

FACSIMILE COMMUNICATION (FAX) SYSTEMS

GENERAL DESCRIPTION, APPLICATIONS, DEFINITIONS

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1. GENERAL

1.01 This section describes facsimile communication (fax), a graphic communications tool. It discusses typical fax applications and provides a glossary of some common terms associated with its technology and use.

1.02 Whenever this section is reissued, the reason for reissue will be specified in this paragraph.

1.03 Section 006-400-101 provides additional information about fax system planning considerations, including system input, intersystem compatibility, transmission considerations, system output, and special capabilities.

1.04 These sections are issued because of the widespread use of fax systems within the Bell System.

1.05 Fax is the process by which a tangible copy (or facsimile) of the content of a paper page is produced electronically from a transmitted signal. A basic fax system can be likened to an office copier, except that in typical applications, the input and output ends of the fax system are geographically separated. It can also be likened to a television system except that it reproduces the received image in hard (paper) rather than soft (viewing screen) form and usually operates at substantially lower speeds. Fax systems

that reproduce the received images in soft form, sometimes referred to as "soft fax," are generally regarded as slow-scan television systems. The output quality of a typical modern business fax system, as compared with the input page, is illustrated in Fig 1.

1.06 The term fax is generally also applied to systems that produce raster mode (video line array) hard copy from artificially generated picture signals, as in a weather chart transmission system in which the input device is a computer or data tape player. It is less often applied to the opposite configuration: a graphic scanner inputting paper page content to a computer or data recorder. Such configurations are customarily described as "image digitizers." Similar systems having microfilm images (micro-images) as the input are referred to as computer input (from) microfilm (CIM) systems. Similarly, systems that output graphic micro-images from computer input are called graphic computer onto microfilm (graphic COM) systems. Fax systems that scan and transmit micro-images and reproduce them remotely in either film or paper form are generally referred to as "microfacsimile" (microfax) systems.

1.07 Fax systems intended primarily for the transmission and faithful reproduction of photographs (eg, news pictures and fingerprint records) are known variously as "photofacsimile," "telephotographic," or (in Europe) "phototelegraphic" systems. Section 314-715-100 describes telephotography from the Bell System standpoint and provides references to other related sections.

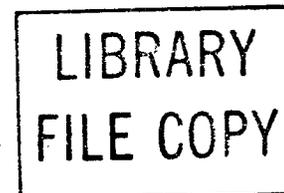
1.08 There is a tendency to refer generically to all fax terminals as *Telecopiers*. However, *Telecopier* is a registered trademark of the Xerox Corporation and applies only to fax devices manufactured and/or marketed by that firm.

1.09 The basic fax principle of converting a page image to electronic form by raster scanning, and then reproducing it in tangible form, is also applied in systems intended for electronic production of

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duplication stencils, color separation negatives, and printing plates.

1.10 Systems that transmit handwritten messages or hand drawn sketches by remotely reproducing human manipulation of writing styli in real time are technically not regarded as fax systems, and will therefore not be covered in this section. The terminals of such systems are generically referred to as *handwriting machines* or *manual graphic terminals*. Two of the more familiar trade names for such systems are *Electrowriter** and *Telescriber*†. The Bell System's *Gemini*® electronic blackboard also belongs in this category.

1.11 This section and its companion section will discuss only conventional fax systems of the kinds used within the Bell System.

2. BASIC PRINCIPLES

2.01 The basic fax principle is depicted in Fig 2. It involves the processes of rectilinear scanning, signal processing, transmission, synchronization, and rectilinear recording.

2.02 Scanning: Rectilinear scanning consists of a concentrated spot of light traversing a page, a segment at a time, much as our eyes do in reading. The scan spot generally traverses the short dimension of the page from left to right, with subsequent scans displaced downward by some predetermined amount. The line-to-line displacement can be achieved by movement of either the spot or the paper along an axis perpendicular to the scan axis. Fig 3 shows examples of both schemes. Note that, in Fig 3b, rectilinear scanning is accomplished by continuous rotation of the page relative to the scan spot, which moves slowly along a perpendicular axis. This mode of operation is commonly known as "drum" or "cylinder" scanning. The mode depicted in Fig 3(a) is commonly known as "flatbed" or "flat feed" scanning. In either case, the varying proportions of light energy reflected from the page as the scan spot encounters light and dark image elements are sensed by a detector and converted to a serial electrical analog. This low-level varying current is the scanner output. (See Fig 4.)

*Registered trademark of Infolink, Inc.

†Registered trademark of Telautograph Corporation.

2.03 Signal Processing: The scanner output, which may be described as a fluctuating "baseband" current, is amplified and is then usually altered in form via one or more processing steps. In an analog fax system it will be applied to a modulator, in effect impressing itself upon a separately generated alternating current of a frequency consistent with the bandpass of the communication channel (usually voiceband). It is this composite signal which is then transmitted to the remote fax machine. See Fig 5. Other possible forms of signal processing include:

(a) **Thresholding** (Fig 6)—reduction of scanner output to dark-light extremes; elimination of intermediate grays. The objective is image enhancement or preparation for digital encoding.

(b) **Analog-to-Digital (A/D) Conversion**—after thresholding, the signal is subjected to precision "clocking," ie, each scan line consists of the same discrete number of decision points, each of which has either a 0 or 1 (black or white) binary value. The usual objective of A/D conversion is to prepare the scanner output for further digital processing.

(c) **Compression Encoding**—after thresholding and A/D conversion, the signal is subjected to a process by which the light-dark-light transitions are encoded into digital "words," which are then transmitted to the remote receiver. The objective of this process is to minimize signal redundancy and thereby improve transmission efficiency.

(d) **Tonal Encoding**—the amplified scanner output is subject to a pulse code modulation (PCM) process in which each of a discrete number of amplitude values is assigned an identifying digital code. At the remote receiver, these codes are interpreted as image tonal values (black, white, and shades of gray) and recorded accordingly. The objective of this process is to permit transmission of pictorial matter via digital facilities.

It is possible, but not common, to have a fax system in which the scanner's analog output undergoes no further processing beyond amplification. The amplified output is transmitted to the remote receiver via a direct dc channel (eg, a simple wire pair). Such systems are known as "baseband" systems and are considered rare.

2.04 Transmission: The appropriately processed scanner output is applied to the communication channel by which the sending and receiving fax machines are interconnected. At the receive end of

the system, the incoming signal is reconverted to baseband form for graphic recording. Typically, the communication channel is a dial-up voiceband channel on the public telephone network. As mentioned in paragraph 2.03, the most basic form of transmission signal processing is modulation. It is, in fact, a prerequisite to transmission via voiceband or other ac-oriented communication links. It follows that demodulation is required at the receive end of the system. Traditionally the modulator/demodulators (modems) of a voiceband fax system are integral to the fax terminals.

2.05 Synchronization (Analog Systems):

Inasmuch as the proper operation of a fax system requires remote reconstruction of serially segmented page images, means must be provided to somehow keep the fax receiver "in step" (synchronized) with the fax transmitter. In a basic real-time analog system, in which a given segment of the received page copy is being recorded at essentially the same instant that the same segment of the original page is being scanned, synchronization is usually accomplished by operation of scanning, recording, and feed motors from pretuned precision power supplies. However, synchronization must be preceded by a phasing step during which the geographically separated scanning and recording motors are made to run at different speeds until local and remote start-of-line pulses coincide. At the sensing of coincidental pulses at the receiver, the speed of the recording motor is instantly changed to that of the remote scanner and, from that point to the end of the page, the separated scanning and recording movements remain reasonably synchronized. Previously, some fax systems relied on the commercial ac power grid, rather than separate integral precision power supplies, for synchronization. However, because of certain inherent limitations, this method has been generally abandoned.

2.06 Synchronization (Digital Systems): In a digital fax system, the sequential codes representing a scanned line are transmitted a line at a time to the receiver, where each received line is momentarily stored and decoded. As each line of restored black-white image pulses is "clocked out" of the storage buffer to the graphic recorder, the sequence of codes for the next line is loaded and decoded, and so on. The delay caused by this "store-and-forwarding" action is usually measurable in milliseconds. To accommodate the stop-start nature of the digital system, stepper motors are used in place of

the continuous rotation variety to advance the paper through the scanner and recorder.

2.07 Recording: Rectilinear graphic recording at the output stage of a fax receiver is essentially the opposite of the scanning process at the transmitter. The incoming series of electrical pulses representing the contents of sequential scan lines at the transmitter are transformed to the level (or form) necessary for them to reproduce analogous dark-light marks on a piece of paper. In a traditional photofacsimile system, the electrical pulses are converted to variations in light intensity, which are recorded as latent images (for subsequent development) on light-sensitive paper. In a more conventional fax system, the pulses are modified to a form in which they can produce marks on the paper directly (or semidirectly) via metal styli. Some of the ways in which received fax images are recorded on paper not sensitive to light include:

- (a) Electroresistive ("Burn-Off")—the dc fluctuations are applied to a stylus in contact with special electrosensitive paper, the white coating of which is burned away in proportion to current variations, revealing a black underlayer.
- (b) Electrolytic—the dc fluctuations are applied to a stylus in contact with paper that is saturated with a wet electrolyte. The paper darkens by chemical action wherever sufficient current passes through it. (This process is widely used in weather chart systems.)
- (c) Electrostatic (Direct)—the dc fluctuations are applied to a stylus (or stylus array) in contact with a special coated paper having electrostatic properties. The current fluctuations cause localized electrostatic charges of varying intensity, resulting in a latent electrostatic image, which is developed by automatic application and fusing of charged "toner" to the paper (as in the developing section of a typical office copier).
- (d) Thermal—the current fluctuations are applied to a special stylus (or stylus array) which converts them to instantaneous temperature variations. The stylus (or array) is in contact with special paper that turns dark when the temperature exceeds a predetermined threshold. This process is presently experiencing increasing popularity in voiceband fax systems. (It is the same process used in some high-speed character printers.)

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In addition to these processes, there is transfer xerography, an electrostatic process in which the latent image is formed by light intensity variations (usually from a laser) on a selenium drum, and transferred to ordinary paper via charged toner. Processes also exist in which the incoming current fluctuations control the applications of quick drying ink to ordinary paper.

2.08 Control Procedure: Not depicted in Fig 1 because it is not basic to system operation is the control or automatic "handshake" procedure (or protocol) by which the send and receive ends of a system can interoperate with varying degrees of automation. It is included in this section only because of its growing importance as fax systems become increasingly automated. It consists of a back-and-forth exchange of pre- and post-message signals which, in their most basic application, permit an automatic answering telephone-connected fax receiver to acknowledge that it is on-line and basically compatible with the calling transmitter. (See Fig 7.) Other functions of the control procedure include:

- (a) Called station identification
- (b) Selection of operating mode
- (c) Preparation for transmission/reception of multiple pages
- (d) Testing of line condition and adjusting to it
- (e) End-of-message acknowledgments.

Both tonal (audio frequency) and binary signaling are used, the latter being applied mainly where more complex procedures are required.

3. BELL SYSTEM APPLICATIONS

3.01 Facsimile systems are used extensively within the Bell System for various applications. In general, their use is confined to the exchange of time-sensitive messages and documentation. Some of the more common applications as determined by usage surveys include:

- (a) Central fax service via mailrooms and communication centers (for the exchange of textual and graphic documentation via dial-up circuits)
- (b) Dispatch of engineering change orders

- (c) Dispatch of priority project reports
- (d) Dispatch of computer program changes
- (e) Service order distribution (a popular but largely transitional application)
- (f) Dispatch of stock transfer and other signed documentation
- (g) Exchange of press releases and press clippings.

3.02 Closed Networks: Fax systems exist in either closed or open network configurations, with the latter predominating. In a true closed network configuration, the terminals or stations are interconnected via dedicated circuits. A typical example is a service order distribution system. A service order generated by a business office is fax-dispatched via dedicated circuits to the Plant Department, the affected Central Office(s), and the Traffic and Commercial Departments, thus enabling rapid implementation of the requested service. Other networks are effectively closed in the way they are used, but rely on dial-up circuits for interconnection and are therefore more flexible. A typical example is a network composed of telephone-coupled fax transceivers at widely dispersed laboratory and manufacturing locations, primarily to dispatch engineering change information and test data in connection with the manufacture of new products.

3.03 Open Networks: Any fax transceiver connected to a line on a corporate or public switched network for the purpose of accessing other compatible terminals, as needed, may be regarded as a station on an "open network." A typical example in the Bell System is the central fax service provided in mailrooms and communication centers.

4. SYSTEM AND TERMINAL CATEGORIES

4.01 Any fax system can be identified as either a convenience or operational system and, if operational, as either conventional or specialized.

4.02 Convenience System: A convenience fax system is maintained for the convenience of occasionally dispatching time-sensitive documentation to other sites. By this definition, the central service fax system in a mailroom or communication center is a convenience system. However, the term is generally

reserved for relatively simple and inexpensive telephone-coupled terminals. Typically, such systems offer only marginal cost justification because of relatively low usage. Their principal justification is that they are usually the fastest way to transmit a few pages to remote sites.

4.03 Operational System: An operational fax system is dedicated to a specific application, such as service order distribution or the dispatching of engineering change orders. The terminals are often interconnected by dedicated circuits. Operational system terminals tend to be more oriented to specific end requirements than convenience system terminals. If, for example, conventional commercial terminals are used in an operational fax system, they are likely to be equipped with added cost options such as high resolution, high speed, automatic polling, etc. Alternatively, specialized or special-purpose fax terminals are available. Some applications to which such terminals are tailored include:

- (a) Transmission of photographs
- (b) Transmission of signature verification cards
- (c) Encrypted transmission for high security applications
- (d) High-resolution transmission of large size masters for remote photo-engraving
- (e) Transmission of weather charts and similar large graphics.

4.04 Classification of Terminals: The terminals used in any fax system can be classified as:

- (a) Conventional or specialized
- (b) Simplex or transceive
- (c) Single mode or multimode
- (d) Attended and unattended
- (e) Desktop or floor-standing.

4.05 Conventional versus Specialized: See 4.03.

4.06 Simplex versus Transceive: Simplex fax terminals (send only, receive only) are used mainly in operational systems in which the traffic flow is characteristically unidirectional. Service order, news

picture, and weather chart distribution systems are typical. However, transceivers tend to predominate in business applications. The choice is between half-duplex (send and receive, but not simultaneously) and duplex (send and receive simultaneously via separate communication channels). Duplex is frequently referred to as "full duplex." Two simplex terminals--one transmitter and one receiver--situated in the same room are equivalent to a single duplex terminal. However, the latter tends to be slightly less expensive, because of the commonality of some circuits and mechanical parts within one shell. Half-duplex transceivers offer more extensive commonality of components and are therefore proportionally less expensive than duplex transceivers. Transceivers with completely separate send and receive mechanisms (this includes some half-duplex transceivers) offer the added capabilities of self-test and local copying.

4.07 Single-Mode versus Multimode: A single-mode fax terminal offers a single speed/quality capability and is either analog or digital. A multimode terminal offers dual or multiple speed/quality combinations and can also operate in an analog or digital mode. In addition, it may offer the following selectable capabilities:

- (a) Choice of amplitude or frequency modulation (AM or FM) in the analog mode
- (b) Polling (automatic transmission triggered by a call from an authorized receive terminal)
- (c) Operation as a local copier.

Speed (of transmission) and quality (of images) are treated here as a single entity because if one is varied, the other is usually affected. The exception is the ability of bandwidth compression and data redundancy reduction techniques to maintain, under normal transmission conditions, a given level of image quality at increased speeds, or provide higher quality at the same speed. Digital operation is usually used to achieve data redundancy reduction. Selectable speed/quality combinations and provision for both analog and digital operation in the same terminal are expedients for expanding technical compatibility among fax terminals. Provision for both AM and FM operation of the same analog terminal serves the same function. Polling is achieved by a slight alteration of the normal control procedure (paragraph 2.08) and assumes some degree of administrative prearrange-

ment with remote transmission sites. The local copy mode, when provided, is used primarily for local terminal testing or a pretransmission quality check.

4.08 Attended versus Unattended: There has been a steady trend toward increasingly automated operation of fax terminals. It is generally only the least expensive convenience-type terminals (see paragraph 4.02), and especially those that use drum scanning and recording methods (see paragraph 2.02), that must be attended by an operator in both the send and receive modes. Unattended reception, including automatic switching to off-hook status upon detection of an incoming ring signal, is easy to achieve with receivers and transceivers in which the recording paper is fed from a roll or from an automatic multisheet feeder. There are two levels of unattended sending, the most common being the ability to load multiple original pages in an automatic feeder. The operator must still dial the intended receive terminal, await acknowledgment, and initiate transmission. The second level of unattended sending provides, in addition to automatic document feeding, means by which the intended receive terminal can be automatically dialed.

4.09 Desktop versus Floor-Standing: Of the two classes, the desktop design predominates, particularly within the convenience realm (see paragraph 4.02). When first introduced, digital data compression fax terminals were available only in floor-standing configurations, but an increasing number of desktop digital terminals are becoming available. Occasionally, the floor-standing configuration is preferred because of a shortage of desktop space.

5. GLOSSARY OF TERMS

5.01 The following definitions are confined to those terms used in this section and in Section 006-400-101 that are essentially peculiar to fax. Technical terms of a more universal nature are excluded, as are those which concern telephotography exclusively. The latter are defined in Section 314-715-100.

Analog Fax

5.02 A facsimile communication (fax) system in which visual tonal variations on the input page are transmitted in the form of analogous variations in the strength or frequency of an electrical current; a fax system in which the characteristic linearity of the

scanner output remains virtually unaltered through transmission and reception. (See also *CCITT Group 1, CCITT Group 2*)

Aperture Distortion

5.03 Distortion in the output waveform of a fax scanner resulting from the scanning aperture's having a finite width; angularity attributable to the scanning aperture in the rise and fall of a theoretically square output pulse.

Automatic Background Control

5.04 Electronic circuitry that effectively maintains, at a constant level, the white (background) component of the output of a fax scanner.

Automatic Feed

5.05 Any mechanism provided with a fax transmitter or receiver for automatic feeding of paper.

Binary Fax

5.06 A term sometimes applied to fax systems that transmit and reproduce all input as 2-level images (no intermediate gray tones). The term especially applies to those analog systems in which the 2-level output is attributable to a band-compression process.

"Burn-Off" Recording (See Electroresistive Recording)

CCITT Group 1

5.07 Designation of an analog FM fax system designed in accordance with international CCITT technical recommendation T.2, which effectively formalizes the traditional voiceband transmission of letter-size pages in 4 or 6 minutes. (See also *Analog Fax*)

CCITT Group 2

5.08 Designation of an analog fax system designed in accordance with international CCITT technical recommendation T.3, which applies a 2:1 band compression technique to permit voiceband transmission of letter-size pages in 2 or 3 minutes, with output legibility comparable to that of Group 1 systems. (See also *Analog Fax*)

CCITT Group 3

5.09 Designation of a digital data compression fax system designed in accordance with international CCITT technical recommendation T.4, which applies sophisticated digital encoding techniques to reduce transmission redundancy. Transmission speeds of less than one minute per letter-size page via voiceband circuits are normal. Speed depends on the ratio of actual image elements to blank space on the page. (See also *Digital Fax, Run-length Coding*)

CCITT Group 4

5.10 Designation of an advanced digital data compression fax system designed in accordance with international CCITT technical recommendations currently under development. The Group 4 system is distinguished from Group 3 systems mainly in that it will permit direct interconnection of fax terminals with computer-switched data networks at possibly higher output resolutions. (See also *Digital Fax, Run-length Coding*)

CCITT T.30

5.11 Designation of the international CCITT technical recommendations for control procedures to be applied to fax systems in the Group 1 through 4 categories. (See also *Control Procedure, "Handshake," Fax*)

"Checkerboarding"

5.12 A term often applied to a visual effect caused by sharply defined, periodic dark-light transitions in the output copy of fax systems employing thresholding, analog/digital conversion, and/or multi-stylus recording arrays.

Convenience Fax

5.13 A term often applied to fax systems maintained for the convenience of occasionally dispatching time-sensitive documentation to other sites; most often applied to relatively simple and inexpensive telephone-coupled terminals.

Control Procedure

5.14 The exchange of control signals between fax transmitter and receiver to ensure terminal

compatibility and to effect automated operation. The exchange takes place automatically before and immediately following each separate transmission of page images. The control procedure is often loosely referred to as a "handshake" or protocol.

Copy Mode

5.15 A term applied to a selectable operational mode in which a fax transceiver transmits copy to itself via an internal closed loop.

Cylinder Scanning/Recording (See Drum Scanning/Recording)**Dead Sector**

5.16 That sector of the total line length of a fax scanner or recorder in which no information is scanned or recorded; the sector reserved for synchronizing pulses.

Density, Image

5.17 The darkness, or light-absorbing, quality of image details. High density (relatively dark) details on a white or near white background is usually the preferred output quality of a typical fax system.

Density, Scan

5.18 A term sometimes substituted for scan resolution; the number of lines or strokes within a given linear dimension.

Digital Fax

5.19 Any fax system in which the transmitted signal is in the form of digital codes. Precision "clocking" of the code bits is usually implied. The term is most often applied to fax systems in which digital data compression techniques are applied to reduce signaling redundancy, thereby improving transmission efficiency. (See also *CCITT Group 3, CCITT Group 4, Redundancy Reduction*)

Digitizing, Image

5.20 The conversion of visual images to digital codes by electronic scanning and subsequent processing of the scanner output.

Direct Recording

5.21 Any of a variety of graphic recording processes in which the recorded image is instantly visible. Except for ink jet recording, direct recording processes generally require specially coated paper. (See *Electrolytic Recording*, *Electroresistive Recording*, *Percussive Recording*, *Thermal Recording*.) Direct recording often includes electrostatic and heat-processed recordings in which a latent image must be separately developed, but by mechanically in-line methods (ie, the recording and developing processes are mechanically integrated).

"Downward" Compatibility

5.22 The ability of a digital data compression fax system to be selectively compatible with analog as well as other digital terminals.

Drum Scanning/Recording

5.23 Scanning and recording processes in which the paper sheet (original page or sheet of recording paper) is attached to a drum or cylinder and rotated to effect rectilinear scanning or recording. Either the drum or the scan or recording head moves relatively slowly along an axis perpendicular to the scan axis in order to properly displace each subsequent scan or recording stroke.

Dry Silver Recording

5.24 A recording process used in some photofacsimile systems in which a latent image is produced by a high-intensity light beam (usually from a laser) on a medium known as dry silver paper, and then made visible by the application of heat. As in more conventional photographic recording, the dry silver latent image must be produced within a light-tight enclosure. (See also *Photographic Recording*)

Electrolytic Recording

5.25 A direct recording process in which the image is produced on paper saturated with a wet electrolyte, by the flow of signal output current through the paper from a contacting metal stylus to a metal backplate. In most uses of this process, the stylus is in the form of a single-turn helix on a revolving drum, and the "backplate" (usually located at

the front, or imaging side of the paper) is in the form of a horizontal bar or blade.

"Electronic Mail"

5.26 A means by which information is electronically transmitted for visual reproduction at a remote site.

Electroresistive ("Burn-Off") Recording

5.27 A direct recording process in which the image is produced by the flow of signal output current through specially coated paper from a contacting metal stylus to a common paper surface connection. The resistive oxide coating on the paper is decomposed by an electrochemical reaction to the current flow, revealing a black carbon underlayer. The higher the signal current, the greater the area of decomposition, and the darker the mark. Typically, marking begins at potentials in excess of about 24 volts.

Electrostatic Recording

5.28 A recording process in which a latent image is produced in the form of localized electrostatic charges on specially coated paper, and then made visible by the application and fusing of oppositely charged, toner. The latent image may be formed by either a high-intensity light beam or direct metallic contact, the latter being preferred in most fax systems using the process. The toner may be a liquid or dry powder, and may be fused by heat, adhesion, or pressure. (Note: in transfer xerography, imaging and toner application occur on a photosensitive drum, from which the toner is then transferred and fused to plain paper.)

Encryption, Scanned Image

5.29 A process of "scrambling" a fax signal for security purposes, usually employing analog-to-digital conversion of the scanner output and application of a "key," a predetermined (but widely alterable) clocked bit stream applied at both the send and receive ends of the system. Application of the key at the send end produces a cipher, the form in which the signal is transmitted. Application of the same key at the receive end deciphers (or "unscrambles") the incoming signal, restoring it to the original data stream.

Facsimile

5.30 The common short form of the term facsimile communication. (See also **Fax**)

Facsimile Communication

5.31 The process by which a tangible copy (or facsimile) of the content of a paper page is produced electronically from a transmitted signal, usually at a point remote from where the original page is input.

Facsimile (Fax) System

5.32 A system consisting basically of a facsimile (fax) transmitter and one or more compatible receivers interconnected (or arranged for demand interconnection) via an electronic communication channel or channels. A single system may consist of multiple transmitters and receivers interconnected in various configurations, either simultaneously or selectably.

Fax

5.33 The commonly accepted abbreviation for facsimile communication.

Flat Bed Scanning (also known as flat scanning)

5.34 A mechanical scanner configuration in which the paper page is fed past the scan point in essentially flat form as distinguished from drum scanning. Accepted usage of this term does not preclude deforming of the paper, during or after scanning, into a curved path that permits its ejection at a convenient location.

Glow Modulator Tube

5.35 A type of gas discharge lamp used for image recording in some photofacsimile receivers; designed to produce intensity variations analogous to the received and recovered picture signal that is input to it. (See **Photographic Recording**)

Graphic; Graphics

5.36 Terms applied to information in essentially pictorial form. This includes line drawings, photographs, signatures, letterheads, charts, graphs, fingerprints, and simple sketches. Reproduction of a page of text or numerics may also be considered

graphic if it is accomplished by an imaging, as opposed to an encoding/decoding, process. Reproduction of pages via a digital fax system is considered graphic because the encoding/decoding process is applied to image elements rather than whole characters.

"Handshake," Fax

5.37 A commonly applied slang term for the exchange of control signals (control procedure) before and immediately following each separate transmission of page images in a fax system. (See **Control Procedure**)

Huffman Code

5.38 A code system used in digital data compression fax systems to represent the lengths of white and black runs within a scan stroke; based on statistical concepts by which code length is varied in accordance with the relative probability of occurrence of given run lengths: the more frequent the occurrence, the shorter the code.

Ink Recording

5.39 A category of fax recording processes using controlled depositing of fast-drying wet ink to form the reproduced image on plain paper. The best known of these processes is ink-jet printing in which a fine spray of ink is electrostatically focused and guided to the paper surface. Some such systems reproduce multiple scan lines simultaneously via a store-and-forward or multiplexing arrangement. Another ink recording process uses an inked ribbon, through which ink impressions are made on the paper by percussion.

Kell Factor

5.40 An expression of the estimated degree of effective resolution degradation attributable to the segmenting of an image by scanning. Normally expressed as 0.70 to signify an estimated effective 30 percent loss in resolution along an axis perpendicular to the scan axis. In a typical digital fax system, Kell factor may be assumed to apply along the scan axis as well.

Laser Recording

5.41 Use of a mechanically deflected, finely focused laser beam to record fax images on a photosensitive medium, or on plain paper via transfer xerogra-

phy. (See *Electrostatic Recording, Photographic Recording*)

Laser Scanning

5.42 Use of a mechanically deflected, finely focused laser beam to scan the input page in a fax system. That portion of the beam energy reflected from the page is electronically detected and converted to an electrical analog of the serial dark-light variations within each scan stroke. The beam may be deflected by oscillating mirrors or rotating prisms.

Latent Image

5.43 An invisible image produced by the action of electrical or radiant energy on an appropriately sensitized surface. The latent image is made visible by one of a variety of development processes. (See *Dry Silver Recording, Electrostatic Recording, Photographic Recording*)

Legibility, Fax

5.44 The ability to visually identify separate components (readability) of a recorded fax image. It involves such factors as resolution, density, contrast, distortion, paper texture, and the effects of signal impairments.

Line Advance (Line Feed)

5.45 The measured distance between one scanned or recorded line and the next; the intervals at which the paper, scan spot, recording stylus, etc. is moved to produce a raster of a given scan resolution.

Moire

5.46 The "interference" effect noted in a fax recording when a scan line intersects an image line at a relatively shallow angle.

Multiline Coding

5.47 A system of transition and run-length coding that permits simultaneous coding of the content of two or more adjacent scan lines.

OCR/Fax

5.48 An electronic communication system in which the content of a page can be selectively converted for transmission by either an optical character

recognition (OCR) or fax mode, depending on the nature of the information. OCR is applicable only to alphanumeric information in compatible fonts; the fax mode is applicable to both alphanumerics and graphics, but transmits alphanumerics less efficiently. Mode selection at both ends of the system may be either manual or automatic.

Percussive Recording

5.49 A system of graphic recording in which the image elements are reproduced by a vibrating stylus acting upon a pressure pigment transfer medium such as carbon paper.

Phasing

5.50 A spatial synchronization process in which a difference in stroke speed between scanner and recorder allows one to catch up with the other in terms of relative instantaneous position on a page; the alignment of start-of-stroke positions between scanner and recorder prior to actual information transmission.

Phone-coupled Fax (See Telephone-coupled Fax)

Photofacsimile

5.51 A fax system in which the intermediate (gray) tones of a scanned photograph are preserved in the output recording.

Photographic Recording

5.52 A fax recording process in which light of varying intensity (analogous to that detected at the scanner) impinges upon a photosensitive medium to produce a faithful reproduction of the transmitted images. Imaging is in two steps: exposure and development. (See *Dry Silver Recording, Glow Modulator Tube, Laser Recording*)

Polarity, Image

5.53 The tonal relationship of contrasting image elements. Photographs or photographic recordings in which tonal values are reproduced in kind (ie, dark for dark, light for light) are said to have positive polarity, those in which tonal values are reversed are said to have negative polarity. Generally, document page reproductions consisting of dark characters or lines on a light background are said to have positive polarity, whereas those having the opposite tonal relationship are said to be negative.

READ Code

5.54 A 2-dimensional run-length code (see *Run-length Coding*) used to achieve improved data compaction in CCITT Group 3 digital fax systems; a coding scheme in which the content of a scan line is encoded and retained in memory for comparison with the content of the succeeding scan line. The coding of each succeeding scan line reflects a comparison with the content of the immediately preceding line so that only the changes in transition locations need be transmitted. READ is an acronym for Relative Element Address Differential.

Recording, Fax

5.55 The reproduction of graphic images in line-by-line fashion in response to electronic signals received from a scanning transmitter. Each separate recorded line represents the linear sequence of dark-light variations detected by the scanner as it successively traverses the input page.

Recording Head

5.56 That part of a fax receiver representing the end point in the fax system's signaling chain; the part containing the stylus or other image-reproducing elements at which the received and detected (or reconstructed) picture signal is terminated.

Redundancy Reduction, Image

5.57 The process of reducing the amount of transmitted information necessary to reproduce a page image in a fax system; achieved by application of data compression (compaction) techniques such as run-length coding; sometimes also referred to as white space skipping.

Resolution, Scan

5.58 The relative fineness with which an image is segmented by scanning; usually expressed in terms of (scan) lines per inch or millimeter; the higher the number, the higher the resolution and the greater the output legibility. Scan resolution, as opposed to the resolution within a scan line, applies only to the resolution along an axis perpendicular to the scan axis. Typically, scan resolution and vertical resolution are synonymous.

Run-length Coding

5.59 A system of encoding the content of a scan line in terms of the number of sequential sampling intervals in which either a white or black condition is sustained. The line content information is thus transmitted as a series of digital codes representing the addresses of occurrence of sequential tonal transitions in terms of the length of the ensuing tonality. (See also *Huffman Code; Multiline Coding; READ Code; Redundancy Reduction, Image; White Space Skipping*)

Scan Head

5.60 That part of a fax transmitter representing the starting point of the fax system's signaling chain; the part containing the photoreceptor (the transducer that converts copy density variations to analogous electric current variations) and, in some cases, the illumination source.

Scan Index

5.61 The mechanical counterpart of scan resolution; the measured interval by which sequential scan lines are separated, usually expressed in terms of total lines per inch or millimeter along an axis perpendicular to the scan axis; more or less synonymous with line advance.

Scan Rate

5.62 The number of scan or recording strokes per minute; applies primarily to conventional analog systems (no redundancy reduction). Systems employing redundancy reduction techniques (run-length coding or white space skipping) to improve transmission efficiency do not scan at fixed rates.

Scan Spot

5.63 The concentrated point of light by which density variations on a scanned page are conveyed to the photoreceptor for conversion to an electrical analog. In solid-state and other scanning methods using sensor arrays there may not be a scan spot, but rather a narrow "strip" of illumination covering the effective scan width.

Skew

5.64 Angular distortion of essentially vertical image lines caused by slight differences in stroke speed between scanner and recorder; the undesired slanting of otherwise vertical image lines.

Skip Mode

5.65 A selectable mode available in many analog systems to increase transmission speed by automatically switching to a higher stroke speed when the scanner senses large blank areas in the copy.

"Soft Fax"

5.66 A term sometimes applied to slow-scan (typically voiceband) television systems when used to transmit document page images; a fax system in which the output is a temporary screen image instead of a paper copy of the input page.

Solid-State Scanning

5.67 The use of a charge-coupled device (CCD) as a virtually self-contained nonmechanical scanner. A typical solid-state fax scanner consists of fixed illumination source, a fixed page-width array of single-line CCDs, and a mechanism to transport the page across the scanning array.

"Stepladder" Effect

5.68 A visual effect in the output copy of a fax recorder caused by the angular displacement of image lines from scan lines and/or sampling segments, and having to do with the fact that segmentation of the image is in finite intervals. The smaller the angle of displacement or the lower (coarser) the system resolution, the more noticeable the effect.

Stroke (Scanning or Recording)

5.69 A scan or recording line in terms of the motion that produces it.

Synchronization, Crystal

5.70 A common method of fax system synchronization, based on the use of separate, precision ac power supplies in each fax terminal, crystal-tuned so that all supplies deliver the same highly stable base frequency, within very tight tolerances, to the terminals' motors.

Synchronization, Power Grid

5.71 A method of fax system synchronization that relies upon the precision with which distributed ac power is synchronized over a wide geographic

area via a grid or network arrangement. This method, seldom used in modern fax systems, permits manufacture of inexpensive fax terminals by eliminating the need for precision local power supplies.

Telephone-coupled Fax

5.72 Any voiceband fax system in which the terminals are connected to the line via a voice telephone installation; most often used when the terminals are acoustically coupled to the line via the telephone handset.

Thermal Recording

5.73 A system of graphic recording in which image elements are reproduced by the effect of rapid temperature changes in a stylus that is in contact with special temperature-sensitive paper. The metal stylus, most often in the form of a linear array of multiple stylii, is normally held just below the threshold temperature at which the paper will turn black at the point of contact; black peaks in the applied picture signal drive the temperature instantaneously over the threshold, thus recording image details.

Three-level Image Signaling

5.74 A bandwidth compression technique in which alternate white peaks (or alternate black peaks) in a fax signal are represented by two different carrier levels, while a fixed medium third level represents black (or white). The result is a halving of the number of zero crossings in the averaged fax baseband, and thus the ability to transmit the same information at twice the speed.

TV/Fax

5.75 A term sometimes applied to fax systems using freeze-frame or slow-scan television cameras as send terminals (eg, the system by which instantaneous views of the earth's cloud cover are transmitted to ground-based fax recorders from orbiting weather satellites).

Turnaround Polling

5.76 A polling (receiver-controlled transmission) option provided with some fax systems in which, immediately following a transmission, a terminal automatically switches to the receive mode and polls the remote transceiver to which it is already interconnected.

Vertical Compression

5.77 A redundancy reduction method in which the data representing scan line content is compressed (compact) both vertically and horizontally. Typically, this is accomplished by automatic comparison of the spatial content of one scan line with that of the one immediately preceding, and the transmitted codes representing only the differences. (See ***READ Code, Run-length Coding***)

White Space Skipping

5.78 A term loosely applied to any redundancy reduction technique in which the speed of a fax scanner (the stroke speed or line-to-line advance speed) is increased when lengthy blank areas are sensed on the page being scanned. (See ***Run-length Coding, Skip Mode***)

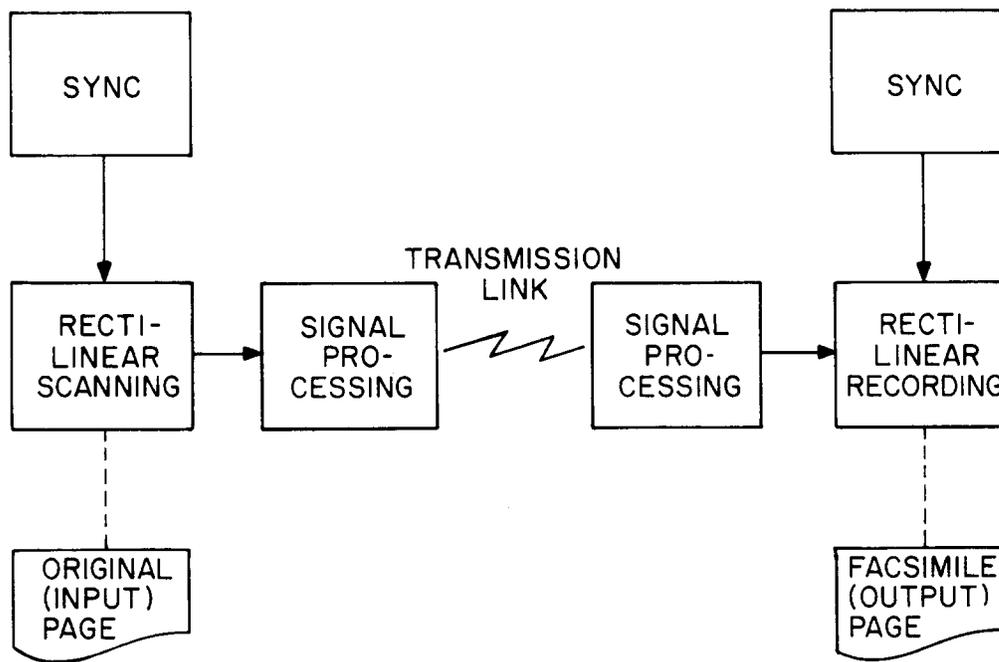


Fig 2—Basic Fax Principle (Rectilinear Scanning Signal Processing, Transmission, Synchronization, Rectilinear Recording)

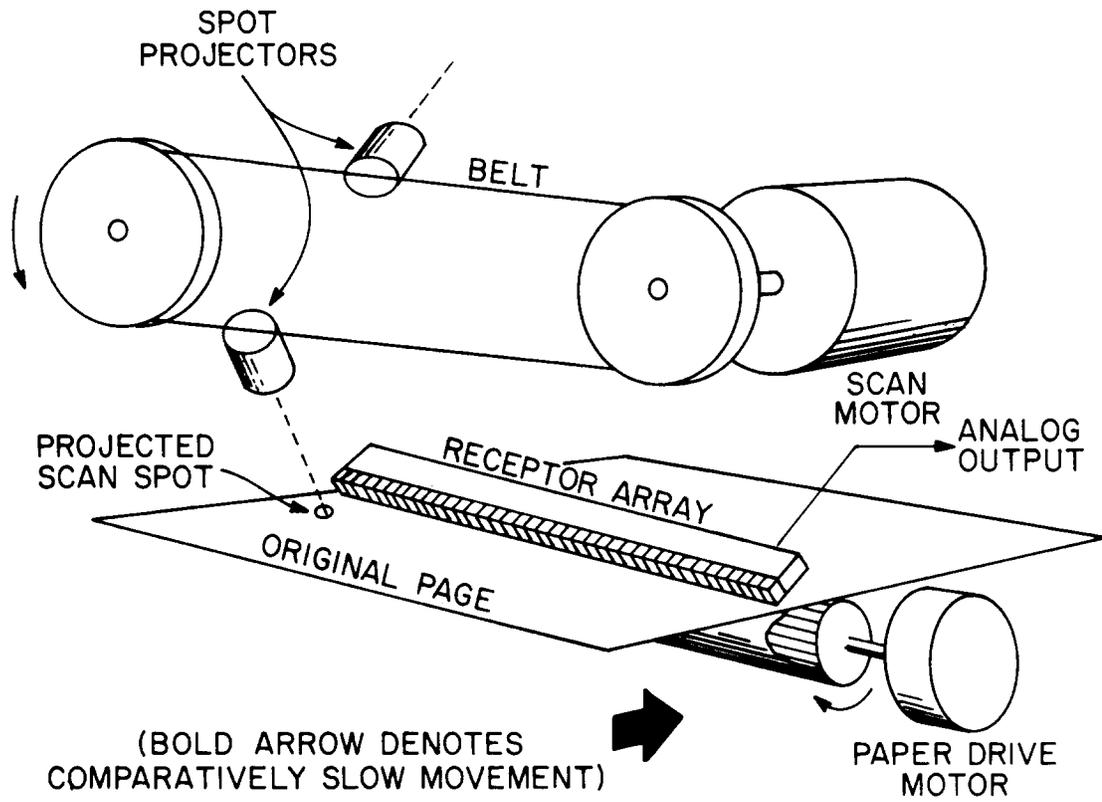


Fig 3(a)—Fax Scanner in Which the Input Page is Transported Slowly Past a Moving Scan Spot

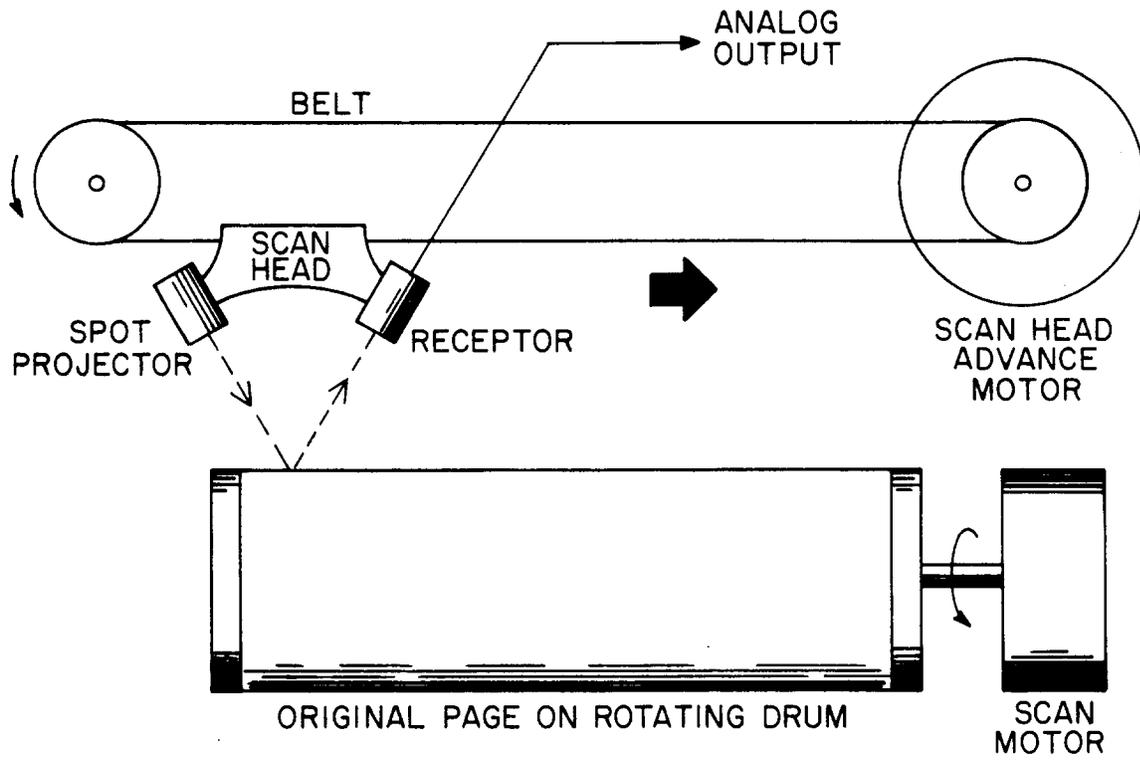


Fig 3(b)—Fax Scanner in Which the Input Page is Rotated Relative to a Scan Spot That Moves Slowly Along a Perpendicular Axis

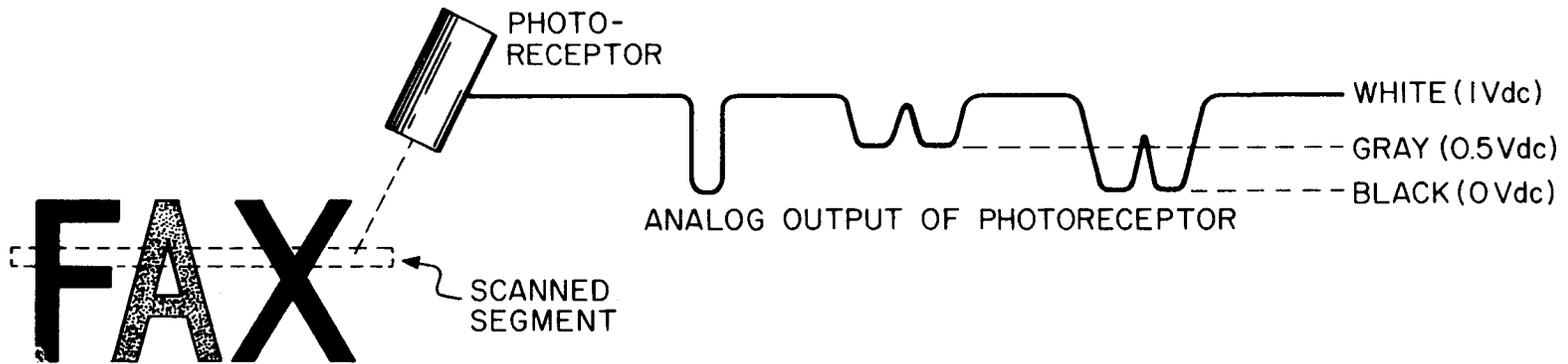


Fig 4—Light and Dark Image Elements are Converted to an Electrical Analog by the Scanner, Which Outputs a Low-level Varying Current

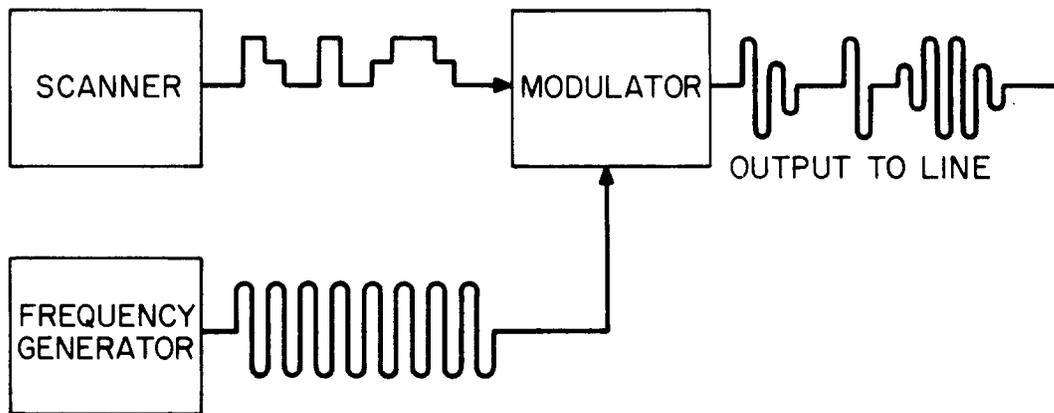


Fig 5—Scanner Output Amplitude-Modulates a Voiceband Carrier

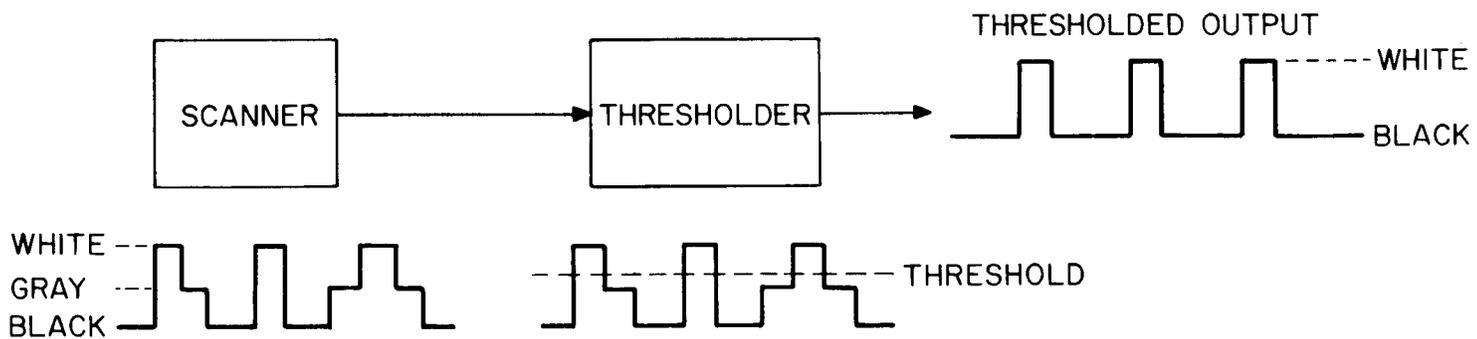
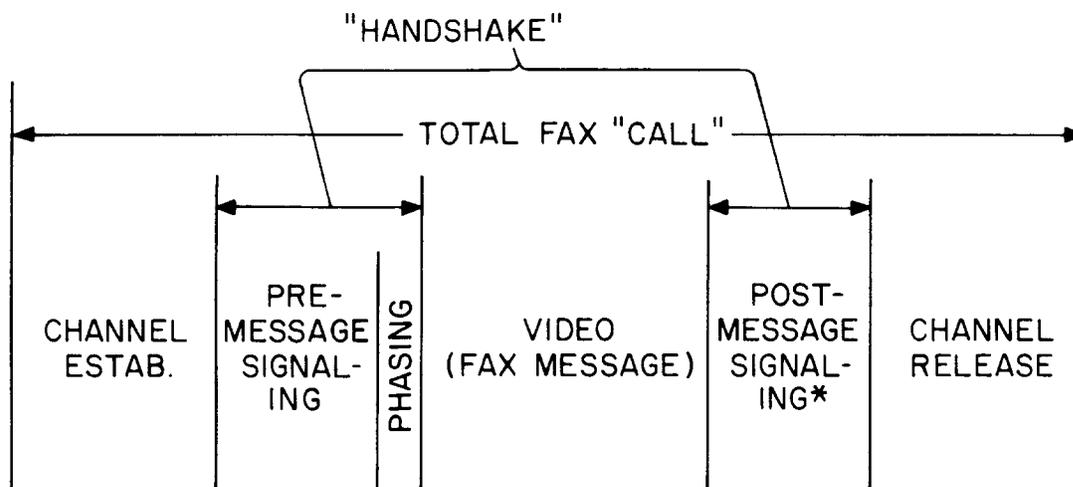


Fig 6—Thresholding Reduces Continuously Variable Scanner Output to Dark-Light Extremes



* INCLUDES INDICATION OF ADDITIONAL PAGE FOLLOWING

Fig 7—Diagram of Fax Control Procedure (Pre- and Post-Message "Handshake")