

# The Wang Professional Image Computer: A New Dimension to Personal and Office Computing

FREDERICK A. WANG, AHMED H. M. EL-SHERBINI, MEMBER, IEEE, STAN FRY, MIKE SMUTEK, MEMBER, IEEE, AND NANCY WEBB

*Invited Paper*

*The Wang Professional Image Computer (PIC) offers image processing technology at the desktop level. The PIC can capture, create, display, alter, store, retrieve, and transmit images in real time. These images can also be merged with text. With PIC, the ability to process data, words, and images and to communicate that information locally or remotely within Wang's family of compatible office products is now available in a single workstation. In this paper, we present a description of the Wang PIC. The system's technical features, architecture, hardware and software components, functions, and applications are discussed and illustrated.*

## I. INTRODUCTION

Office automation is based on the development and application of six technologies [1]

1. Data Processing
2. Word Processing
3. Image Processing
4. Audio Processing
5. Networking
6. Human Factors

In spite of all the office automation products available today, the user's needs for image processing capabilities and advanced systems integration have not yet been met [2]–[6]. The storage of and access to written information which comes into an organization from the "outside world" is still a manual process, even if the organization has office automation equipments. Companies that produce documents that require input from many different sources need to have the ability to create, modify, and transmit documents with images quickly and efficiently.

Traditionally, computer manipulation of images was a task that only large machines could accomplish [7], [8] because of the following reasons:

1. Dealing with digitized images means manipulating huge amounts of data (several million bits per image) which was beyond the capabilities of small machines.

Manuscript received November 18, 1983; revised December 15, 1983.

The authors are with Wang Laboratories Inc., Lowell, MA 01851, USA.

2. Real-time performance required in many applications (such as the office) was not possible due to the limited speeds of the available microcomputers.
3. The memory capacity required far exceeded that available on the small machines.
4. Permanent storage of such large amounts of data was very expensive.

Now, the Wang Professional Image Computer (PIC), shown in Fig. 1 offers image processing technology at the desktop level.

Based on the Wang Professional Computer (PC), the PIC includes: a desktop, camera-like scanner to digitize images from a sheet of paper; a high-resolution monitor capable of displaying the image; and a desktop thermal printer capable of printing the image. The PIC image processing software permits users to scan, digitize, create, display, alter, store, retrieve, and transmit images. These images can be merged with text. The PIC can handle image information that includes pictures, handwritten notes, margin notations on correspondence, drawings, as well as text. With PIC, the ability to process images, words, and data, and to communicate and transmit that information locally or remotely within Wang's entire family of compatible office products is now available in a single workstation.

The PIC is an integration of the six technologies on one system. With its imaging capabilities, the PIC is more than a personal computer, more than an image storage and retrieval device, more than a facsimile machine, and more than a management workstation. It is a synergistic computer with all the fundamental features adding up to make it a superior office automation tool.

The next section gives a brief description of the Wang PC on which the PIC is based. Section III presents an overview of the PIC, Sections IV, V, and VI give detailed description of the PIC hardware and software components, the architecture, and the applications.

## II. WANG PC

The Wang PC [9] is a key element in our overall office automation strategy. Its main characteristics are summarized in Table 1. The Wang PC uses an Intel 16-bit 8086 micro-



Fig. 1. A PIC photograph.

**Table 1** Wang Professional Computer Summary

|                  | Standard                       | Optional  |
|------------------|--------------------------------|---|
| Processor        | 8086 16-bit microprocessor     | 8087 numeric data processor   |
| Memory           | 128-kbyte RAM                  | 128 kbytes, 256 kbytes, or 512 kbytes for a total of up to 640 kbytes   |
| Storage          | 320-kbyte diskette drive       | 2nd 320-kbyte diskette drive or 5-Mbyte fixed Winchester drive  |
| Communications   | RS-232C adapter                | Asynchronous Communications:<br>TTY<br>2236DW terminal emulation<br><br>Synchronous Communications:<br>2780/3780/WPC protocol<br><br>Emulation of the following terminals:<br>VS 2246S<br>VS 2256C<br>OIS 5536-4<br>ALLIANCE 5536-4 |
| Operating system | Microsoft DOS                  | CP/M 80 emulator  |
| Languages        | Microsoft BASIC-86 interpreter | Microsoft BASIC compiler<br>Microsoft COBOL<br>Microsoft FORTRAN<br>Microsoft Pascal  |
| Applications     |                                | Wang PC-Word Processing<br>PC Database<br>PC Multiplan<br>Third party general business applications   |
| Printer          | Parallel printer connector     | 20 CPS Daisy<br>80 CPS Matrix<br>Third party parallel printers<br>Third party serial printers   |
| Monitor          |                                | Wang Monochrome Display with Character or Character and Graphics capabilities, or a customer-supplied NTSC B & W or color television, or B & W or RGB color monitor   |

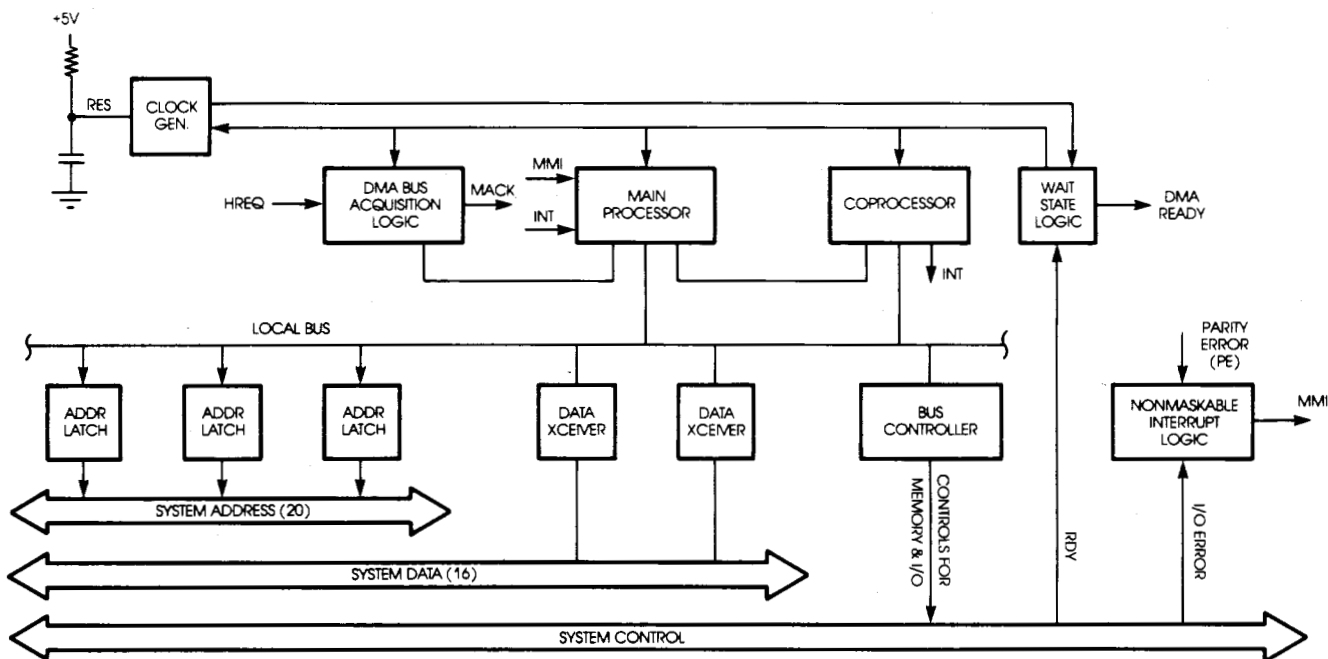


Fig. 2. Wang PC processor block diagram.

processor running at up to 8 MHz; an optional 8-MHz 8087 co-processor can be installed for high-performance numeric data processing. The 8086 and its 8087 co-processor communicate with each other via a local interprocessor bus. Both processors communicate with memory and I/O components via the system bus by means of address latches, data transceivers, and a bus controller chip. The processor block diagram is shown in Fig. 2.

The system board memory includes 128 kbytes of dynamic RAM that can store system programs, application programs, or data. The 64-kbit RAM chips that are used have 200-ns access time and 350-ns cycle time, achieving high memory array density at reasonable cost. An optional extended memory board augments the 128 kbytes of standard system memory with 128, 256, or 512 kbytes of extended dynamic RAM with parity check. The four-channel DMA Controller (Direct Memory Access) allocates one channel for dynamic RAM refresh, leaving three channels available for general use. It transfers only byte data, not word data. The maximum DMA transfer rate is 300 kbytes/s. The controller is programmed for rotating priority to give every channel equal access to the system bus. The system bus provides 16 bidirectional data lines, 20 address lines, and miscellaneous control signals. The 8086 is normally the bus master; it relinquishes the bus and grants it to the DMA controller or the 8087 when either device requests a bus cycle. A programmable interrupt controller provides eight levels of maskable priority interrupts.

The PC comes with a separate and detachable, ergonomically designed keyboard. The keyboard contains a dedicated microprocessor that accepts commands from the 8086 while retrieving both keyboard status data and keystroke data. The PC's operating system is the Microsoft Disk Operating System (MSDOS), which is a 16-bit industry standard operating system. As enhanced by Wang, this operating

system has a user interface designed to be used by the professional. The system is interactive and menu driven.

The system has an Extended Programmable Communication Interface (EPCI) which is programmed by the 8086 to support RS-232C asynchronous serial data communications in full or half-duplex mode. It also has a Parallel Peripheral Interface Chip (PPI) which implements the Parallel I/O interface. The floppy disk controller (FDC) operates one or two 5.25-in double-sided, double-density, floppy disk drives recorded at 48 tracks/in (320-kbytes). The diskette drive is enclosed in the lightweight, compact enclosure.

### III. OVERVIEW OF THE PIC

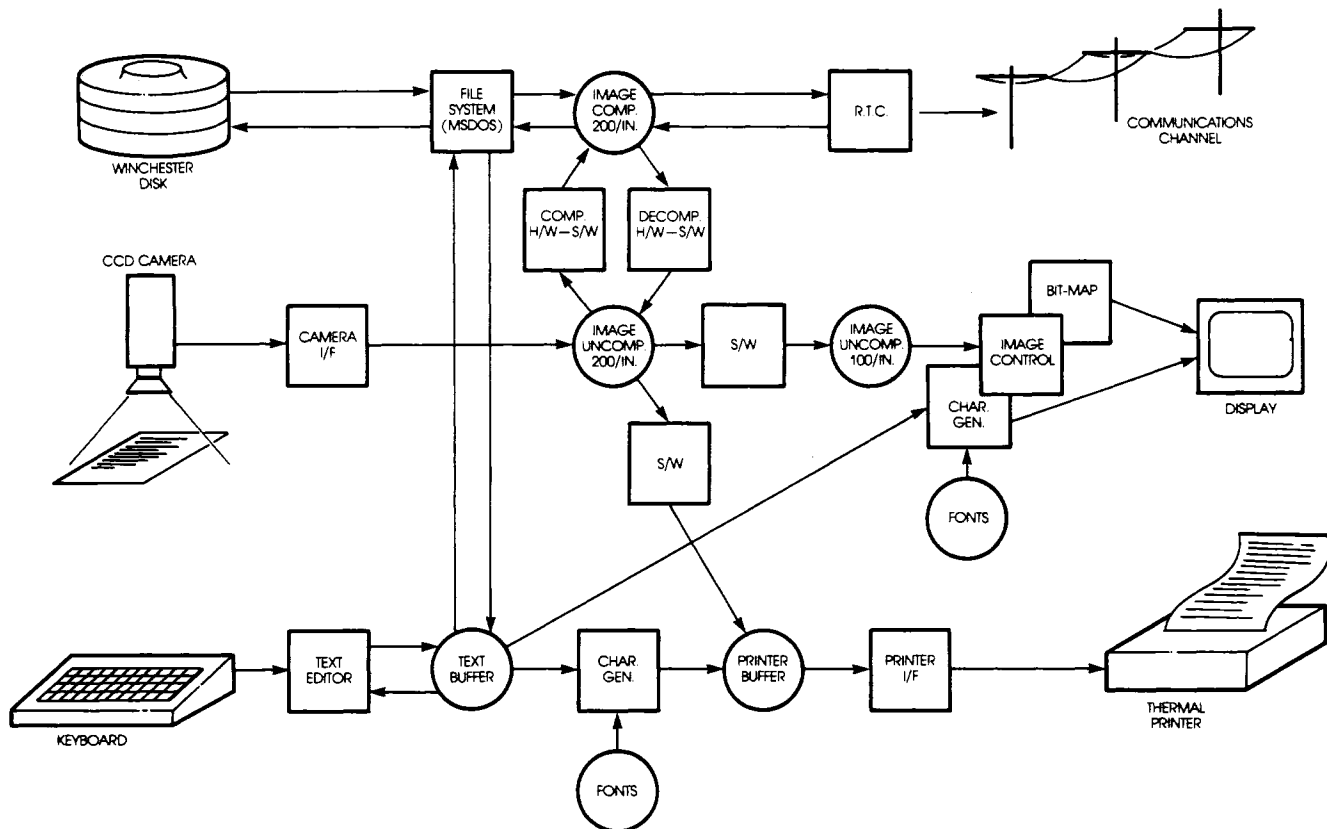
The PIC is a highly integrated office product designed to capture, manage, and communicate various forms of information, including image, text, data, and voice. With its extensive communications and networking capabilities, the PIC is also a multifunction workstation which can be linked to other Wang systems, including the VS, OIS, and Alliance. The PIC's design is based upon the Wang PC. The imaging capabilities enable several operations: scan, display, alter, integrate with structured and unstructured information, store, retrieve, and communicate. These capabilities are enabled by compatible plug-in controller cards and add-on imaging components and imaging software. Required and optional system components are summarized in Table 2. Fig. 3 shows the data flow in the PIC, while Fig. 4 shows the PIC system cards and connections.

### IV. PIC HARDWARE

The major hardware components that upgrade the Wang PC into a PIC are the image scanner, the thermal or laser printer, the camera/printer interface card, the high-resolution monitor, and the CRT controller.

**Table 2** PIC System Required and Optional Hardware and Software

|           | Required  | Optional   |
|-----------|---|--|
| Hardware  | <ul style="list-style-type: none"> <li>• PC chassis—8-slot OR 5-slot</li> <li>• 512-kbyte Memory Expansion Card</li> <li>• 10-Mbyte Winchester Disk and Controller Card</li> <li>• Text/Image/Graphics Card</li> <li>• Wang Image Monitor</li> <li>• PC Keyboard</li> </ul> | <ul style="list-style-type: none"> <li>• Scanner/Printer Card</li> <li>• Image Scanner</li> <li>• Wang Thermal Printer</li> <li>• LIS-12 Laser Imaging System</li> <li>• Local Communications Option</li> <li>• Local Interconnect Option</li> <li>• Remote Communications Option</li> </ul> |
| Software: | <ul style="list-style-type: none"> <li>• Image Processing</li> <li>• Image Composition</li> </ul>   | <ul style="list-style-type: none"> <li>• Integrated Word Processing</li> <li>• Integrated Notebook</li> <li>• Integrated Database</li> <li>• Image Forms-Fill</li> </ul>   |



**Fig. 3.** PIC data flow diagram.

*The Image Scanner*

The PIC image scanner, pictured in Fig. 5, is a desktop scanning device used to input images into the PIC. It consists of a flat base upon which the material to be scanned is placed face up. An adjustable upright column mounted to the base supports the scanning assembly above the document and lets the user zoom in or out. A reticule projected down through the lens of the scanning assembly and onto the document provides a visible frame for positioning the document and targets for adjusting the focus. Lamps for illumination are provided in fold-out arms mounted to the scanning assembly.

The face-up scanning arrangement is an important part of

the camera design. It gives the user the ability to easily scan thick material, such as books or magazines, and sections of oversize material, such as engineering drawings or blueprints. It makes it easy for a user to target in on a specific area, and to point to or write on the document while it is in scanning position.

The scanner supports two modes of operation: a text mode and a photo mode. In the text mode, the camera is set to scan any document that contains text or typing, and in the photo mode the camera will output a dithered or "half-tone like" images which are useful for media containing photographs [10]–[12]. The scanner uses a custom designed fixed aperture lens. The lens focuses the input document onto a linear CCD array which is 1728 × 1 pixels in

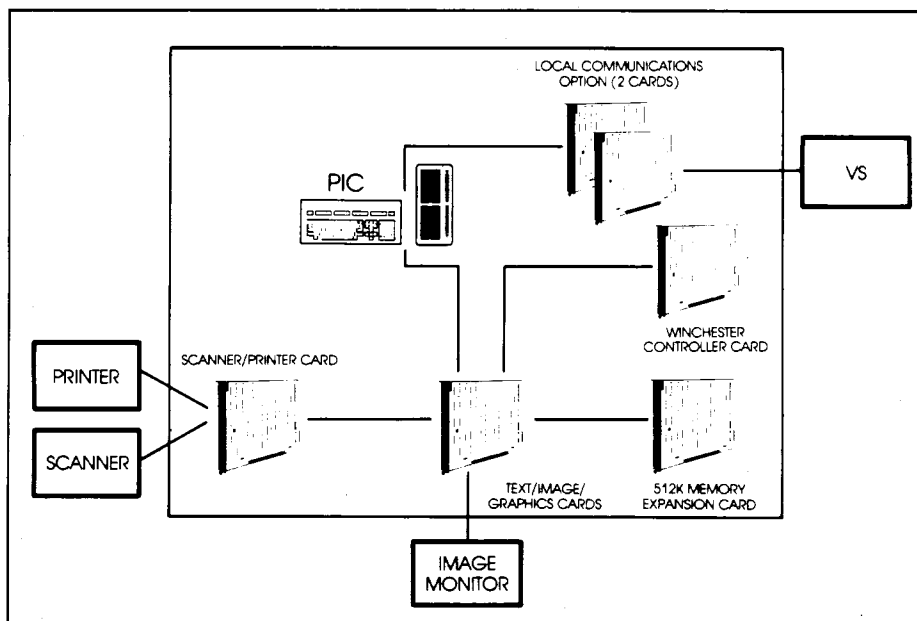


Fig. 4. PIC system diagram.

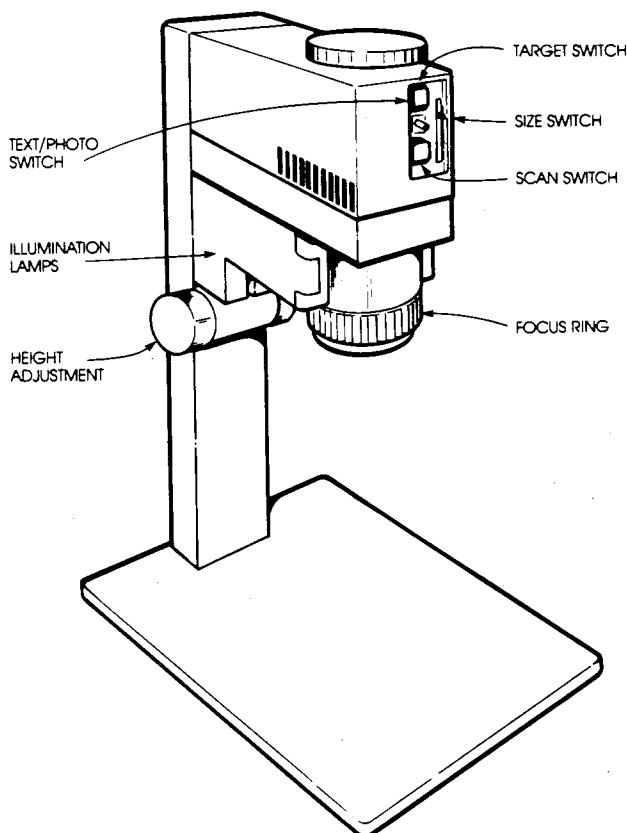


Fig. 5. PIC image scanner.

size. The array, which moves smoothly across the image plane while scanning, is mounted on a movable carriage driven by a lead screw. A complete scan cycle takes approximately 12 s: 2 s to move the reticule out of the way, 4 s active scan time, and 6 s to return to the rest position. The scanner digitizes at a resolution of 200 dots per inch, providing resolution equivalent to group-3 facsimile system.

The electronics in the scanner consists of a microprocessor, an analog-to-digital converter, and a high-speed signal processor. The microprocessor performs control functions of communicating with the host interface, monitoring and responding to the controls on the operators panel, turning the lamps on and off, operating the motor which drives the lead screw, performing power-on diagnostics, and providing input to the signal processor. The signal processor thresholds the digital video signal to produce the binary image data. It is programmed to dynamically adjust its threshold to compensate for variations in document contrast and lighting [13].

The data out of the signal processor are sent serially to the interface board within the PIC chassis. There the data are deserialized and transferred via direct memory access (DMA) into the main memory of the CPU. The data are clocked at 1.25 MHz during the active part of each scan line with a dead time of about  $430 \mu\text{s}$  between scan lines. A large FIFO register buffers the data to accommodate the worst case latency of the DMA channel. During the active portion of the scan, the data transfer rate of the present camera averages about 120 000 bytes/s. Once begun, the scan cycle proceeds without interruption so the CPU is required to accept the entire 475 200 bytes of image data within just 4 s. A block diagram of the scanner electronics is shown in Fig. 6.

#### CRT Monitor and Controller

The PIC uses an interlaced monochrome display with an active display area of  $800 \times 600$  pixels which can show both characters and bit-mapped image. The 12-in screen has an active area of approximately 8 by 6 in, producing equal pixel density of 100 pixels/inch in each direction and eliminating anamorphic distortion. Furthermore, at normal size, the displayed data have been decimated to a nominal density of 100 pixels/in so that an image as viewed on the screen is close to its true size.

The display is used in both negative and positive contrast

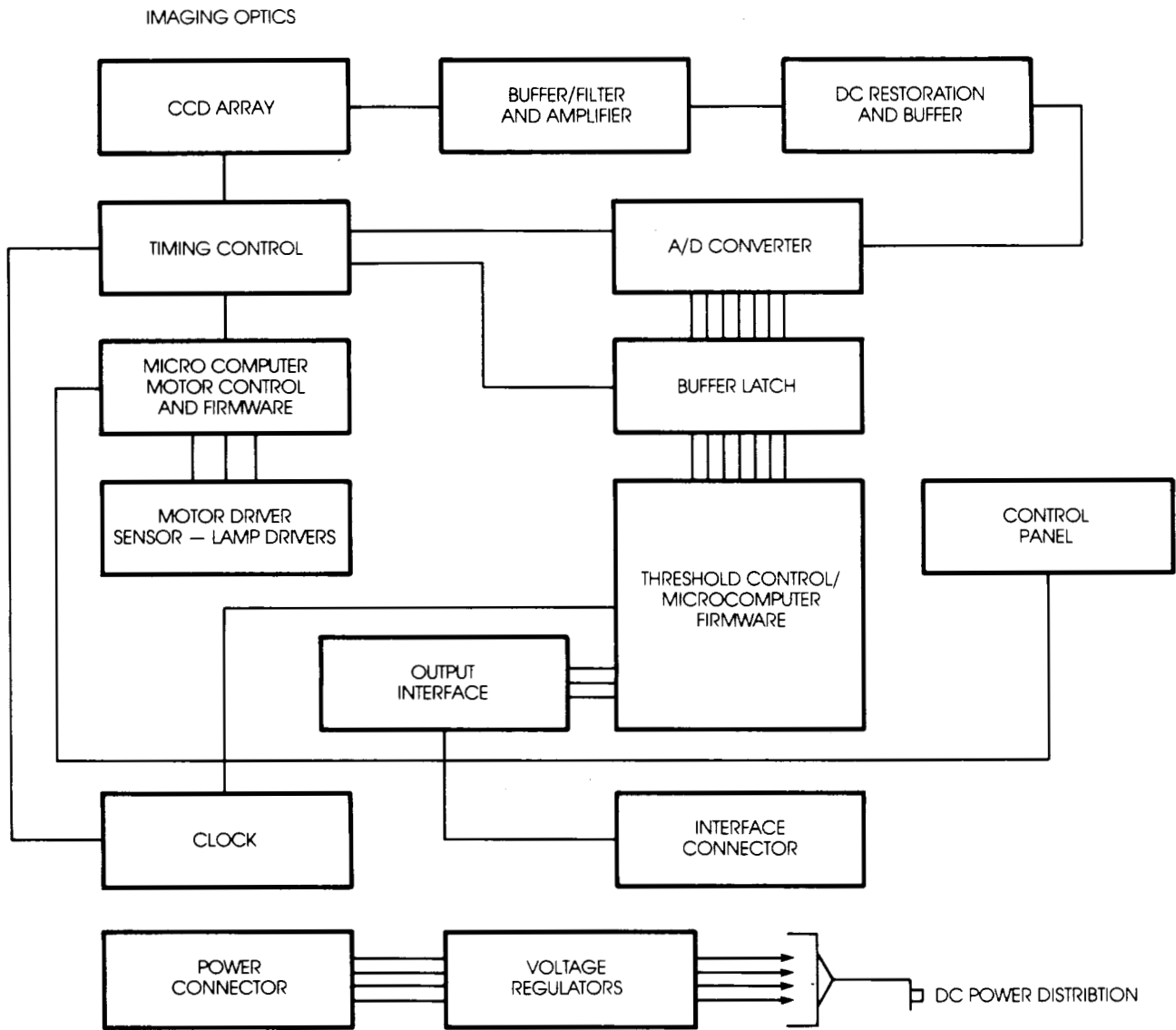


Fig. 6. Block diagram of scanner electronics.

modes. Images (and images combined with text) are usually displayed as black on a white background, a feature that avoids giving the impression that the displayed image is a "negative" or a "blueprint." Furthermore, because large areas are often illuminated as a result, a white color (rather than green phosphor) was preferred because it is more pleasing to look at. Text-only screens such as menus are usually displayed as white characters on a black background, a presentation common for most CRT displays.

The CRT controller is self-contained and includes bit-map, text, and font memory on a single 8 x 12-in printed circuit board which fits in a standard "option" slot in the chassis. The implementation uses two Graphic Controllers (GCs), one for text and the other for image and graphics. All of the memory on the controller board is accessed through the GCs which arbitrate memory accesses and perform memory refreshes. None of the memory appears in the PC memory address space. Bulk data transfers can be performed in either direction by DMA through the graphic controllers and the DMA facilities of the CPU.

The number of pixels of data which must be delivered to the screen in a given time is proportional to the refresh rate,

i.e., the vertical frame rate of the display. In general, supporting a higher frame rate requires faster memory devices or a wider data path. To help keep the memory bandwidth and device costs down, the display employs interlace at a vertical rate of 40 Hz. The interlace technique works well as long as the display's spatial frequencies are band limited in the vertical direction. Fortunately, for most actual images this is true and the resultant display is flicker-free.

The controller provides two separate display planes, one for characters and one for bit-maps. The two planes are operated by separate GC controller devices which are synchronized but otherwise operate independently. The two GC devices must be synchronized by the software initially at power up and whenever the basic timing parameters of the GCs are changed. The GC controlling the character display is designated as master and the bit-map GC as the slave. During synchronization, the slave monitors the timing signals of the master and "locks-on" within a few frame times after which both GCs are "started." Once started, the GC's synchronization process is over and both free run independently. Obviously, the timing parameters for the two must be equivalent or they will immediately get out of

synchronization. Also, both are driven by clock signals derived from the same crystal-controlled oscillator to prevent any long-term drift in their timing. The video signals from the two planes are combined for display by a loadable look-up table arrangement which provides considerable flexibility.

### Printers

For hardcopy printouts, the PIC supports two high-quality printers: the Wang thermal printer, and the laser imaging system model LIS-12.

The Wang thermal printer, which connects to the scanner/printer card, can print both image and text. This compact (4.4-in height, 11.4-in depth, 16.5-in width, and 12-lb weight), high-resolution peripheral prints at 200 dots/in.

The LIS-12 laser imaging system provides high-quality outputs for PIC generated images, text, and documents integrating image and text. The LIS-12 prints at speeds of up to 12 pages/min at a print resolution of 300 dots/in. LIS-12 consists of a laser xerographic printing system and a text/image/graphics processing unit containing all the printer electronics. The printer supports numerous paper sizes up to 11 × 14 in and 26 different character sets including Boston, Courier, Geneva, Gothic, and Prestige elite [14].

### V. PIC SOFTWARE

The PIC offers six major software functions which provide the generic tools required to create custom applications. One of the key areas of the PIC is the ability to maintain structured and unstructured information in a database. Integrating images with the tools of a database permits the user to perform functions not available on existing personal computers or host computers. Coupling the powerful query capabilities of the database products with the PIC attached to the hosts systems permits the user to store and retrieve large volumes of information. Images have been integrated with three database products on the PIC. Another key area of the PIC is the composition of images and the integration of images with word processing. The PIC functions are described in the following subsections.

#### Image Processing

The image processing core software allows the user to create, review, print, delete, send, and receive documents containing image pages. Once an image document has been created, the user can capture (scan and digitize) images, manipulate image content, and store images on disk. When an image page is displayed, the user can perform operations such as view half of an image, view an image in the positive (white background) or in the negative (dark background), scroll through an image horizontally and vertically, and lighten or darken an image. The aspect of an

image can be changed from portrait (vertical) to landscape (horizontal), that is, rotating the image 90° [15], [16]. Furthermore, a portion of the image can be viewed at the size that it was originally scanned, and can be enlarged or reduced by a factor of 2 [17]–[20]. The user can also insert image pages into any location of the document, replace, delete, or print image pages (either on the thermal or the laser printer), and enter search words to aid in the recall of particular documents for reviewing or printing.

In terms of actual file structure, each image file contains one "image document." There may be several separate images ("pages") in a file, each identified by a unique image ID. This image ID is the method by which the various keywords and data blocks which make up an image are logically combined into a "page." Throughout this paper, the terms "document" and "page" will refer to image files and individual images. There are four types of information stored in PIC image files:

1. An index block which allows for reconstruction of an Integrated Index entry.
2. A Page Table which maps images into "pages" in an image "document."
3. A header block for each image which describes parameters specific to that image.
4. The actual image data. Image data are stored in 2K blocks and referenced by CBAM (Compressed B-Tree Access Method) pointers [21], [22].

Every image is compressed (coded) before transmission or storage on the disk. Compression reduces storage requirements and allows for faster transmission [23]–[26]. The compression scheme that we use is the 1-D modified Huffman run length code [27]. This coding scheme is the CCITT (the International Telephone and Telegraph Consultative Committee) Recommendation T.4 for group-3 facsimile machines [28], which makes Wang PIC compatible with most of the existing facsimile machines. Huffman code is a compact uniquely decodable code and is implemented in an efficient table look-up fashion. Several compression schemes were considered (e.g., 2-D READ code [29]) but the 1-D Huffman was chosen for ease of implementation, reduced memory and processing time requirements, and compatibility reasons [28]–[31]. Table 3 shows the average compression ratios of the two coding schemes for different picture resolutions. On the average, 100 compressed images can be stored on the 10-Mbyte disk.

#### Image Composition

Full-page images often include areas which are not needed by the application into which the images are integrated. In addition, it is desirable to be able to create new images and new visual effects by combining sections from a number of images. This created a need for a method to define areas of images, and to associate these areas in a manner which would be easy for an application to access.

**Table 3** Compression Ratios of the Two Coding Schemes

|                              | Picture Resolution—100 dots/in | Picture Resolution—200 dots/in |
|------------------------------|--------------------------------|--------------------------------|
| 1-D Modified Huffman Code    | 5.025                          | 8.794                          |
| 2-D READ Code<br>( $k = 4$ ) | 9.05                           | 12.955                         |

The PIC uses a composite structure of descriptions defining image cropping parameters, relative positioning of image sections, display formatting information, etc. This general structure allows for combining many different types of media, although currently it is implemented only for images. The full-page image is cropped by reference, leaving the original data intact. By accessing images only by reference, many composites can share the same image data without the storage overhead of multiple copies of the same data. This also provides the ability to return to the original data and recrop if the desired effect was not achieved by the initial definition. Changes to a "master" image can be made without necessarily having to respecify all composites which reference it. Storage requirements can be reduced further by physically cropping portions of the image which the user decides will never be needed, or by scanning shorter sections of an image.

The Composite Editor is part of the Image Processing Editor. Using the standard PC keyboard, rectangles may be defined and positioned into a composite. A group of image descriptions is given a unique name which can be accessed by applications. Using the Composite Editor, "libraries" of composites are created which may be accessed globally throughout the system. Simply stated, the image composition package allows the user to perform composition of image information in a manner similar to "cut-and-paste" operations performed with paper.

### *Integrated Word Processing*

The first application into which images were integrated was the PC Word Processing (WP) package. Since the PC/WP was a released product with a defined document structure already in use in the field, images had to be integrated in a way which did not change the existing document structure. Documents created by PIC/WP had to be editable on PCs without the imaging option.

This led to the implementation of the composite token and the Complex Information Descriptor (CID) file. Each WP document has associated with it a file which contains descriptions of images in that document (composites). The composites are referenced by token characters in the document text stream. Each token has an associated ID number which refers to an entry in the CID file. The token is a flag to the Word Processing Editor to escape to software which can interpret the external data. Since the specifics of the composite are generally unknown to word processing, this allows the flexibility to add other media, such as graphics, without a major impact on WP. The composite token occupies the space of a standard text character, thus the document structure is not affected. To a WP editor which does not include image processing capabilities, it is an unrecognizable character which can be displayed although not interpreted. This also facilitates manipulation of the composite within the document. To the user, the token is simply another character which can be accessed via normal WP functions (copy, move, search, etc.).

There are two methods of inserting a composite into a document. In either case, a composite token is placed into the document, and an ID is allocated in the CID file. The composite is taken from a global library of composites, or created interactively as a composite private to the document. In the first method, a composite library is specified, and a composite name selected from within that library. A

copy of the composite is placed in the CID file. In the second method, the Image Processing/Composite Editor is invoked from within Word Processing. This makes available the full range of image processing functions. A composite built using this method may be assembled from existing and/or newly scanned images. It may be inserted in a global library, or defined solely for the use of the current document. In the latter case, the composite is placed directly in the CID file. In either case, the image sections defined by the composite are displayed at the specified position in the document. The two-plane display of the PIC provides flexibility for formatting text with images. The text may be formatted around the images, or may be entered over them. Even with the flexibility of text formatting, it may be necessary to make minor adjustments to the positioning of image sections within a composite. A "mini-editor" can be accessed during word processing without the overhead of invoking the entire image processing editor. Using the mini-editor, individual image sections may be selected and moved horizontally or vertically within the composite, while viewing the text into which the image has been placed. The repositioning is performed on the CID copies of the composite, therefore neither library composites nor image data are affected.

An example of output generated using the PIC image and text integrating capability is shown in Fig. 7.

### *Integrated Notebook*

Integrated Notebook permits the user to define textual information (notes) and attach images and image documents to each note. The notes can be retrieved through free format text retrieval based on word or set of words in the note. Fig. 8 shows an example of attaching images in the Integrated Notebook.

This package allows the user to organize mixed information (notes/images) in a form which conceptually resembles "paper" file folder (notebook entries with images attached). Information can be created, reviewed, printed, and/or deleted. The information may be purely textually entered notes or may contain both the note and related image information. When a user creates or edits a note, the user may attach an image document (which can contain multiple image pages) by signaling to the system that image information is to be associated with the currently selected note. The image document can also be accessed by any of the other image software packages. When a user has selected (through positioning and/or searching) a note, a single keystroke will bring the associated image to the screen and the Integrated Notebook package enters normal image processing.

With the Integrated Notebook, categories can be established to aid in the organization of both text and image information; information search, at the note level, is fully word indexed allowing the user to search and recall notes fitting the entered criteria. Operation of the notebook, down to the note level, is identical to that of PC Notebook [32]. The new image feature of notebook allows the user to "attach" specific notes to specific image documents.

### *Integrated Database*

Integrated Database is a relational database which permits the user to define structured data and text and to relate images with each data record. Fig. 9 shows examples

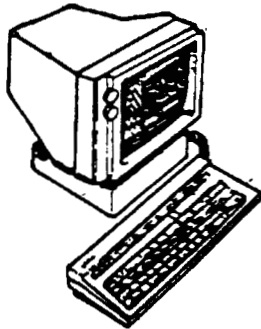




LABORATORIES, INC.  
One Industrial Avenue, Lowell, Massachusetts 01851

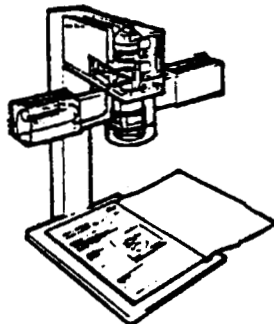
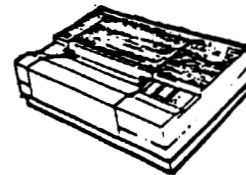
### The Wang Professional Image Computer

At the heart of the Professional Image Computer is the Wang Professional Computer. Since it uses standard PC components, the PIC can run all of the usual PC applications including Wang's renowned word processing, the Multiplan spreadsheet package, and business graphics.



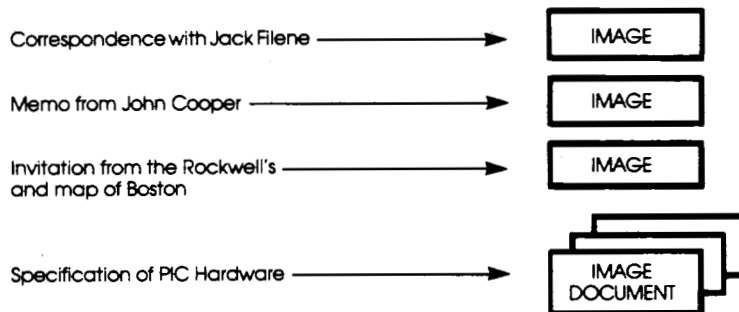
It can be used as a stand-alone personal system, as a node in a network of PICs, or as a workstation attached to an OIS or VS system. The Image Capable Workstation includes a high resolution display of 800 by 600 dots for clear, crisp images. It has a full page bit-map which can contain a full 8.5" x 11" image and a separate plane of text memory which holds over 4000 characters. This allows images and text to be combined. This display is an option on the standard PC but is required for imaging capabilities.

For output the Professional Image Computer includes a quality dot-matrix thermal printer. The printer complements the image scanner and permits images, text, and graphics to be output quickly, quietly, and cleanly. Together with the small size and low cost, these features will make the printer an irresistible component at every workstation.



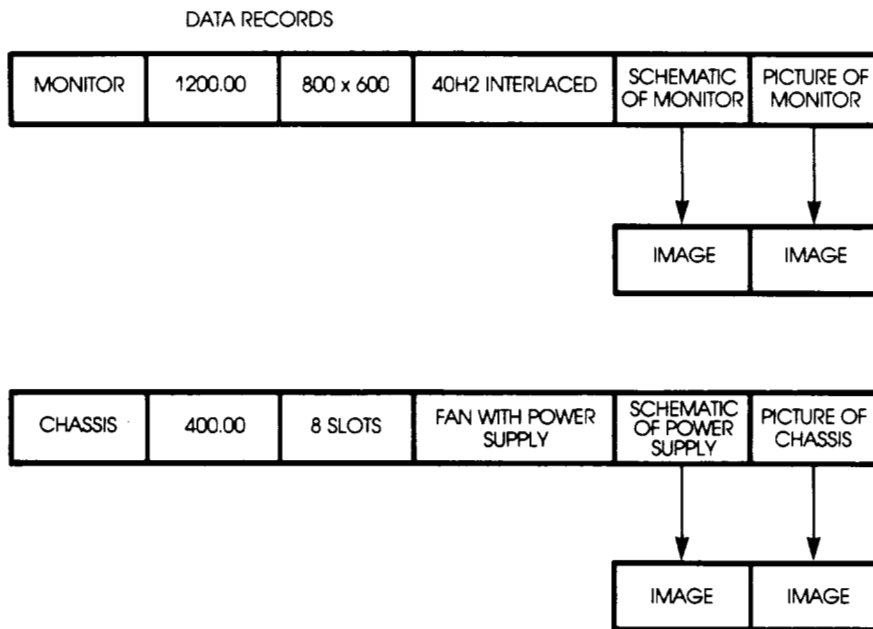
The Wang Image Scanner is the most unique component of the system. Advanced image scanning techniques let it scan full pages with amazing clarity and definition. Yet, true to the Wang tradition, the operation of the scanner is easy and uncomplicated. Best of all, the scanner is priced so that it is reasonable to include one with every workstation.

Fig. 7. Example of a page produced by using the PIC image and text integrating capability.



Any word or words in the text could be entered to retrieve the note and image(s).

Fig. 8. Example of attaching images in the Integrated Notebook.



**Fig. 9.** Examples of data records in the Integrated Database.

of data records in the Integrated Database. Queries may span many record types, and can be based on any of the information within the record, including the identification of the images in the data record. Information search within the database for image fields or text fields is word-indexed allowing the user to enter categories of information to aid in the search and recall of the images and the associated data records.

When Integrated Database is selected, the same PC database selections are available to the user from the database main menu. Operations of database, down to the record and field levels, are identical to those of PC database [32], [33]. The new image feature of database allows the user to "attach" specific fields to specific image document.

If a field is to point to an image document, it is created normally (up to a maximum field length of 50 characters) and designated as an image field. All words entered in the field are automatically word indexed and are used as a descriptive narrative of what the image document contains. The user simply enters the GOTO key to automatically create the image document which holds the image information. The particular field is then associated with the specific image document until the field is deleted. The image document can also be accessed by any of the other image software packages. When a user has selected (through positioning/search functions) a field, a single keystroke will bring the associated image to the screen. Fields which allow images to be attached are identified to the user through a change in the database menu options at the bottom of the screen.

#### *Image Forms-Fill Processing*

Forms-Fill provides the capability of using a relational database which is defined and manipulated through a form. The form can be a standard paper form which has been captured in the system. Fields may be defined in free format anywhere on the form.

This package allows the user to define forms, databases, records, and fields which contain both image and data information. The significant advantages of this approach are:

- An image form can be used as the background for form/field definition, data entry and edit, query and response, sort, and print.
- The image form can be aligned to allow the precise positioning of fields.
- In addition to the standard field definitions (alpha, numeric, and date), a new field definition option for image information has been provided. This allows the user to go from data information to image information based on conventional data processing techniques.
- Both the image form and specific data records can be merged within word processing documents.

Five field types are supported within Forms-Fill processing: Alpha, Numeric, Date, Auto Dial, and Image Reference.

Any character or set of characters may be used as prompts and entered during format definition. The literal corresponds exactly to the typical prompting portion of normal data processing during screen definition. That is, "Enter Customer Name" would be a literal/prompt.

During form definition, the user can optionally designate an image form to be the form background information. With normal image processing, the real form can be placed under the scanner and the digitized image scanned into the system. If the user desires, the scanned form can be modified for alignment with actual field placement. The alignment would normally be used for forms where the typed entry falls slightly above or below the space designated on the form. A single copy of the background form is stored and used with each data record of the file for viewing, editing, etc. This reduces the system's storage requirements.

An "image field" is the descriptor of the image document and serves as the link to attach images to specific records in the database. The entered information for an image field

"links" the current data record to image documents. Because of the flexibility that this field adds to traditional applications, an example is provided below on how this field (combined with image processing (scan and store) and traditional data processing) may be employed.

Most organizations maintain personnel databases which contain such pieces of information as individuals' names, addresses, phone numbers, positions, and salary levels. Other information associated with an individual's profile such as resumes, reviews, letters of appreciation, is filed separately on paper. With the PIC, both the data and the paper information related to individuals can be maintained in the same information database. Traditional data fields about the individual can be established on the form (name, address, etc.). Paper information attachments can also be added to the data record through image fields which have scanned documents associated with them. A record could consist of not only the data information, but image information such as a current resume, all reviews, correspondence to personnel about this person, etc. From this base of information, very detailed forms could be created that would allow for more accurate information to be maintained on employees. Once a form definition of this type has been established, individual personnel information is entered.

At any time, any individual's record can be recalled based on traditional search criteria (name, social security, employee number) as long as that information has been entered into the database. Once the record is recalled, the user can review the data portions and/or position to any image field and direct the system to go to the image document which corresponds to that field. For example, the user may wish to review the individual's letters of appreciation. The system will then enter image processing mode directly and display the image document which contains those letters. When the user is finished reviewing the information, the system is directed back to the individual's form.

All fields are automatically identified as "indexable" fields. Therefore, all data entered into the system can be searched. Information can be recalled and processed through the query function. Lists which satisfy the query request can be built, sorted, and output. While a user is executing the integrated word processing package, information within the image/forms database can be recalled, and both the image form as well as the record information can be added to (or inserted to) the integrated word processing document. When the system is directed to print information from the information database, both the form background (if used during the form definition) and the data record are output.

## VI. IMAGE COMMUNICATIONS

One of the most important uses of image processing is the communication of image information to other systems, which is an active area of research and development [34]–[38]. A properly configured Wang PIC system equipped with the image processing software, can scan, transmit, and exchange images. It provides the following three communication options [39]:

1. local communication option
2. local interconnect option
3. remote communications option

The communications protocol for the transfer of images

requires synchronous modems, switched or leased lines, and a minimum transmission speed of 4800 bits/s.

Two applications have been created with the use of communications of images: these are TELE-SEND and TELE-MAIL.

The TELE-SEND application is used when a system user is having a phone conversation and wants to transfer (paper) information which is to be discussed in the conversation. The TELE-SEND application can be invoked and the paper can be scanned and transmitted to the receiving party. When the transmission is complete the voice conversation can continue on the same phone line.

The TELE-MAIL application permits the user to transmit images, image documents, word processing documents, or databases to a specified user. When the destination is identified, the system will deliver the specified information to the user's mailbox either through the telephone network or through local network connections.

## VII. CONCLUSION

In this paper, an overview of the Wang Professional Image Computer (PIC) is presented. Its features, architecture, and components are illustrated. The PIC is an integrated office computer system that offers image processing technology at the desktop level. It has the ability to process images, words, and data, and to communicate and transmit that information locally or remotely. In developing the PIC, we created an architecture that allows applications to be integrated efficiently, to fit the office business needs, in a low-cost workstation.

As price/performance continues to improve, image processing will become an integral part of the office information processing environment. Among the future trends in office automation, the following topics are advancing rapidly and will reshape the future office workstations:

- Development of high-performance specialized processors.
- Further integration of images with office business needs.
- Integration of Optical Character Recognition (OCR) capabilities with image processing, for efficient mixed document processing.
- Development of high-capacity/low-cost storage devices.
- Automatic speech recognition and synthesis, and further integration of images, speech, and text.
- Powerful networking capabilities for the office equipments.

Wang Laboratories is doing research on speech subsystems for the PIC, and will be considering product offerings in the future. This combination of sophisticated image and speech processing capabilities will add a new dimension to the power of personal computers for office automation applications.

## REFERENCES

- [1] F. Wang, "Office automation," *Mini-Micro Syst.*, pp. 198–207, Dec. 1982.
- [2] R. A. Myers, "Trends in office automation technology," *IEEE Commun. Mag.*, pp. 10–16, Sept. 1982.
- [3] A. Gupta, "Emerging trends in office technology," in *Office*

- Information Systems*. Amsterdam, The Netherlands: North-Holland, 1982, pp. 599–626.
- [4] K. J. King and F. J. Maryanski, "Information management trends in office automation," *Proc. IEEE*, vol. 71, no. 4, pp. 519–528, Apr. 1983.
- [5] B. R. Gaines, "From word processing to image processing in office systems," in *Proc. Int. Electrical Electronics Conf.* (Toronto, Ont., Canada, Sept. 1983), pp. 622–625.
- [6] N. Naffah, "Editorial," in *Office Information Systems*. Amsterdam, The Netherlands: North-Holland, 1982.
- [7] *Proc. IEEE* (Special Issue on Image Processing), vol. 69, May 1981.
- [8] E. Hall, *Computer Image Processing and Recognition*. New York: Academic Press, 1979.
- [9] *The Wang Professional Image Computer Guide*, Wang Labs., Lowell, MA, Dec. 1982.
- [10] B. E. Bayer, "An optimum method for two-level rendition of continuous tone pictures," in *Proc. IEEE Int. Conf. on Communications*, pp. 11–15, 1973.
- [11] D. Anastassiou, and K. S. Pennington, "Digital halftoning of images," *IBM J. Res. Develop.*, vol. 26, pp. 687–697, Nov. 1982.
- [12] J. F. Jarvis, C. N. Judice, and W. H. Ninke, "A survey of techniques for the display of continuous tone pictures on bilevel displays," *Comp. Graph. Image Process.*, vol. 5, pp. 13–40, 1976.
- [13] A. Moyer, "Adaptive threshold for low cost fax," Internal Rep., Wang Labs., Lowell, MA, Mar. 1983.
- [14] P. Archibald, *Fonts Manual, Version 2*, IBM Thomas Watson Res. Cent., Yorktown Heights, NY, Sept. 1977.
- [15] M. Smutek, "Rotation by 90 degrees in the Wang PIC," Internal Rep., Wang Labs., Lowell, MA, Mar. 1983.
- [16] R. W. Floyd, "Permuting information in idealized two-level storage," in *Proc. Symp. on Complexity of Computer Computations*. New York: Plenum Press, 1972, pp. 105–110.
- [17] I. E. Abdou and K. Y. Wong, "Analysis of linear interpolation schemes for bi level image applications," *IBM J. Res. Develop.*, vol. 26, no. 6, Nov. 1982.
- [18] A. Moyer, "Interpolation algorithm for Fax output and display," Internal Rep., Wang Labs., Lowell, MA, Apr. 1983.
- [19] A. El-Sherbini, "Linear interpolation for the PIC," Internal Rep., Wang Labs., Lowell, MA, May 1983.
- [20] \_\_\_\_\_, "Display of dithered images on the PIC monitor," Internal Rep., Wang Labs., Lowell, MA, Dec. 1983.
- [21] D. Comer, "The ubiquitous B-tree," *ACM Comput. Surv.*, vol. 11, no. 2, June 1979.
- [22] A. Waisman and R. Wenig, "Compressed B-tree access method for 8086," Internal Rep., Wang Labs., Lowell, MA, May 1983.
- [23] A. N. Netravali and J. O. Limb, "Picture coding: A review," *Proc. IEEE*, vol. 68, no. 3, pp. 366–406, Mar. 1980.
- [24] D. Ting and B. Prasada, "Digital processing techniques for encoding of graphics," *Proc. IEEE*, vol. 68, no. 7, July 1980.
- [25] A. N. Netravali, F. W. Mounts, and J. D. Beyer, "Techniques for coding dithered two-level pictures," *Bell. Syst. Tech. J.*, pp. 809–819, May–June 1977.
- [26] A. El-Sherbini, "An efficient coding scheme for dithered images," Internal Rep., Wang Labs., Lowell, MA, Nov. 1983.
- [27] D. A. Huffman, "A method for the construction of minimum redundancy codes," *Proc. IRE*, vol. 40, pp. 1098–1101, Sept. 1972.
- [28] R. Hunter and A. H. Robinson, "International digital facsimile coding standards," *Proc. IEEE*, vol. 68, no. 7, pp. 854–867, July 1980.
- [29] "Proposal for draft recommendation of two-dimensional coding scheme" (a proposal by the Japanese Government), CCITT SGXIV Doc. No. 24, Aug. 1978.
- [30] A. Moyer, "Evaluation of Fax run-length compression techniques," Internal Rep., Wang Labs., Lowell, MA, Feb. 1983.
- [31] H. G. Musmann and D. Preuss, "Comparison of redundancy reducing codes for facsimile transmission of documents," *IEEE Trans. Commun.*, vol. COM-25, no. 11, Nov. 1977.
- [32] The Professional Computer NCC Announcement, *FOCUS*, May 16, 1982.
- [33] *The Wang Professional Computer Database Reference Guide*, Wang Labs., Lowell, MA, Jan. 1984.
- [34] H. Teramura *et al.*, "Experimental facsimile communication system on packet switched data networks," *IEEE Trans. Commun.*, vol. COM-29, no. 12, pp. 1942–1951, Dec. 1981.
- [35] O. Johnsen and A. N. Netravali, "Progressive transmission of two-tone images," *IEEE Trans. Commun.*, vol. COM-29, no. 17, pp. 1934–1941, Dec. 1981.
- [36] W. Horak, "Interchanging mixed text image documents in the office environment," *Comput. Graph.*, vol. 7, no. 1, pp. 13–29, 1983.
- [37] H. Tominaga and R. Itoh, "Mix mode image processing for document transmission," in *Proc. Globecom '83* (San Diego, CA, Nov.–Dec. 1983), pp. 179–183.
- [38] T. Kawasaki *et al.*, "A 4800 bps full-duplex communication system for combined voice and facsimile data," in *Proc. Globecom '83* (San Diego, CA, Nov.–Dec. 1983), pp. 1261–1267.
- [39] A. El-Sherbini and M. Smutek, "The Wang professional image computer: An overview," to be published in *Proc. Micro-Delcon '84* (Delaware, Mar. 1984).



Fig. 1. A PIC photograph.