transmitted to the parties already connected to the switch matrix. If the party is busy, station busy tone is returned to the calling party(s). Station status tones (busy, ringback, etc.) are retired by a second depression of the DSS key.

3.3.2.4 *Register Recall*. After a call has been established on a given link, either party, if equipped with a register recall button, may add stations to the call by depressing the register recall key (up to four parties total). In much the same way as in DSS, the involved link is re-enabled and connected to the register. In this instance, however, the register returns dial tone to the calling station. Dialing and the resulting status tones then occur as for a normal dialed call. The first two parties will have a video connection; the third and fourth parties will be brought in as audio-only participants. Station status tones (busy, ringback, etc.) may be retired by a second depression of the register recall key.

3.3.2.5 *PBX or CO Line Add-On Transfer*. Each PBX or CO line that is capable of being switched into the intercom may be connected to any one of the three system links. Assume a two-party intercom *Picturephone* call has been established and that one of the intercom stations wishes to add a CO party. The controlling intercom party would first place the intercom call on hold. He would next access a CO line and dial the desired party. When the CO party answers, the controlling station depresses the add-on key associated with the involved line which in turn causes the CO line audio pair to be bridged across the loop of the link in use. The controlling intercom station may then select

the party he wishes to view by depressing either the line or intercom key. The controlling party is seen by the party associated with the depressed key; however, the third party receives a blank screen. All three parties have continuous audio. Upon hang-up of either intercom station, the video from the added-on line is transferred to the remaining party.

**3.3.2.6 Paging.** The purpose of this feature is to provide an intercom user microphone access to a customer-provided public address system. The paging control circuit replaces a station circuit and, therefore, is represented by the station code it replaces. The circuit is the interface between the intercom and a customer-provided loudspeaker paging circuit. The paging control circuit automatically answers upon being dialed and disconnects when the intercom station disconnects (calling party control).

**3.3.2.7 Attendant Operation.** An attendant position may be provided and has the same appearance in the system as a normal station circuit. It may or may not be equipped for *Picturephone* service as desired by the customer. The position would normally be assigned the station code "0" but is not restricted to this code. If a system user does not have access to a PBX or CO line (audio or video) and an attendant position is equipped, the attendant can provide the intercom station access to an outside line.

#### IV. ADD-ON-CONFERENCE SERVICE

The add-on-conference feature is provided for single-group and multi-group line users as well as for single-link intercom subscribers. Conferencing is provided between:

- (i) 2 PBX lines,
- (ii) 1 PBX or CO line and a single-link intercom line, and
- (iii) 1 CO line and 1 PBX line.

The *Picturephone* multilink intercom provides a similar feature called PBX or CO line add-on transfer which has previously been discussed in Section 3.3.2.5.

Assume that a two-party *Picturephone* call has been established on a PBX line and that one of the parties wishes to add an intercom station. The controlling party would first place the PBX call on hold. He would then access the intercom and dial the desired party. When the intercom party answers, the controlling station would depress his add-on-conference key which would in turn cause the intercom audio pair to be bridged across the PBX line in use. The controlling station



would choose the desired video connection by depressing the line button associated with the station to which he wishes to be connected. He would see that station and that station would see him. The controlling station can switch from one line to another by depressing the appropriate line button. The station which is not seeing anyone is in turn not being seen by anyone. At the completion of the conference, the controlling party may continue to talk to either of the parties when the third party hangs up or he may drop both parties by hanging up himself.

#### V. POWER

Seven potentials are used in the circuitry of the *Picturephone* key telephone services:

<i>Potential</i>	<i>Uses</i>
-24 Volts Talk	Talking Battery Cable Equalizers
-24 Volts Signal	Switching Circuitry
+10 Volts	Red <i>Picturephone</i> Lamps
-10 Volts	White Audio Lamps
10 Volt AC	Interrupter Motor
18 Volt AC	Buzzers
117 Volt, 30 Hz	Ringing Supply

The DC potentials are obtained from solid-state diode rectifiers supplied with alternating current from a single core, multiwinding transformer, connected to commercial 60-Hertz single-phase power. Ringing power is provided by a 30-Hertz subharmonic oscillator operating on commercial ac power.

Reserve power arrangements have not been made for the *Picturephone* key telephone services; however, in the event of a power failure, telephone service will be functional. Outgoing telephone calls may be made in the usual way. Incoming telephone calls will cause line ringing to be applied to the main station of each line; however, lamp signals will not be available.

#### VI. EQUIPMENT ARRANGEMENTS

The *Picturephone* key telephone circuits consist of solid-state elements, miniature flat spring relays and assorted components assembled on circuit packs which plug into equipment units that in turn are wired

together into one assembly. The wired and factory-tested units are connected at the time of installation by plug-in cables and quick-connect wall-mounted connector blocks. These plug-in modular design features minimize the time spent on the subscriber's premises for installation and maintenance.

Two types of equipment units will be available to house the *Picturephone* key equipments: a wall-mounted key service unit (KSU) will accommodate the small installations, whereas floor-mounted 7-foot frames will handle the larger installations and the multilink intercom system. Using dedicated connectors, the KSU shown in Fig. 6 may be equipped with the following *Picturephone* services:

- (i) Two single-group *Picturephone* lines, each picked up by a *Picturephone* station, or
- (ii) One single-group line picked up by a *Picturephone* station plus a six-station single-link intercom, or
- (iii) One ten-station single-link intercom.

The KSU shown in Fig. 6 measures 27 inches high by 16 inches wide by 12 inches deep and is equipped with one single-group line and a six-station single-link intercom.

Figure 7 shows the arrangements available in the frame-mounted equipment arrangement. Each of the top three carriers provides for: (i) single-group service for two *Picturephone* lines picked up by one station or one *Picturephone* line picked up by one station, and (ii) add-on conferencing. The fourth carrier provides the same service as the KSU. A total of eight single-group *Picturephone* lines may therefore be accommodated on this frame. Connecting cables are used to complete the connections from the frame to connecting blocks mounted to the wall. The frame shown in Fig. 7 measures 7 feet high by 24 inches wide and has carriers 1 and 4 equipped with circuit packs.

Multigroup *Picturephone* line service is provided by a seven-foot frame similar to the one shown in Fig. 7 except it is arranged to accommodate a total of six *Picturephone* lines. The top two carriers are wired to provide four lines of single-group *Picturephone* service. The bottom two carriers furnish service for one multigroup *Picturephone* line each. Each multigroup carrier is arranged so that shared service can be offered for up to nine *Picturephone* groups (stations).

Basic multilink intercom service will be provided on a seven-foot frame to accommodate a maximum of 27 stations and a maximum of three links.

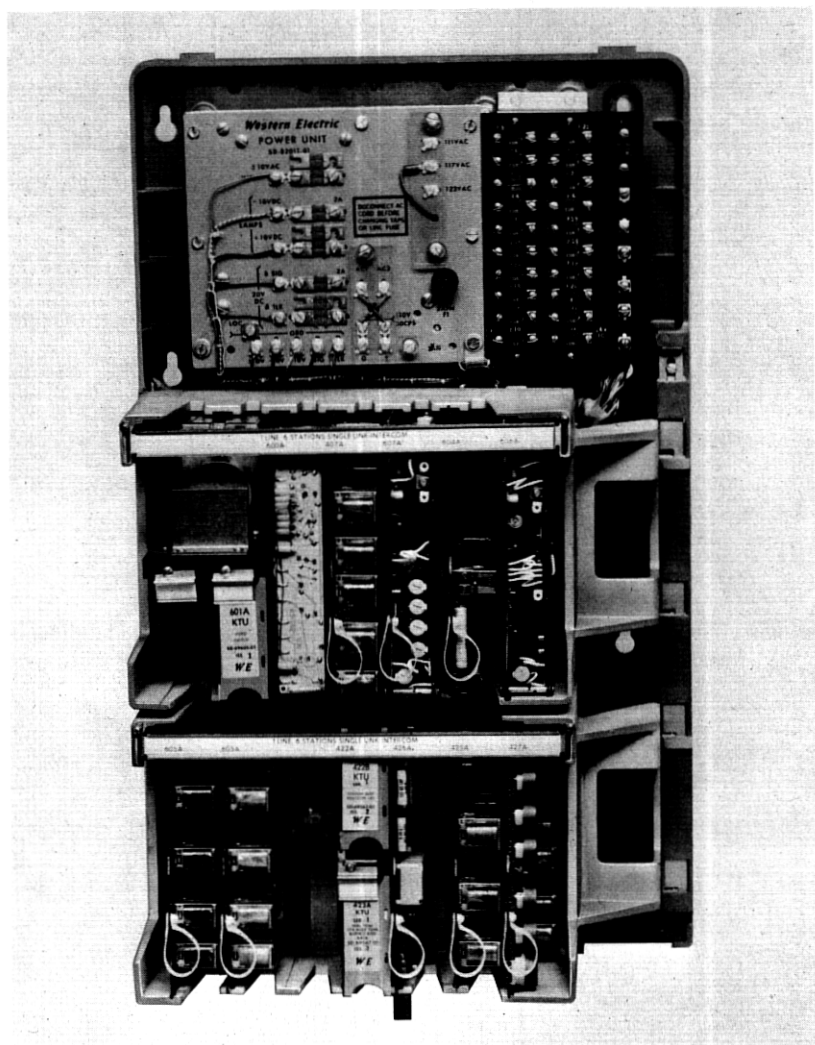


Fig. 6—Key service unit equipped with one *Picturephone* single-group line and a six-station intercom.

#### 6.1 *Plug-in Circuit Pack Physical Characteristics*

Two sizes of circuit packs are used in the *Picturephone* KTS: one is 3.5 inches high by 5.5 inches deep and the other 7.5 inches high by 5.5 inches deep. Figure 8 shows typical examples of the two types of packs.

The double-sided etched epoxy-clad metal boards are gold-plated with either 40 or 80 contacts depending on the size of the circuit pack. The highest component on any of the circuit packs is 1.25 inches with spacing between circuit packs held to 1.5 inches.

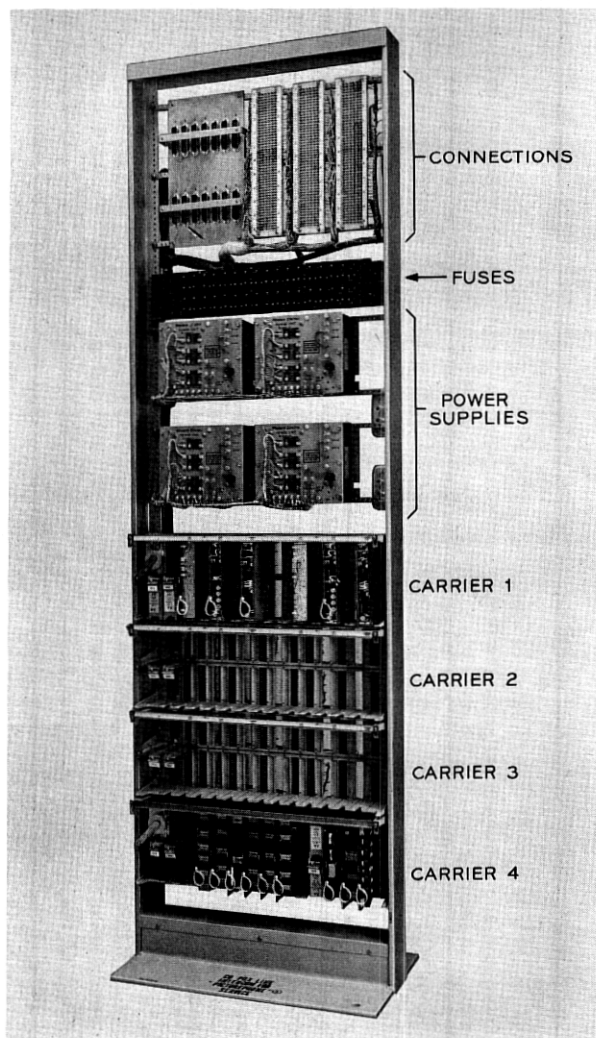


Fig. 7—Frame-mounted equipment arrangement.

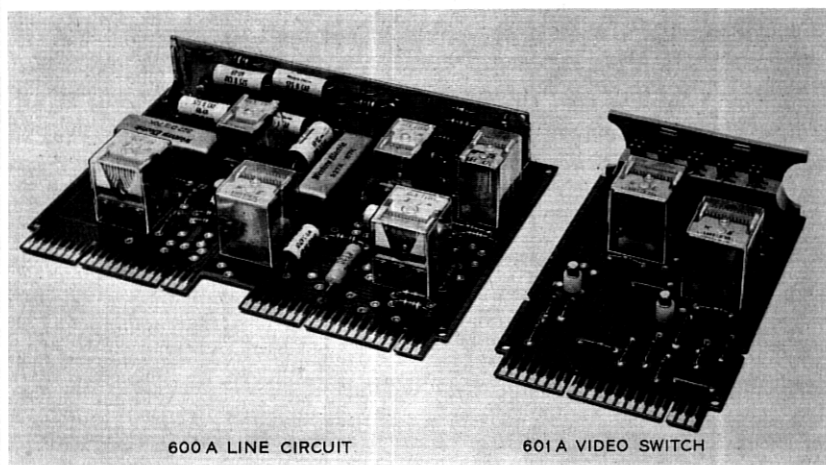


Fig. 8—Circuit packs.

### 6.2 Apparatus Mountings

The circuit packs plug into die-cast aluminum apparatus mountings consisting of trays that are 23 inches wide. The card guide castings on the top and bottom of the tray have slots on 1.5 inch centers to accept the circuit packs. A connector mounts into slots at the rear of the casting to mate with the circuit pack plug. This connector is arranged for up to three levels of wire wrapping.

### 6.3 Wiring and Cabling

The equipment within each apparatus mounting is wired to accept the full complement of circuit packs and is tested before shipment to the field. The various equipment features and options are implemented by inserting or removing a circuit pack or by replacing one circuit pack code by another in dedicated slots.

Only two cable pairs of standard inside wiring cable are required to carry the video signal between a *Picturephone* station set and the *Picturephone* key equipment regardless of the number of *Picturephone* lines or intercoms associated with the *Picturephone* station. This is possible because all the video switching functions take place at the *Picturephone* key equipment location. Audio connections associated with the *Picturephone* lines and intercoms, such as tip and ring, are

made using the standard key telephone system wiring plan. Pair assignment within the cable was made to reduce video self-crosstalk.<sup>7</sup>

The cable length between a *Picturephone* station and the *Picturephone* key equipment is restricted to a maximum of approximately 400 feet of 24-gauge cable. Beyond this distance, video equalizers<sup>4</sup> are required in order to satisfy overall transmission objectives.<sup>7</sup> If the cable length exceeds 1000 feet of 24 gauge, additional circuits are required to extend the control and lamp functions to the *Picturephone* station. The key systems described herein and illustrated in Figs. 1-5 are restricted to cable lengths of up to approximately 400 feet. Circuits and equipment arrangements to extend the cable length to beyond 1000 feet are currently under development.

#### VIII. ACKNOWLEDGMENTS

The design of the *Picturephone* key system described herein has involved a number of persons. In particular, Messrs. G. D. Weed, R. D. Reese, G. E. Brumfield, and M. K. Bunce contributed in a major way. The author wishes to acknowledge other contributors to the circuit design, physical design and systems planning areas too numerous to mention, but without whose help and talents this work could not have been completed.

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