FORM 1 652549 SPRUSON & FERGUSON

COMMONWEALTH OF AUSTRALIA

PATENTS ACT 1952

APPLICATION FOR A STANDARD PATENT

Canon Kabushiki Kaisha, incorporated in Japan, of 30-2, 3-chome, Shimomaruko, Ohta-ku, Tokyo, JAPAN, hereby apply for the grant of a standard patent for an invention entitled:

Data Processing Apparatus with Display Device

which is described in the accompanying complete specification.

Details of basic application~~(s)~~:-

Basic Applic. No:	Country:	Application Date:
468,605	US	19 January 1990

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DATED this SEVENTEENTH day of JANUARY 1991

Canon Kabushiki Kaisha

By: [signature]

Registered Patent Attorney

TO: THE COMMISSIONER OF PATENTS
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Spruson & Ferguson

COMMONWEALTH OF AUSTRALIA

THE PATENTS ACT 1952

DECLARATION IN SUPPORT OF A CONVENTION APPLICATION FOR A PATENT

AUSTRALIA CONVENTION STANDARD & PETTY PATENT DECLARATION SFP4

In support of the Convention Application made for a patent for an invention entitled:

CFO 6477 AU

Title of Invention

Data Processing Apparatus with Display Device

Full name(s) and address(es) of Declarant(s)

I/~~We~~ Giichi Marushima

care of Canon Kabushiki Kaisha, 30-2, 3-chome, Shimomaruko, Ohta-ku, Tokyo, Japan

do solemnly and sincerely declare as follows:–

Full name(s) of Applicant(s)

1. ~~I am/We are the applicant(s) for the patent~~

(or, in the case of an application by a body corporate)

1. I am/~~We are~~ authorised by Canon Kabushiki Kaisha

the applicant(~~s~~) for the patent to make this declaration on its/~~their~~ behalf.

2. The basic application(~~s~~) as defined by Section 141 of the Act was/~~were~~ made

Basic Country(ies)

in United States of America

Priority Date(s)

on 19 January 1990

Basic Applicant(s)

by Hiroshi Inoue

Full name(s) and address(es) of inventor(s)

3. ~~I am/We are the actual inventor(s) of the invention referred to in the basic application(s)~~

(or where a person other than the inventor is the applicant)

3. Hiroshi Inoue

care of Canon Kabushiki Kaisha, 30-2, 3-chome, Shimomaruko, Ohta-ku, Tokyo, Japan

~~(respectively)~~

is/~~are~~ the actual inventor(~~s~~) of the invention and the facts upon which the applicant(~~s~~) is/~~are~~ entitled to make the application are as follows:

Set out how Applicant(s) derive title from actual inventor(s) e.g. The Applicant(s) is/are the assignee(s) of the invention from the inventor(s)

The said applicant is the assignee of the actual inventor.

4. The basic application(~~s~~) referred to in paragraph 2 of this Declaration was/~~were~~ the first application(~~s~~) made in a Convention country in respect of the invention (~~s~~) the subject of the application.

Declared at Tokyo, Japan this 10th day of January 1991

CANON KABUSHIKI KAISHA

Signature of Declarant(s)

GIICHI MARUSHIMA:Managing Director

SFP4 To: The Commissioner of Patents 11/81

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(56) Prior Art Documents
US 4965551
US 4819189
EP 200172

(57) Claim

1. A data processing apparatus comprising:

a host processor including multitasking means for executing a plurality of processes in a time sharing manner or event drive manner, and scheduling means for scheduling drawing requests from the plurality of processes and forming the drawing requests into a single sequence; and

a graphics device for controlling a display device to draw a picture in accordance with a set of drawing commands transferred from the single sequence in said scheduling means;

wherein said scheduling means monitors an execution status of the set of drawing commands at the graphics device, and reserves the scheduling of the drawing request from each of the processes until the set of drawing command has been substantially executed at the graphic device; and

said drawing requests from the plurality of processes include a drawing request related to a hardware event and said scheduling means schedules the hardware event-related drawing request with priority.

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FORM 10

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COMPLETE SPECIFICATION

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Related Art:

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Complete Specification for the invention entitled:

Data Processing Apparatus with Display Device

The following statement is a full description of this invention, including the best method of performing it known to me/us

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ABSTRACT OF THE DISCLOSURE

On a data processing apparatus comprising a host processor including a multitasking unit in a time sharing manner, and a scheduling unit for scheduling drawing requests to a graphics device from the plurality of user processes and forming a single sequence of commands each associated with each of the drawing requests, a scheduling unit monitors the execution status of drawing commands at the graphics device processor, and reserves the scheduling of the drawing request from the user process until the execution status advances to a predetermined stage.

DATA PROCESSING APPARATUS WITH DISPLAY DEVICE

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a data processing apparatus with a display device, and more particularly to a data processing apparatus for multitasking operation and multi-windows used with a pointing device such as a mouse.

Description of Related Background Art

In a multitask operation system such as UNIX or OS/2 (UNIX is a registered trade mark of AT and T, OS/2 is a registered trade mark of IBM Corp.), tasks are executed by the data processing system concurrently and asynchronously. For example, one or more tasks can be executed by the data processing system at the same time that the system is engaged in controlling its display. Also, in a group of several host computers interconnected by a network, a task may be sent for processing from the system where it originated to any other of the host computers. In a multi-window system, information relating respectively to each task in progress can be displayed simultaneously in a different respective window of a single screen. X-window is one of typical multi-window systems presently available (X-window is a registered trade mark of Massachusetts Institute of Technology).

Heretofore, as a computer terminal display device, a refresh-scan-type CRT (cathode ray tube) has been generally used, and a vector-scan-type CRT having a memory characteristic is sometimes used as a large, high-resolution display for CAD (computer-aided design). On a vector-scan-type CRT, an image, once displayed, is not refreshed because of its memory characteristic until a subsequent screen refresh (that is, a refresh of the entire screen) is performed. However, the operation speed is relatively low so that, it is not well suited as a display for a real-time man-machine interfacial display, such as a moving cursor display, a moving icon display, a pointing device such as a mouse, or an editorial display. On the other hand, a refresh-scan-type CRT requires a refresh cycle with a frame frequency because it is not provided with a memory characteristic. The display is provided with a new picture at the frame frequency. The frame frequency is expressed as the reciprocal of the product of the number of scanning lines per frame and the horizontal scanning time for each line. The frame frequency is desired to be 60 Hz or more for the purpose of preventing the display from flickering. A non-interlaced scanning scheme is adopted for both types of CRT so that a moving display of data on a screen, e.g., a moving display of an icon, is easy for the user to observe and follow.

With both types of CRT, the higher the desired display resolution becomes for the purpose of, for example, clearly displaying multi-windows, the larger the display becomes, resulting in higher power consumption, a larger driver and a higher cost. Such a large, high-power high-resolution CRT results in various inconveniences. For this reason, flat panel type displays have been recently developed.

At present, there are various flat display panels. One employs a highly multiplexed drive system using super twisted nematic liquid (STN) crystals. A second is a modification thereof, used for a white-and-black display. A third is a plasma display system. All of these adopt the image data transfer scheme of the CRT system and a non-interlaced scanning scheme with a frame frequency of 60 Hz or higher for screen refreshing, and therefore require a total number of scanning lines on the order of 400 to 480 lines for one full screen. A large flat display panel having, e.g., 1000 or more scanning lines is not still in practical use. This is because these display panels require a refresh cycle with a frame frequency of 60 Hz or higher to prevent flicker. Also, this requirement in turn leads to a single-line scanning time of 10 to 50 μsec or shorter, which is too short to provide good contrast.

With a CRT, an image formed on a fluorescent screen persists for a certain time due to the fluorescence.

In a TN-type LCD (twisted nematic-type liquid crystal device), an image is formed by utilizing transmittance changes effected by an application of a sufficient driving voltage. In both types of device, it is necessary to use a high frame frequency 30 Hz or higher.

For example, for a CRT display or TN-type LCD comprising 1920 scanning lines and 2560 pixels per line, i.e., 4,915,200 pixels, the horizontal scanning time is about 17.5 μsec and the horizontal dot clock frequency is about 147 MHz. In the case of a CRT, a horizontal dot clock frequency of 147 MHz leads to a very high beam scanning speed which far exceeds the maximum electron beam modulation frequency of the beam guns used in picture tubes available at present, so that accurate image formation cannot be effected. In the case of a TN-type LCD, driving a total of 1920 scanning lines corresponds to a duty factor of 1/1920, which is much lower than the minimum usable duty factor of about 1/400 now possible. On the other hand, if driving at a practical horizontal scanning speed is used, the frame frequency becomes lower than 30 Hz, and flickering impairs the display quality. For these reasons, enlargement and densification of the picture obtainable with CRT's and TN-type LCD's has been limited because the number of scanning lines cannot be sufficiently increased.

In recent years, Clark and Lagerwall (U.S.

Patent No. 4,367,924) have proposed a ferroelectric liquid crystal device (FLCD) having both a high-speed responsive characteristic and a memory characteristic (bistability). The FLCD shows a smectic C phase (SmC*) or H phase (SmH*) in a specific temperature range, and has optical bistability. The FLCD shows quick response to changes in the applied electric field and is therefore expected to be widely used as a high speed memory-type display device.

The FLCD is capable of being used in a large, high-resolution display which surpasses the above-described flat panel display device. In view of its low frame-frequency drive, it is provided with a partial rewriting scanning scheme utilizing a memory characteristic in order to provide a man-machine interfacial display device. In the partial rewriting scanning scheme, only a region on a screen to be overwritten is scanned to make a new picture. Such partial rewriting scanning has been disclosed in U.S. Patent No. 4,655,561. A flat panel display comprising of 1920 scanning lines x 2560 pixels per line has been achieved using the bistability effect of the FLCD.

In a line by line scanning scheme of the FLCD, the frame refresh frequency decreases as the number of scanning line increases. For example, the frame frequency for the FLCD with the speed of 50 μsec/line is;

1920 (lines) x 50 (μsec/line) = 96 (msec) = 10 (Hz).

On the other hand, it is a very important factor for the operability of computers that the speed for the real time response and smoothness for the pointing device movement and for the keyboard input are sufficient. The pointing device symbol (e.g., mouse font) and character are relatively small in terms of their display area but requires the higher response rate for displaying them. For example, a mouse font is written normally at 60 Hz, and a character is written at 30 Hz. Therefore, the frame frequency of 10 Hz is not sufficient for such operation. The use of aforementioned "partial rewriting scanning technique" enables the display to rewrite only the necessary portion of the display with a new information, thereby largely reducing the time required for updating the displayed information. For example, if the mouse font is defined by 32 x 32 bits data, the speed for displaying the data is;

32 (lines) x 50 (μsec/line) = 1.6 (msec) = 525 (Hz).

However, to actually use this "partial rewriting scanning technique", it is necessary to recognize the "partial rewriting requests" and to indicate the display device the number of lines to be rewritten. Moreover, the actual frequency for the partial rewriting is on the order of about 300 Hz because of some other factors. However, in general, the use of the FLCD as a large display device provides a greatly improved real time display of a mouse font or the like.

However, for a display device for displaying in real time a plurality of tasks on multi-windows, there arises another problem. Referring to Fig. 8A, three windows 1, 2, 3 are open in the screen of one display device. In window 1 a first task displays a clock with its hands moving from time to time. In window 2 a second task displays a rotating line rotating in the direction of the arrow. In window 3 a third task like a text editor displays characters. Also, in a base (root) window, a system task displays a mouse font of an arrow moving from one location to another. Fig. 8B illustrates the time sequence of the generation of drawing commands and the time sequence of the execution of those commands.

As illustrated in Fig. 8B, it is assumed that eight commands to draw a line are generated during the period between the generation of a first mouse font display command and a second mouse font display command. Even with a computer which executes multi-tasks, drawing commands from the multi-tasks are not processed concurrently in parallel but processed one command after another as a single sequence. Therefore, the second mouse font display command is executed only after the previously generated eight commands to draw a line are executed. If the execution time of a drawing command, i.e., the actual drawing time by a graphics device (depending mainly upon hardware attributes of the device), takes longer than the speed of the generation of commands, time delay occurs between the generation and execution of a command. As a result, the second mouse font display is delayed correspondingly.

In order to make such time delay small, it is necessary to improve the hardware operation speed of a graphics device and the software operation by adopting such as aforementioned partial rewriting scanning technique. It is a main issue to be considered here that a real time display of a hardware event is considerably imparted by a drawing command generated by another task (or in rare case, generated by its own task). For this reason, there is a possibility of a problem, particularly with a multi-window system, that a mouse font display on the screen becomes unable to follow the actual mouse operation.

In computer operations, inputs from a mouse and keyboard are called hardware (H/W) events. The real time processing of H/W events in a computer system should be ensured as much as possible, because such H/W events are directly associated with the operation by an operator and the real time processing of H/W events essentially means the operability of the system.

SUMMARY OF THE INVENTION

It is an object of the present to provide a data processing apparatus with an improved real time display of a hardware event.

In accordance with one aspect of the present invention there is disclosed a data processing apparatus comprising:

a host processor including multitasking means for executing a plurality of processes in a time sharing manner or event drive manner, and scheduling means for scheduling drawing requests from the plurality of processes and forming the drawing requests into a single sequence; and

a graphics device for controlling a display device to draw a picture in accordance with a set of drawing commands transferred from the single sequence in said scheduling means;

wherein said scheduling means monitors an execution status of the set of drawing commands at the graphics device, and reserves the scheduling of the drawing request from each of the processes until the set of drawing command has been substantially executed at the graphic device; and

said drawing requests from the plurality of processes include a drawing request related to a hardware event and said scheduling means schedules the hardware event-related drawing request with priority.

In accordance with another aspect of the present invention there is disclosed a data processing apparatus comprising graphics device means for drawing a picture on a screen in accordance with a drawing command, and a processor for running a process of generating the drawing command and transferring the generated drawing command to said graphics device means;

wherein said processor monitors a drawing request from the running process, and sequentially registers the drawing command generated in response to the monitored drawing request in a first queue;

wherein said processor monitors the execution status of the drawing command transferred to said graphics device means, and controls, in accordance with the execution status, the registration in said first queue; and

wherein said processor suspends the monitoring of the drawing request until the execution of the drawing command transferred to said graphics device means has been substantially completed; and

said drawing request from the running process includes a drawing request related to a hardware event and said processor schedules the hardware event-related drawing request with priority.

Other aspects of the present invention are also disclosed.

~~predetermined stage.~~

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram showing the hardware arrangement of a computer system embodying the present invention;

Fig. 2 is a block diagram showing the detail of the graphics controller shown in Fig. 1;

Fig. 3 is a block diagram showing the detail of the graphics card shown in Fig. 1;

Fig. 4 shows the arrangement of an X-window system under the environment under which the embodiment of this invention operates;

Fig. 5 shows the module arrangement of the X-window system;

Fig. 6 is a flow chart showing event scheduling;

Fig. 7 shows the structure of layers of the server;

Fig. 8A illustrates how a picture is drawn in X-windows of a multi-window system;

Fig. 8B illustrates a conventional time sequence of drawing commands and their execution in a multi-window system;

Fig. 9A illustrates how a picture is drawn in X-windows of a multi-window system;

Fig. 9B illustrates a time sequence of drawing commands and their execution in a multi-window system according to an embodiment of this invention;

Fig. 10 is a block diagram showing a queue system according to an embodiment of this invention;

Fig. 11 is a flow chart illustrating the QSpace () in the WaitForSomething () routine;

Fig. 12A is a flow chart showing a first example of the WaitForSomething () routine;

Fig. 12B is a flow chart showing a second example of the WaitForSomething () routine;

Fig. 13 shows signal waveforms in the graphics card shown in Fig. 2;

Fig. 14 illustrates the concept of the layer structure of scheduling according to this invention;

Fig. 15A illustrates the Heat, Tail and contiguous free space of the graphics command buffer;

Fig. 15B shows examples of the Head addresses, Tail addresses, and sizes of contiguous free spaces;

Fig. 16A is a flow chart illustrating the command transfer at the host side;

Fig. 16B is a flow chart illustrating the first half of the PutBlock () in the transfer flow shown in Fig. 16A;

Fig. 16C is a flow chart illustrating the second half of the PutBlock () of the transfer flow shown in Fig. 16A;

Fig. 17A is a right half flow chart illustrating the command reception and execution at the remote side;

Fig. 17B is a left half flow chart illustrating the command reception and execution at the remote side;

Fig. 17C is a flow chart illustrating the GetBlock () in the flow shown in Fig. 17A;

Fig. 18 is a flow chart illustrating the ReadREquestsFromClient ();

Fig. 19 shows another structure of the graphics command buffer the present invention is applicable to;

Fig. 20 is a flow chart illustrating the QSpace () using the buffer structure shown in Fig. 19; and

Fig. 21 is a flow chart illustrating the WaitForSomething () using the QSpace () shown in Fig. 20.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

(1) Structure of Hardware

As an embodiment of this invention, there is provided a computer system with a ferroelectric liquid crystal display FLCD. Fig. 1 is an illustration of the outline of the hardware structure of the system. The system is constructed of a section controlled by a host processor and a section controlled by a graphics device processor. The host and graphics device processors operate independently from each other. The term "graphics device" used herein collectively means a device inclusive of a graphics card, a graphics controller and a FLCD panel. The host processor is provided with OS for executing processes in a time sharing manner. A drawing command generated by each process is given via a bus interface to the graphics card of the graphics device. The graphics card has a function to develop the contents of a drawing command into a video VRAM and a function to manage specific partial rewriting of the contents of a drawing command on the FLCD panel. The contents of VRAM are supplied in the form of digital signals to the next stage, i.e., the graphics controller. In accordance with the digital signals representative of the contents of VRAM including partial rewriting information, the graphics controller generates drive signals for displaying graphics images on the FLCD panel at proper addresses and sends them to a driver IC.

A block diagram of the embodiment of the graphics card is given in Fig. 3. The graphics card is constructed of a graphics processor 20 and a memory controller 22 for the control of an interface 28 and a memory 34. The memory 34 is constructed of a RAM 34-1 for storing commands, VRAMs 34-2 and 34-3 for storing video outputs, and a ROM 34-4 for storing initial control commands for the graphics processor 20. A graphics command buffer for the graphics device to be described later is logically realized by RAM 34-1. Some of these memories may be realized on the main memory of the host. Data is transferred between the processor 20 and the memory 34 by means of the memory controller 22. A video timing unit 32 provides a clock 30 to the graphics processor 20 as its timing signal. The outputs of VRAMs 34-1 and 34-2 are inputted to an output interface 50. The data supplied to the output interface 50 passes through a multiplexer 36 and is given a proper gray scale or a color signal level. The output from the multiplexer is supplied to a digital interface 40. The digital interface 40 generates screen address data, image data (signal lines PD0 to PD7), a signal AH/DL for discriminating between address data and image data, and a timing signal CLK, all being supplied to the next stage graphics controller.

The graphics processor 20 may be for example a Texas Instruments GSP34010 processor, which can execute both graphics commands and general-purpose commands, and the interface may be an IBM "AT Bus", both of which are familiar to those skilled in the art. The GSP34010 processor is described in detail in the TMS34010 User's Guide published by Texas Instruments Inc (publication number SPVU007).

Fig. 2 is a block diagram of the graphics controller for receiving drawing data from the graphics card and driving the FLCD panel. The FLCD panel comprises a matrix electrode structure composed of 1920 scan electrodes and 2560 data electrodes, the former being connected to a scan electrode driver 82 and the latter to a data electrode driver 62. The data electrode driver 62 includes a decoder 78, a line address memory 80, and an address detection circuit. The data electrode driver 64 includes a shift register 72, a line memory 74 and a buffer 70.

Scan electrode address data (A0, A1, A2, ..., A15) for addressing the scan electrodes 84 designating the drawing position on the panel screen and image data (D0, D1, D2, ..., D2559) are transferred through the same signal lines PD0 to PD7. Thus, the signal AH/DL is sent to the processor 89 at the same time for identifying if the transferred data is the address data or the image data. The control circuit 68 causes the signal on PD0 to PD7 to be received by the address detection circuit 88, if the AH/DL signal is high level indicating that the signal is the scan electrode address data. If the AH/DL signal is low level indicating that the signal is the image data, the signal is received by the line buffer 70. The AH/DL signal also serves as a transfer start signal for transferring data.

The image data received by the line buffer 70 is temporarily stored therein, and sent via the shift register 72 and line buffer 74 to the data electrode driver 76 during the horizontal scan period. The address data detected by the address detection circuit 88 is decoded into a scan electrode drive signal by the decoder

78, and sent via the line address memory 80 to the scan electrode driver 82.

In this embodiment, driving the display panel 60 is not synchronous with the generation of the scan electrode address data A0 to A15 and image data D0 to D2559 by the processor of the graphics card, so that it is necessary to synchronize the control circuit 68 and the graphics processor when data is transferred. For this purpose, the control circuit generates a synchro signal Hsync for each horizontal scan. This Hsync signal is related in time to the signal AH/DL. The graphics processor 20 monitors the Hsync signal and stands by for data transfer when the Hsync signal changes from high level to low level. Thereafter, the graphics processor 20 changes the AH/DL signal from low level to high level to transfer the scan electrode address data, and again changes the AH/DL signal from high level to low level to transfer the image data. The detailed signal waveforms thereof are shown in Fig. 13.

According to the present invention, real time processing for an H/W event of the graphics device shown in Fig. 1 is improved. The characteristic feature of this invention resides in a logical interface structure between the host and the graphics device.

(2) Structure of Software (Logics)

Summary

In the logical structure of this invention, there is used an X-window graphics user interface (GUI) running on an UNIX operation system (OS) and implemented on the hardware shown in Fig. 1. The essential portion of the UNIX operation system is called a kernel. A user program interacts with the kernel in response to a system call such as open (), read () and the like. UNIX functions such as file systems, multitask mechanism (time sharing), inter-process communication, and the like are supplied from the kernel. OS is a system software constructed of a plurality of modules supplied from a vendor to a user. A device driver, which is one of modules of OS, directly controls an input/output hardware device and provides an interface to the kernel specific to UNIX, independent from a hardware device. This device driver controls the display device, and a user program instructs the device driver to draw a picture on the display device. The device driver is programmed using following I/O system calls while considering the function of the kernel and the hardware attributes of the device.

```
#include <temio.h>
int ioctl (fd, cmd, tbuf) /* terminal device control */
int fd; /* open file descriptor */
int cmd; /* command for designating operation to be
```

executed */ struct termio * tbuf; /* pointer to structure for terminal information */

For example, a command TCGETA is a command to fill a termio structure with terminal information referred by fd. Although the device driver is linked to the kernel to become a new kernel image, it is not inherent to the UNIX kernel.

The X-window is a software system for providing a user with multi-window programming environments as a GUI configured on the UNIX kernel including the graphics device driver function. The outline of the system arrangement of the X-window system is shown in Fig. 4. The x-window system is a GUI for generating multi-windows on a screen, and is expressed by a server/client model. A server program is the essence of the X-window (base window system) and interacts with a work station generally equipped with a screen, a keyboard, and a mouse, to generate and display windows on the screen and form graphics images on the windows, or to detect and process a hardware H/W event from the keyboard or mouse. A client program means a user program, X library, and window manager. Namely, a client or user process can rely graphics processing on the server. In this case, a client can describe a multi-window function without considering the hardware attributes of the graphics device. The hardware attributes are absorbed by the server.

Data transfer between the client and the server relies on an X-protocol. The server executes operations dependent on the vender such as OS and hardware, so that the client can describe programs not considering hardware if a partner system understands the X-protocol. The client at host 1 communicates with the server at host 0 via a network using the X-protocol to control the work station at host 0. In other words, the X-window system is network-transparent. The server process at host 0 (remote) serves as an agent for the client process at host 1 (local). If an object client is at host 0, communication is conducted via its server without using the network. An application does not handle the X-protocol directly, but it calls a library function Xlib which in turn provides the X-protocol. The server at host 0 can provide multitask services to two processes at host 0 and host 1.

Fig. 5 illustrates the modular structure of the X-window system. The following is an example of a user application program using Xlib functions by which a client displays a 500 x 300 window w on the screen.

```
#include <XII/Xlib.h>
#include <XII/Xutil.h>
main ()
{
   Display  *d;
```

```
  Window   w;
  Unsigned long black, white;
  d = XOpenDisplay (NULL)
  w = XCreateSimpleWindow (d, RootWindow (d, 0), 100, 500,
                           300, 2, BlackPixel (d, 0),
                           WhitePixel (d, 0));
  XMapWindow (d, w);
}
```

The XOpenDisplay () is an Xlib function to establish a connection between the user process and the designated server within the network system, the XCreateSimpleWindow () is an Xlib function to generate a 500 x 300 window w on the screen under control of the server, and the XMapWindow () is an Xlib function to generate the X-protocol for displaying the generated window on the screen and supply the X-protocol to the X server.

Structure of Server

The main task of the server is to establish a connection to a client, to process requests from a plurality of clients in a balanced manner, and to distribute an event from hardware such as a display, mouse and keyboard to a plurality of clients. As shown in Fig. 7, the server is constructed of four layers including a DIX (Device Independent X), DDX (Device Dependent X), OS, and Extension function (EXT: Extension). It is important for the description of this invention to understand these layers.

DIX layer: all operations by the server is executed by first calling a function at another layer from DIX. In accordance with the called function, client requests are processed, input events are read, and distributed to clients. DIX is not dependent on the machine, devices and OS, but communicates with a client by the X-protocol. A routine Dispatch () for scheduling event processes belongs to the DIX layer.

DDX layer: this layer includes all functions to directly control input/output devices, and is described considering the devices and OS. This layer consists of an input section and an output section. The input section is used for controlling an input device, such as reading an event from hardware, adjusting the mouse motion sensitivity, generating mapping information of key codes. The output section is used for controlling an output device, such as generating/changing a graphic context (GC). These functions for each device are called from DIX with the data structure being accompanied.

OS layer: this layer performs a read/write function for the client connection, network connection and the communication therebetween and a function for notifying the client of any input event (this function is sometimes performed with DDX). This layer also performs a function for smoothly controlling the time sharing among clients, an interface access function for accessing a font file, and a low level memory management function.

EXT layer: This layer is used for extending the server function and X-protocol. This layer is not required for an ordinary server, and is used for a display device having a particular function.

As described above, the X-window system is an operating system configured on the UNIX kernel for providing a user with a network-transparent multi-window environment. A user can access the multi-window function via the X-protocol as well as the aforementioned functions specific to UNIX. The X-window system is provided in the host computer of the embodiment shown in Fig. 1, and the hardware attributes of the graphics device FLCD are described in DDX and OS layers.

To help understand the system operation, a client user program for a server is illustratively given below for displaying a character X on the screen at a click point of the mouse.

```
#include <XII/Xlib.h>
#include <XII/Xutil.h>
main ()
{
  Display  *d;
  Window   w;
  Font  f;
  GC  gc;
```

```
XEvent   e;
.
.
.
XSelectInput (d, w, ButtonPressMask);
.
.
.
XNext Event (d, $e)
XDrawString (d, w, gc, e.xbutton.x, e.xbutton.y,
            "x",1);
}
```

This program asks the server to inform of a mouse click event by setting XSelectInput (). An XNextEvent () reads an H/W event, and the mouse position coordinate information at the time of the click is described in the x and y members of XButtonEvent structural member e. An XDrawString () instructs the server to draw a character X in the window at the screen position designated by x and y members. The server performs a detection of an H/W event and a notice thereof to the client. The client receives a drawing command generated in response to the H/W event, and controls the graphics device to draw the character. As above, the client user program is described independent from a hardware device, and the server interfaces with the hardware device to provide services to the client.

Scheduling

The server is a single process provided in correspondence with a single work station (terminal: screen, keyboard, mouse) for the control of the work station. The server nevertheless provides services to a plurality of processes, i.e., a plurality of clients. The term "process" herein used means an environment under which a program runs. A process is constructed of three segments including a command segment, a user data segment, and a system data segment. A program is used for initializing a command and user data. A program can be executed by a plurality of processes in parallel with each other with respect to time. A multitasking system executes a plurality of processes in parallel in a time sharing manner. This time sharing of a plurality of processes is executed by the UNIX kernel. The scheduling by the server defines the order of processing a generated drawing request and a service request such as processing an H/W event. A queue system according to an embodiment of this invention is shown in Fig. 10, the queue system making services of a plurality of clients. Drawing commands generated by clients are stored in client queues 101 to 103 provided for each client, in the order of generation.

The stored command is transferred from an entry point 104 to a server queue 105. Specifically, commands from a plurality of clients are formed in a single sequence and inputted to the server queue 105 for sequential processing like a single task. A certain group of commands in the server queue 105 of the host processor is passed to a graphics command buffer 106 of the graphics device processor. After passing the command group to the graphics device processor, the host processor executes another process, while ~~for its own by making~~ the graphics device processor executing ~~execute~~ the passed command group. The command group is developed into commands for the graphics device processor in the graphics command buffer 106 and stored in the area between Tail to Head - 1 as shown in Fig. 10. The graphics device processor sequentially executes the commands starting from Tail to Head. Tail comes near Head as the commands are executed one after another. When it becomes Tail = Head, it means that the passed command group has been executed. Then, the next command group is passed from the server queue 105 ~~106~~ to the graphics command buffer 106. This next command group is stored at the address higher than the former Head. Namely, Tail of the commands developed from the next command group becomes the former Head. The graphics command buffer 106 is shown schematically as a ring shape in Fig. 10. It is to be noted that Head > Tail at (a) in Fig. 10, and Tail > Head at (d) in Fig. 10.

As shown in Figs. 8A and 8B, the reason why a graphics image cannot be formed in real time upon occurrence of an H/W event such as a mouse event, is that the process speed at the graphics device is not so fast as the occurrence of drawing commands so that many commands not-yet-executed remain in the server queue 105 at the time when an event occurs. Although the server system detects an H/W event with priority over other processes and informs the client of the occurrence of the event, the drawing command generated by the client for the H/W event is executed after the commands remaining in the server queue 105 at that time have been executed, because the server queue 105 sequentially executes commands merely in a single task manner.

Events to be serviced by the server are generated asynchronously from a plurality of client processes or hardware devices. The routine Dispatch () in the DIX layer of the server schedules the events and controls the process flow thereof. Specifically, generated events are scheduled by the Dispatch () routine of the DIX layer. The command associated with the event is transferred from the client queue to the server queue in order to execute it at the graphics device under control of the server in accordance with the routine called from the DIX layer. If both a drawing request from the client and an H/W event conflicts each other, the Dispatch () routine selects the H/W event with priority over the drawing request, to thereby realize real time processing.

Fig. 6 is a flow chart illustrating the scheduling by the Dispatch () routine.

Step 1: It is checked if there is an H/W event (operation of keyboard, mouse). Head and tail pointers to the event queue are checked. If two pointers are different, the stored event is read from the event queue.

Step 2: If the H/W event check is YES, there is executed a process of character display or mouse cursor display for that event. Data transfer between the server and the client is performed by the WriteToClient () called from the OS layer. The detected H/W event is informed to the client, and the drawing command generated by the client for that event is stored in the server queue, to thereafter terminate the process and returns to step 1.

Step 3: If the H/W event check is NO, the WaitForSomething () is called from the OS layer. The detail of the WaitForSomething () is illustrated in Fig. 12. This function, as explicitly described, waits for and monitors an event. An event to be waited for includes;

* an event from a hardware, user,

* a request from a client already connected to the server (drawing command), and

* request for connection of an unconnected client to a designated server.

Upon occurrence of such an event, necessary information such as the type of event is set and sent back to the Dispatch () of the DIX layer.

Step 4: If a generated event is a request from a connected client, the ReadRequest-Client () is called from the OS layer to read for example a drawing command in the client queue and store it in the server queue to thereafter return to step 1.

Step 5: If a generated event is a connection request of a client to a server, data for connection establishment is written in the client by the WriteTo-Client () of the OS layer, to thereafter return to step 1.

The Dispatch () of the DIX layer is a function for the scheduling of service requests to the server. With this function, the flow branches to a routine process necessary for the service type to execute a drawing process at the branched routine process. This scheduling takes the H/W event with priority over other processes. Namely, if there is a stored event in the event queue, it is executed with priority to realize real time processing.

As discussed previously, use of only the Dispatch () scheduling for scheduling a stored event in the event queue with priority poses a problem of inability of real time processing of an H/W event, because there may be present between two H/W events of a client a not-executed drawing command of another client which is required to be executed first at the graphics device. Such a case results from the fact that the host server generating a command and the graphics device processing the command operate asynchronously. The above asynchronous operation problem is solved by the present invention in such a manner that the server monitors the process status of the graphics device through the WaitForSomething () to control the event processing scheduling.

WaitForSomething()

Prior to describing the WaitForSomething () routine, the concepts of the Head, Tail and contiguous free space of the graphics command buffer 106 will be described with reference to Figs. 15A and 15B. Figs. 15A and 15B show various structures of command data developed within the graphics command buffer. The data transferred from the server queue 105 is sequentially written into the graphics command buffer starting from the Tail address to the Head address, and is executed by the graphics processor from the Tail address to the Head address. The Head address is updated each time data is written in the graphics command buffer 106, and the Tail address is updated as data is executed by the graphics processor. The structures indicated at (a) and (c) in Fig. 15A are for the case where the Head address is greater than the Tail address. The structures indicated at (b) and (d) in Fig. 15A are for the case where the Head address equals the Tail address. The structure indicated at (e) in Fig. 15A is for the case where the Tail address is greater than the Head address. Fig. 15B illustrates examples of the Head addresses, Tail addresses and sizes of contiguous free spaces using the Qspace () routine of this invention to be described later.

According to this invention, the WaitForSomething () routine of the DIX layer shown in Fig. 12A first calls the XQSpace function () which is obtained by developing the QSpace () function shown in Fig. 11 into the X-window. The QSpace () is used for monitoring the graphics command buffer 106 and receiving the Tail and Head addresses to calculate the contiguous free space. In order to monitor the buffer state of the graphics device, there is opened a channel through which a device access permission is requested to the OS layer. Immediately after monitoring, the channel is closed. The channel open/close before and after calculation ensures the multitasking efficiency. When the device access is permitted, the physical memory space occupied by the device is locked in order for the OS layer not to assign it to another program. This results in the state that a virtual storage system of multitasking is occupied by one process similar to the single task system. Since this "lock" state depends on the result of monitoring the device processing capability, a new request is intercepted to be processed until the lock state is released even if the graphics processor is busy. In this manner, the QSpace () substantially synchronizes the operations of the graphics processor and OS in accordance with the processing capability. Such a lock state is to be avoided as much as possible in the UNIX system, and its multitasking state is to be resumed as soon as possible. In view of this, the QSpace () is called and the channel is opened immediately before calculation, the memory is locked, and after the execution the channel is closed to release the memory.

When a channel is opened by the QSpace (), the Head and Tail addresses of the graphics command buffer are received. If Head > Tail, the contiguous free space is calculated from (CMDBUFSIZE) - Head, whereas if Head < Tail, it is calculated from Tail - Head. The received and calculated data by the QSpace is sent back to the WaitForSomething ().

At step S2 shown in Fig. 12A, it is checked if Head ≠ Tail (i.e., not-executed command is present within the graphics command buffer) and if the contiguous free space is smaller than a predetermined value PART-QUE (i.e., free space within the graphics command buffer for storing the next command group from the server queue is insufficient). If YES, it means that the next command group is not prepared to be received and executed. Thus, at step S3 the QSpace () is again called to access the graphics command queue and receive the Tail and Head addresses. As the command execution processes proceed from the previous QSpace () and there is no command not executed, then the check at step S4 indicates that Head = Tail to thereby advance to step S5. However, if there is a command not executed and the check at step S4 is NO, then the flow loops to return to step S3 until a command not executed becomes not present, i.e., Head = Tail. If the check at step S2 is NO, i.e., if the data obtained by the QSpace at step S1 indicates that Head = Tail or Head $\neq$ Tail, and if there is a sufficient contiguous free space for storing the next command group, then the flow advances to step S5.

At step S5, monitored is an occurrence of a service request event (H/W event, drawing request from a connected client, connection request of an unconnected client to a server) at the H/W event queue and the client queue. If there is an event in the queue, the information including the event type is sent to the Dispatch () of the DIX layer to advance to step S4 in the flow chart shown in Fig. 6.

As described above, with the WaitForSomething () of this invention, monitoring a service request event at step S5 is not allowed to start until the graphics device processor becomes able to execute the next drawing process. Thus, a drawing request from the client is suspended if the operation status of the drawing process by the graphics device is not proper, without immediately and executing the request and storing the drawing command in the server queue. In the H/W event priority scheduling, if an H/W event is stored in the H/W event queue, it is executed with priority over a drawing request from the client. On the other hand, if there is not stored an H/W event in the H/W event queue, the client request is sequentially executed and stored in the server queue irrespective of the operation state of the drawing process by the graphics processor. The characteristic feature of this invention is that without immediately executing a drawing request from the client even if there is no event in the H/W event queue and so there is no need of the priority processing of an H/W event, the operation state of the graphics device processor is monitored, and in accordance with the monitor results a client request is processed. Accordingly, a number of commands will not be stored in the server queue which otherwise delay the real time processing of an H/W event, thereby improving the real time processing of an H/W event.

Fig. 12B shows another embodiment of the WaitForSomething (). At step S1, using the QSpace (), the Head and Tail addresses are received from the graphics command buffer. At step S2, it is checked if Head ≠ Tail. If Head ≠ Tail, the service request is immediately executed at step S5. If Head = Tail, the flow loops until it becomes Head = Tail, and thereafter enters step S5.

Fig. 14 shows the concept of the layer structure of scheduling according to the present invention. The Dispatch is present in the DIX layer which is the outermost shell of the server, and directly communicates with the client and H/W device for the scheduling which is independent from the H/W device and OS. The WaitForSomething () is present in the OS layer and called from the Dispatch () for the processing of a service request dependent on OS. The QSpace () is present in the innermost shell and called from the WaitForSomething (), and directly accesses the graphics device to monitor it.

Command Data Transfer from Server Queue to Graphics Command Queue

The command data in the server queue 105 is developed into a basic graphics function by a Host Dispatcher at the server side (host side), and transferred to the graphics command buffer 106 at the graphics device side (remote side) by a BeginCommand (). The command developed in the graphics command buffer 106 is read by a GetCommand () at the remote side and developed into a graphics processor function corresponding to the Host dispatcher by a Remote Dispatcher to execute a predetermined drawing process for VRAM.

Figs. 16A to 16C give an outline of the Begin-Command () at the host side, and Figs. 17A to 17C give an outline of the GetCommand () at the remote side, with communication and management of the graphics command buffer 106 being mainly illustrated. Variable X and Y shown in Fig. 16 and variables Z and Y shown in Fig. 17 take optional values, and Head and Tail represent the head and tail addresses of a command data storage area of the graphics command buffer 106. The BeginCommand () corresponds to the transfer flow of a graphics command sent from the host side server queue 105, and the GetCommand () corresponds to the command reception and execution flow at the remote side. Both the transmission and reception sides are synchronized at the start and end times of transmission/reception. This synchronization is carried out because the remote side is a single processor and a plurality of independent scans (refresh) cannot be performed at a time for the display device. In accordance with a graphics command to be sent from the host side server queue 105, the Host Dispatcher sends a certain unit of basic graphics function group to a PutWords () function. The detail of a PutBlock () function is given in Figs. 16B and 16C.

The PutBlock () reads the current Head and Tail values of the command buffer 106, stores them in variables X and Y, and calculates the contiguous free space. After the graphics command buffer 106 is subjected to a specific process, the data is transferred thereto. In order to check the transfer end timing, the WaitCommand () function waits for a reception end acknowledgement from the remote side. Thereafter, the new Head position of the graphics command buffer 106 is set to then wait for the next data transfer. After transferring all data, the PutBlock () is terminated, and the PutWords () and BeginCommand () are also terminated.

With the GetCommand () at the remote side, the capture of a data area in the buffer is processed in a different manner as the type of command changes as shown in Fig. 17A (monolithic command (a single and simple command without parameter) or chunked command (command with a plurality of parameters)). In both the cases, the GetBlock () shown in Fig. 17C stores (receives) a command data from the host side in the command buffer 106. Thereafter, as shown in Fig. 17B, using the Head and Tail values of the command queue 105, the command data is read and executed. The internal operation of the GetBlock () is shown in Fig. 17C. It is first checked if the values of Head and Tail are different. If all commands from the remote side have been executed, then Head = Tail. If the host side transfers a new command thereafter, the Head value is updated as shown in Fig. 16C so that it becomes Head = Tail. Checking the Head and Tail values is performed from another reason that the host side and remote side enter an independent and asynchronous operation except during the data communication so that it is necessary to check the state of the host side at the time of data reception.

The data size is calculated basing upon the read Head and Tail values, a wrap process is performed to receive the data from the host side, and the Tail is updated and such effect is informed to the Host side. This information is used for the discrimination of a busy state of the remote side when the host side transfers a command data to the remote side. When a response from the remote side is received, it is discriminated that the remote side is in an idle state and then the transfer starts.

In the above manner, "Head" is updated by the host side BeginCommand, and "Tail" is updated by the remote side GetCommand such that the host and remote sides basically perform asynchronous execution and they are synchronized when data is transferred therebetween.

Figs. 9A and 9B show an example of a display status according to the embodiment of this invention. Fig. 9A shows three windows similar to those shown in Fig. 8A. The left side of Fig. 9B shows a sequence of graphics commands generated at the host side, and the right side shows a sequence of executions of the generated commands. It is to be noted that a command for drawing a mouse cursor font is executed not in the order of command generation. Although the commands with oblique lines are already present in the client queue before the drawing command for the second mouse cursor font, according to this invention they are not sent to the server queue before the occurrence of the second mouse event without executing the scheduling for the commands by the WaitForSomething () routine including the QSpace (). The mouse event as an H/W event is executed and scheduled with priority over other requests stored in the client queue, and the drawing command for the mouse event is sent to the server queue and executed.

Another Embodiment

In the above embodiment, there has been described an example of client scheduling with respect to the server queue while mainly paying attention to the H/W event. It is apparent that the client queue itself may be scheduled in accordance with the QSpace (), i.e., in accordance with the execution status at the graphics side. For example, the flow at step S2 shown in Fig. 6 may be changed by calling the QSpace () before or after the process by the WriteToClient event function to monitor the execution status of the buffer at the remote side. Such a change may be executed at another step in Fig. 6. At what step the QSpace () is called and what process is to be executed, depend on the system concerned.

Furthermore, the present invention is not limited to the structure of the graphics command buffer 106 and the management method thereof at the remote side. But, the invention is applicable to the arrangement only if it can obtain the information by which the execution status of the graphics device side can be monitored. For example, there will be given another method wherein each command is provided with an optional length buffer instead of the fixed size buffer, a number is allocated to each command without managing it by the Head and Tail, and in accordance with this number the execution status is managed. Fig. 18 shows a buffer having four pointers to storage areas of commands. Pointers rooms #1 to #4 store three different commands (opcodes) and data necessary for executing them, the storage area and sizes thereof being stored in rooms #1 to #3. It is assumed that as the execution progresses, the command in room #1 has been executed already and the command in room #2 is now being executed. In this case, the QSpace () monitors the number # and size as illustrated in Fig. 20. The WaitForSomething () function using the QSpace () function (for X-window, XQSpace ()) is illustrated in Fig. 21. The EXIT condition from the loop of the QSpace () function depends on the number # and size instead of the Head and Tail values. The fundamental algorithm and effects are the same as the first-described embodiment.

The claims defining the invention are as follows:

1. A data processing apparatus comprising:

a host processor including multitasking means for executing a plurality of processes in a time sharing manner or event drive manner, and scheduling means for scheduling drawing requests from the plurality of processes and forming the drawing requests into a single sequence; and

a graphics device for controlling a display device to draw a picture in accordance with a set of drawing commands transferred from the single sequence in said scheduling means;

wherein said scheduling means monitors an execution status of the set of drawing commands at the graphics device, and reserves the scheduling of the drawing request from each of the processes until the set of drawing command has been substantially executed at the graphic device; and

said drawing requests from the plurality of processes include a drawing request related to a hardware event and said scheduling means schedules the hardware event-related drawing request with priority.

2. A data processing apparatus according to claim 1, wherein the hardware event is generated in response to an operation of a device selected from the group consisting of a keyboard, a mouse, a light pen, a touch screen and a track ball.

3. A data processing apparatus according to claim 1, wherein said plurality of processes provide multi-windows on a single screen of said graphics device.

4. A data processing apparatus according to claim 1, wherein said display device comprises a ferroelectric liquid crystal display panel.

5. A data processing apparatus comprising graphics device means for drawing a picture on a screen in accordance with a drawing command, and a processor for running a process of generating the drawing command and transferring the generated drawing command to said graphics device means;

wherein said processor monitors a drawing request from the running process, and sequentially registers the drawing command generated in response to the monitored drawing request in a first queue;

wherein said processor monitors the execution status of the drawing command transferred to said graphics device means, and controls, in accordance with the execution status, the registration in said first queue; and

wherein said processor suspends the monitoring of the drawing request until the execution of the drawing command transferred to said graphics device means has been substantially completed; and

said drawing request from the running process includes a drawing request related to a hardware event and said processor schedules the hardware event-related drawing request with priority.

6. A data processing apparatus according to claim 5, wherein said processor provides a plurality of processes run in a time sharing manner, registers the generated drawing command in a second queue provided for each drawing generation process by said processors, controls the registered drawing commands in said second queue as a single sequence, and stores the registered drawing commands in said first0 queue.

7. A data processing apparatus according to claim 5, wherein the hardware event is generated in response to an operation of a device selected from the group consisting of a keyboard, a mouse, a light pen, a touch screen and a track ball.

8. A data processing apparatus according to claim 5, wherein said graphics device means comprises a ferroelectric liquid crystal display panel device.

~~9. A data processing apparatus for processing plural tasks concurrently and~~ asynchronously and for outputting data from each of the plural tasks, said data processing apparatus comprising:

an input means for inputting data;

memory means for storing data output from each of the plural tasks and data input via said input means;

display means, comprising a display memory means for storing data transferred by said memory means;

wherein said display means displays data stored in said display memory means; and

control means for monitoring the data transferred to said display means from said memory means and for controlling, in accordance with the monitoring, transferring of data output by the plural tasks and of data input via said input means to said display memory means;

wherein said control means obtains starting and ending addresses of the data stored in said display memory means;

wherein said control means determines if data has been input via said input means;

wherein, when the starting address is equal to the ending address and said control means determines that data has been input via said input means, the data input via said input means is transferred to said memory means prior to storage in said memory means of any other data processed by the plural tasks but not yet stored in said memory means; and

wherein, when the starting address is not equal to the ending address, and said control means determines data has been input via said input means, (1) said control means monitors the starting address and the ending address until the starting address equals the ending address, (2) and the data input via said input means is stored in said memory means prior to storage in said second memory means of any other data processed ~~by any of the plural tasks but not yet stored in said memory means.~~

~~10. A data processing apparatus for processing plural tasks concurrently and~~ asynchronously and for outputting data from each of the plural tasks, said data processing apparatus comprising:

an input means for inputting data;

memory means, for storing data output from each of the plural tasks and data input via said input means;

display means, comprising a display memory means for storing data transferred by said memory means, wherein said display means displays data stored in said display memory means; and

control means for monitoring the data transferred to said display means from said memory means and for controlling, in accordance with the monitoring, transferring of data output by the plural tasks and data output by said input means to said memory means;

wherein said control means obtains starting and ending addresses of the data stored in said display memory means, said control means determines an amount of data therein; and

said control means determines if the data has been input via said input means;

wherein, when (1) either the starting address is equal to the ending address or the amount of memory having no data stored therein is greater than a predetermined number and (2) said control means determines that data has been input via said input means, the data input via said input means is transferred to said memory means prior to storage in said memory means of any other data processed by the plural tasks but not yet stored into said memory means; and

wherein, when the starting address is not equal to the ending address and the amount of memory having no data stored therein is less than the predetermined number, and said control means determines that data has been input via said input means, (1) said control means monitors the starting address and the ending address until the starting address equals the ending address, and (2) the data input via said input means is stored in said memory means prior to storage in said second memory means of any other data ~~processed by any of the plural tasks but not yet stored in said memory means.~~

9. A data processing apparatus substantially as described herein with reference to Figs. 1 to 7 or Figs. 9A to 21 of the drawings.

Dated this Eleventh Day of April 1994

Canon Kabushiki Kaisha

Patent Attorneys for the Applicant

SPRUSON AND FERGUSON

69466/91

FIG. 1

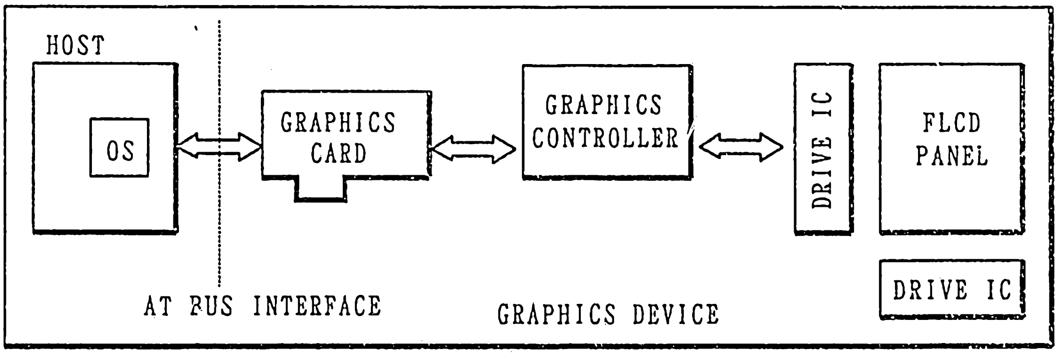
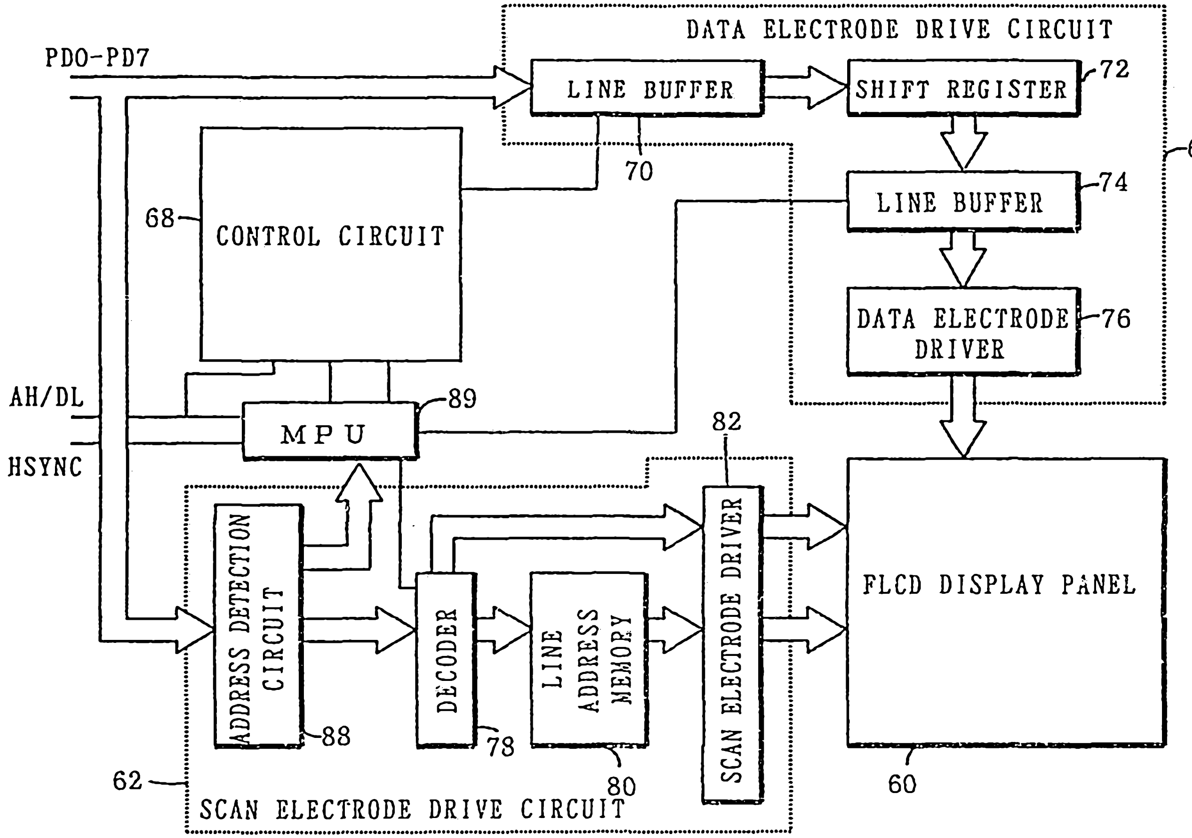


FIG. 2



69466/91

FIG.3

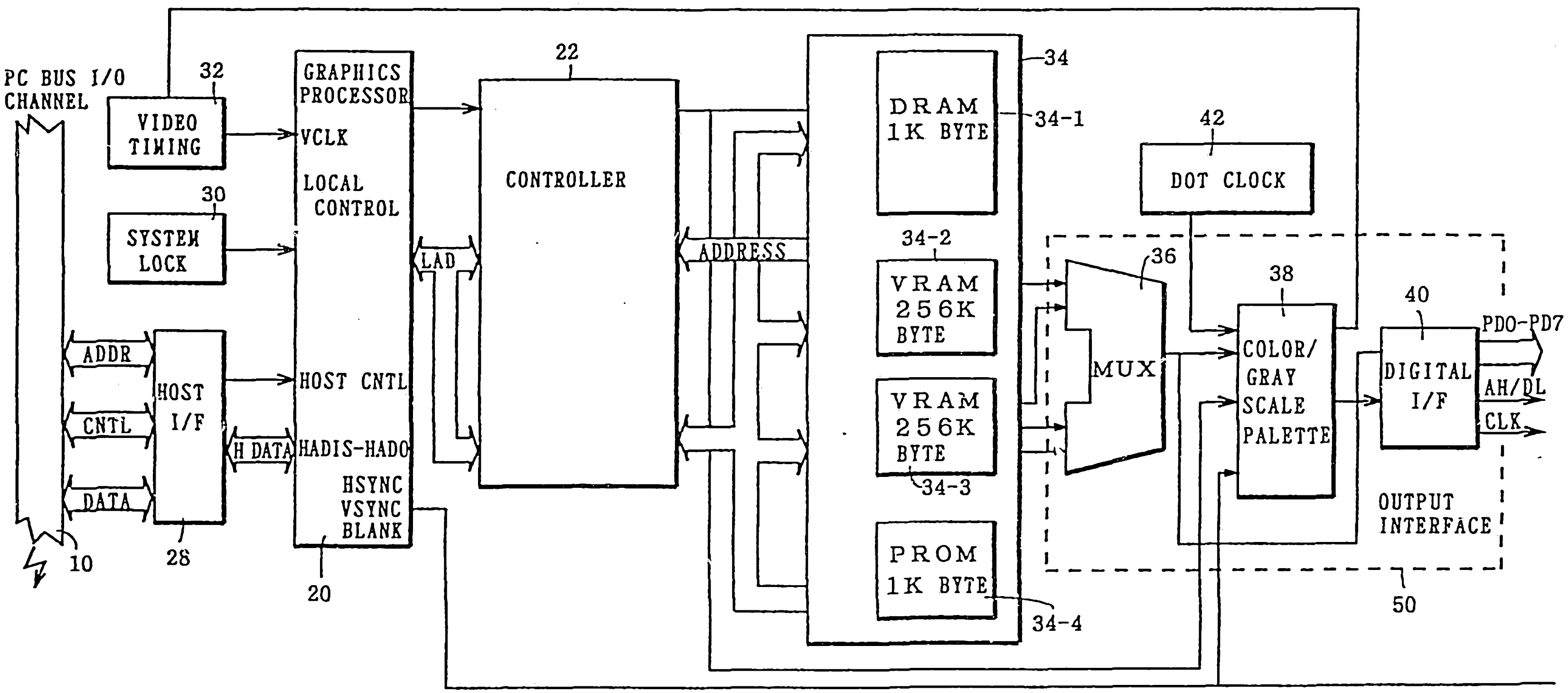

PC BUS I/O CHANNEL
10
VIDEO TIMING
32
SYSTEM LOCK
30
ADDR
CNTL
DATA
HOST I/F
28
H DATA
GRAPHICS PROCESSOR
VCLK
LOCAL CONTROL
HOST CNTL
HADIS-HADO
HSYNC
VSYNC
BLANK
20
LAD
22
CONTROLLER
ADDRESS
34
DRAM 1K BYTE
34-1
34-2
VRAM 256K BYTE
VRAM 256K BYTE
34-3
PROM 1K BYTE
34-4
36
MUX
42
DOT CLOCK
38
COLOR/ GRAY SCALE PALETTE
40
DIGITAL I/F
PDO-PD7
AH/DL
CLK
OUTPUT INTERFACE
50

FIG.4

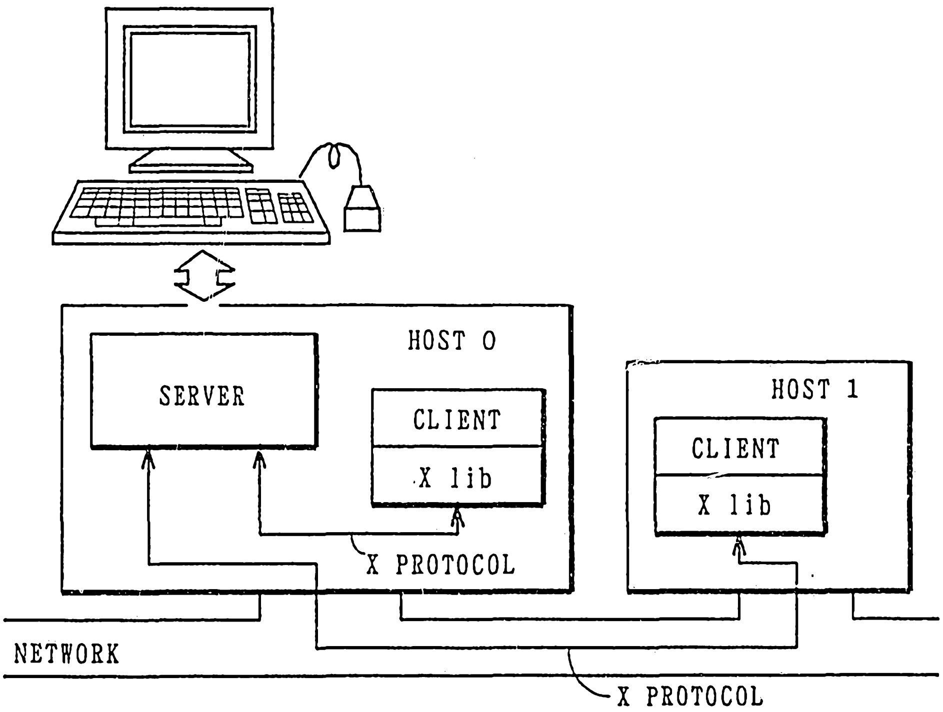

HOST 0
SERVER
CLIENT
X lib
X PROTOCOL
HOST 1
CLIENT
X lib
NETWORK
X PROTOCOL

FIG. 5

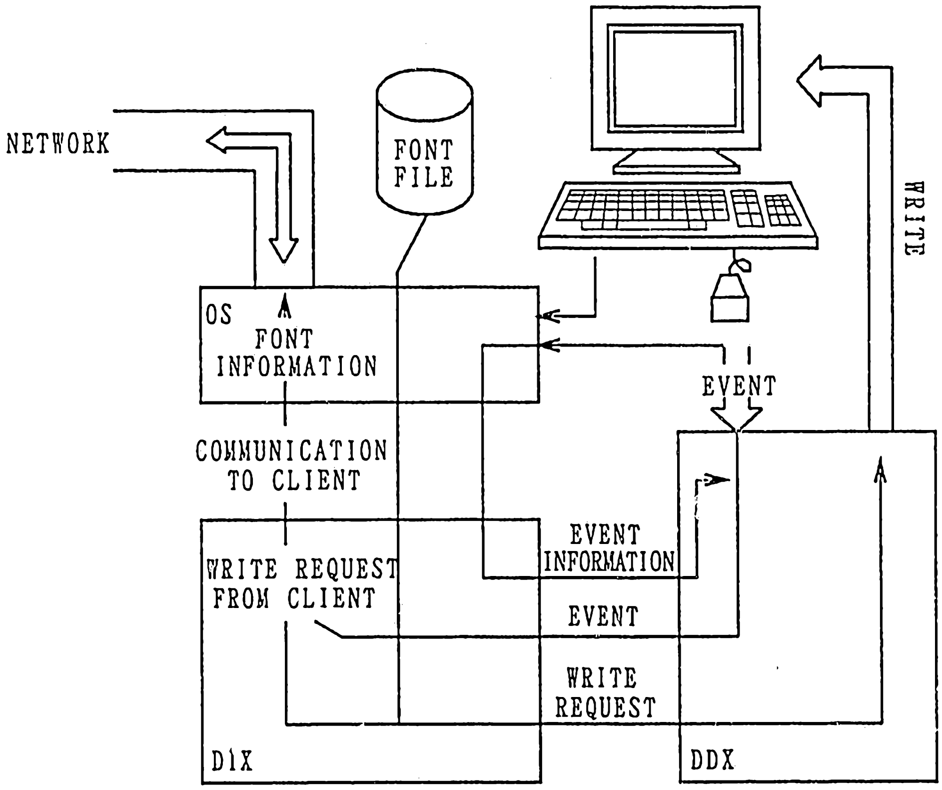
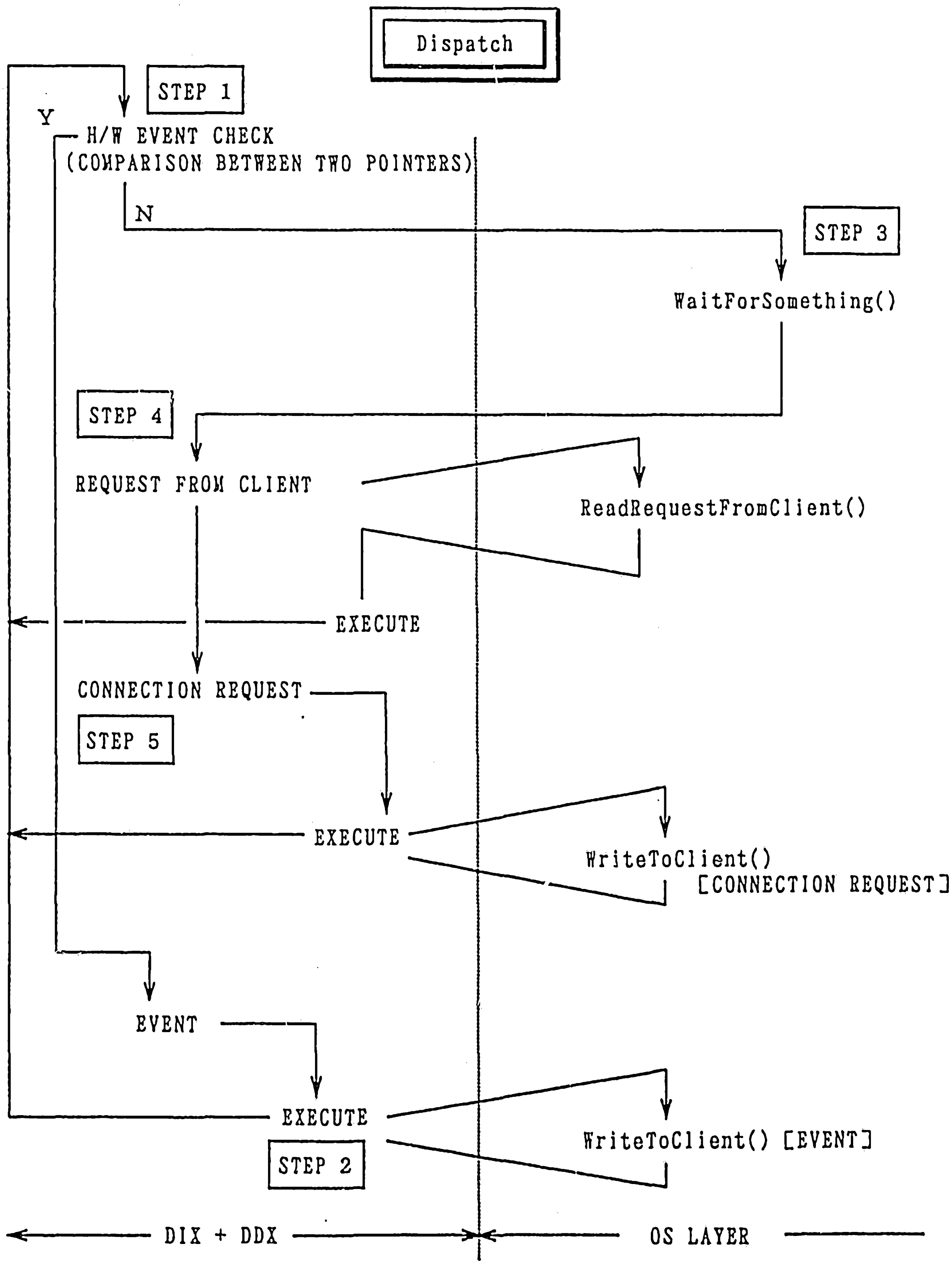
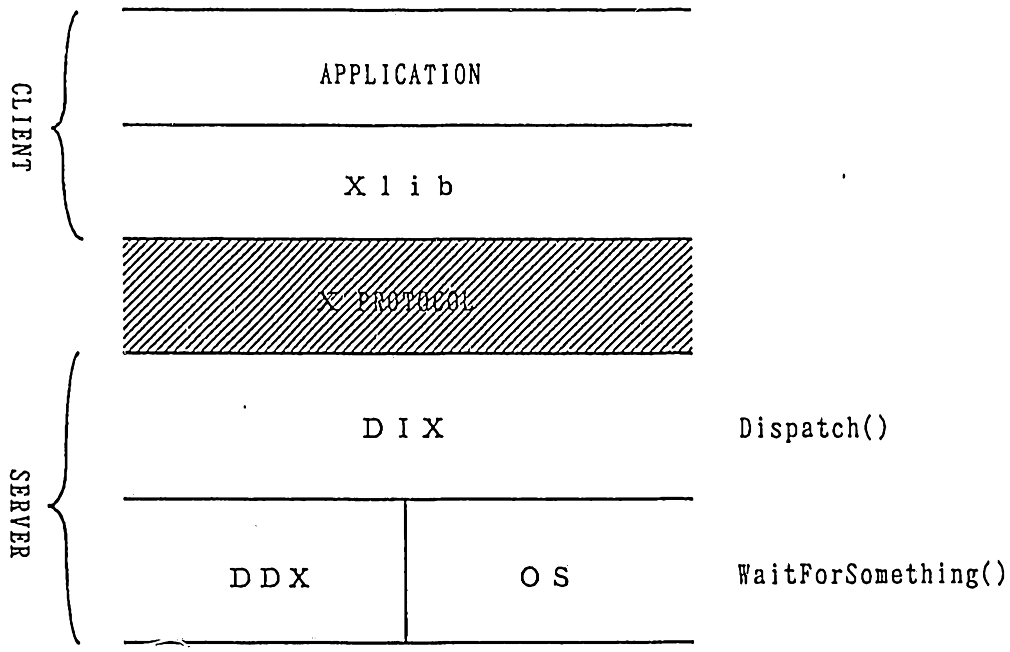

NETWORK
FONT FILE
WRITE
OS
FONT INFORMATION
EVENT
COMMUNICATION TO CLIENT
EVENT INFORMATION
WRITE REQUEST FROM CLIENT
EVENT
WRITE REQUEST
DIX
DDX

FIG.6


Dispatch
STEP 1
Y
H/W EVENT CHECK
(COMPARISON BETWEEN TWO POINTERS)
N
STEP 3
WaitForSomething()
STEP 4
REQUEST FROM CLIENT
ReadRequestFromClient()
EXECUTE
CONNECTION REQUEST
STEP 5
EXECUTE
WriteToClient()
[CONNECTION REQUEST]
EVENT
EXECUTE
STEP 2
WriteToClient() [EVENT]
DIX + DDX
OS LAYER

F I G. 7



CLIENT
APPLICATION
Xlib
X PROTOCOL
SERVER
DIX
Dispatch()
DDX
OS
WaitForSomething()

F I G. 8A

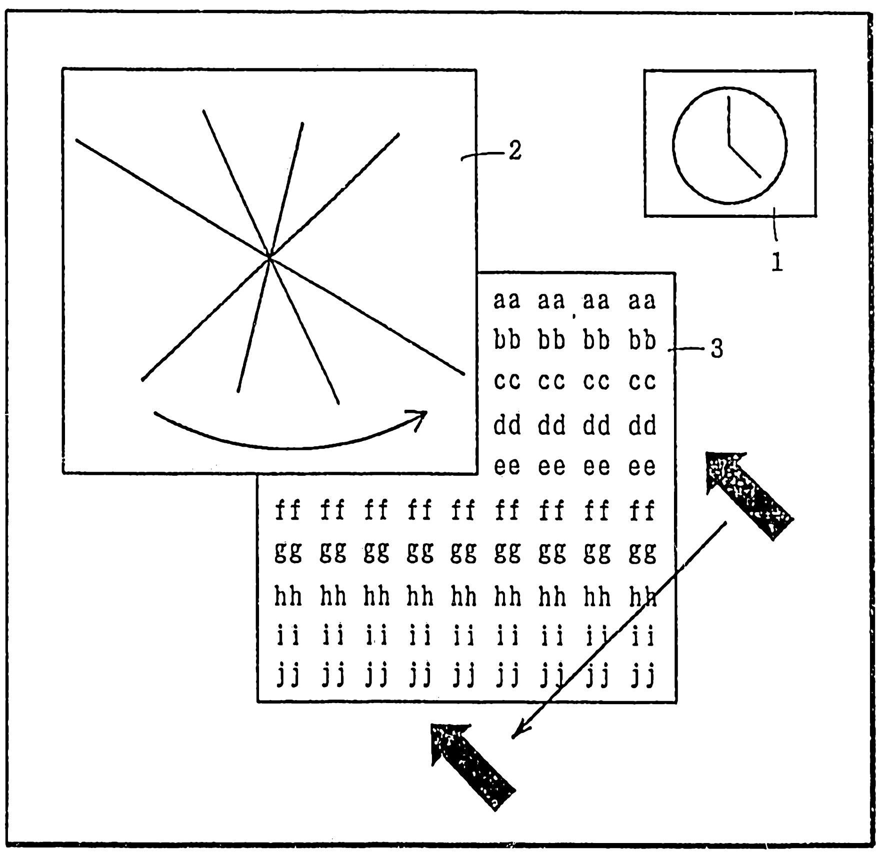

2
1
aa aa aa aa
bb bb bb bb
cc cc cc cc
dd dd dd dd
ee ee ee ee
ff ff ff ff ff ff ff ff ff
gg gg gg gg gg gg gg gg gg
hh hh hh hh hh hh hh hh hh
ii ii ii ii ii ii ii ii ii
jj jj jj jj jj jj jj jj jj
3

FIG. 8B

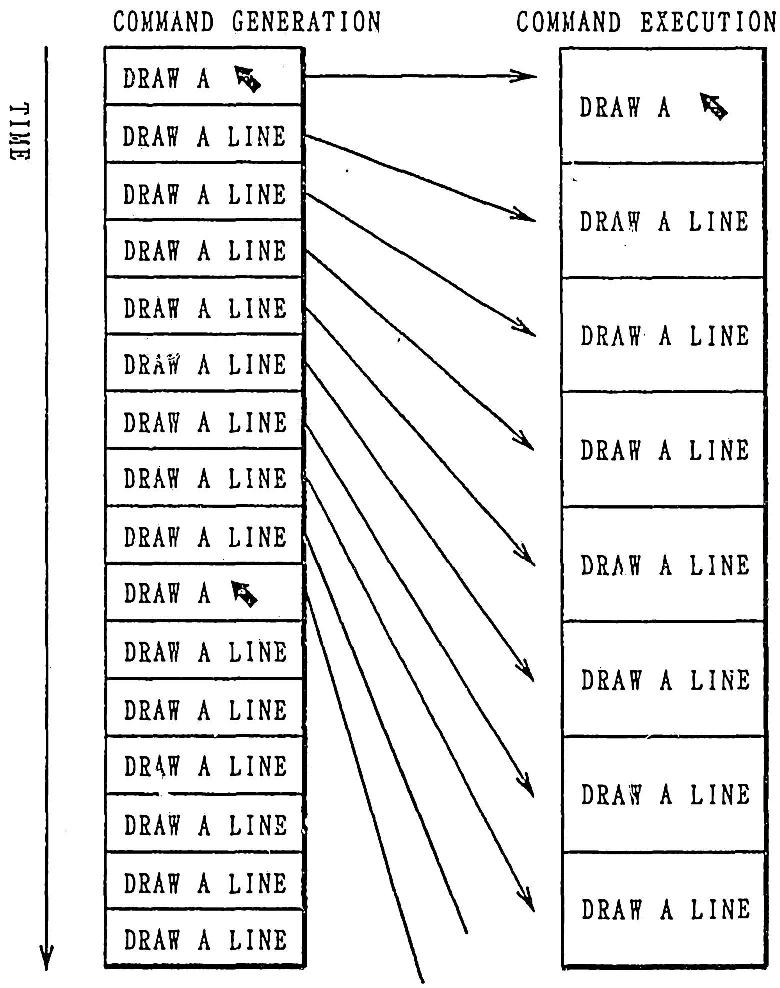
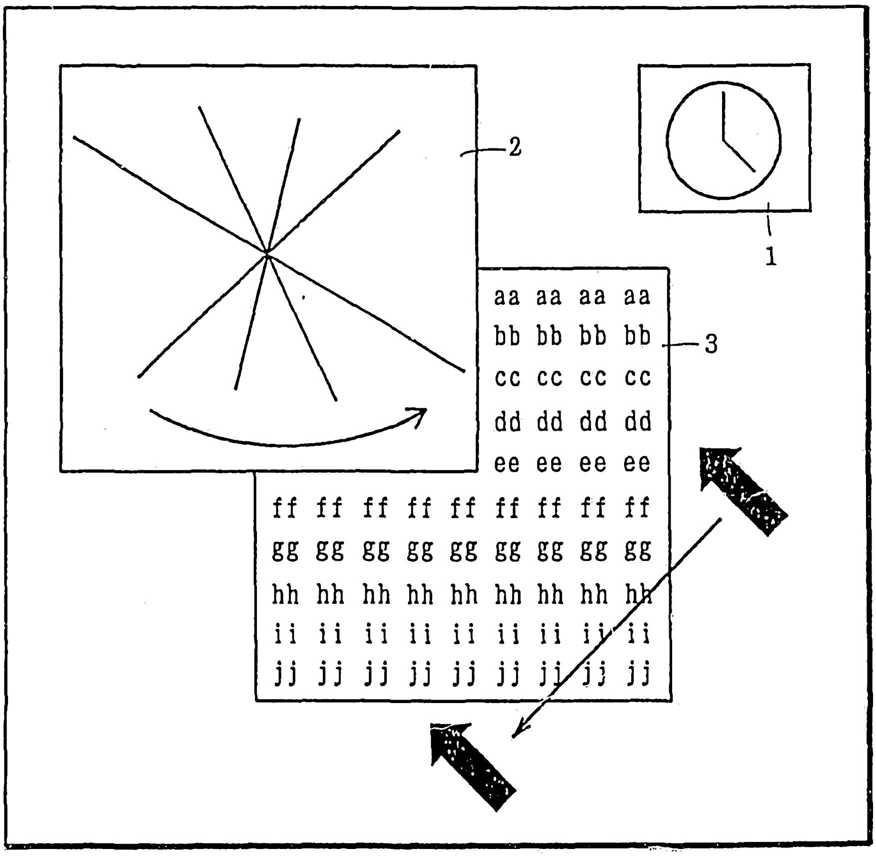

COMMAND GENERATION
COMMAND EXECUTION
TIME
DRAW A
DRAW A LINE
DRAW A LINE
DRAW A LINE
DRAW A LINE
DRAW A LINE
DRAW A LINE
DRAW A LINE
DRAW A LINE
DRAW A
DRAW A LINE
DRAW A LINE
DRAW A LINE
DRAW A LINE
DRAW A LINE
DRAW A LINE
DRAW A
DRAW A LINE
DRAW A LINE
DRAW A LINE
DRAW A LINE
DRAW A LINE
DRAW A LINE
DRAW A LINE

FIG. 9A



2
1
3
aa aa aa aa
bb bb bb bb
cc cc cc cc
dd dd dd dd
ee ee ee ee
ff ff ff ff ff ff ff ff ff
gg gg gg gg gg gg gg gg gg
hh hh hh hh hh hh hh hh hh
ii ii ii ii ii ii ii ii ii
jj jj jj jj jj jj jj jj jj

FIG. 9B

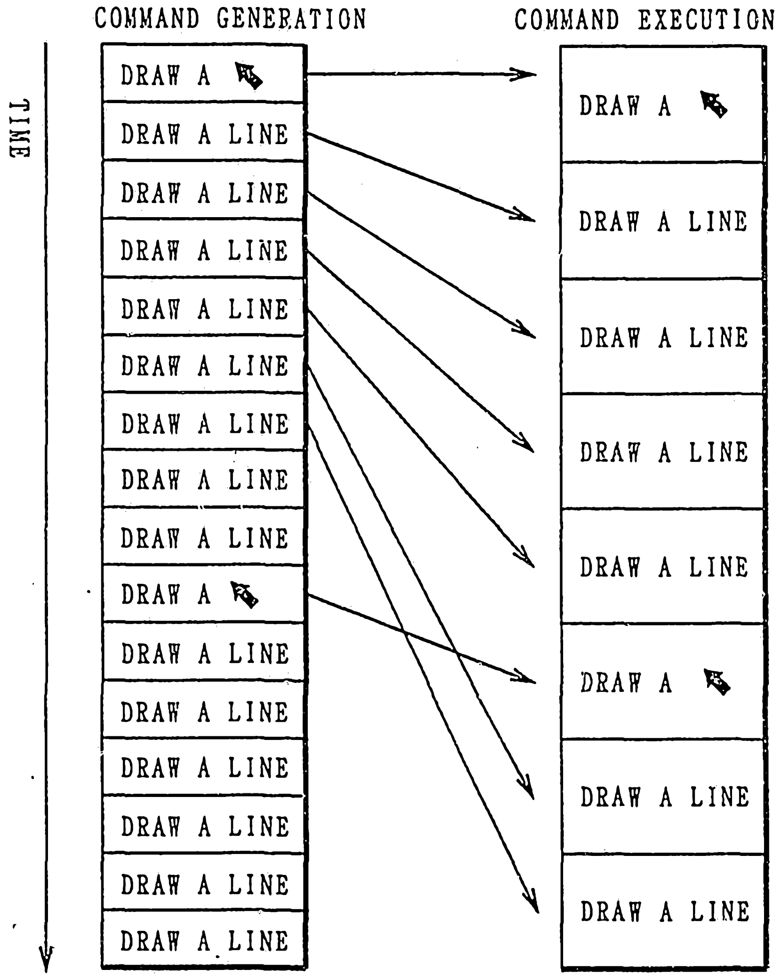

COMMAND GENERATION
COMMAND EXECUTION
TIME
DRAW A
DRAW A LINE
DRAW A LINE
DRAW A LINE
DRAW A LINE
DRAW A LINE
DRAW A LINE
DRAW A LINE
DRAW A LINE
DRAW A
DRAW A LINE
DRAW A LINE
DRAW A LINE
DRAW A LINE
DRAW A LINE
DRAW A LINE
DRAW A
DRAW A LINE
DRAW A LINE
DRAW A LINE
DRAW A LINE
DRAW A
DRAW A LINE
DRAW A LINE

FIG. 10

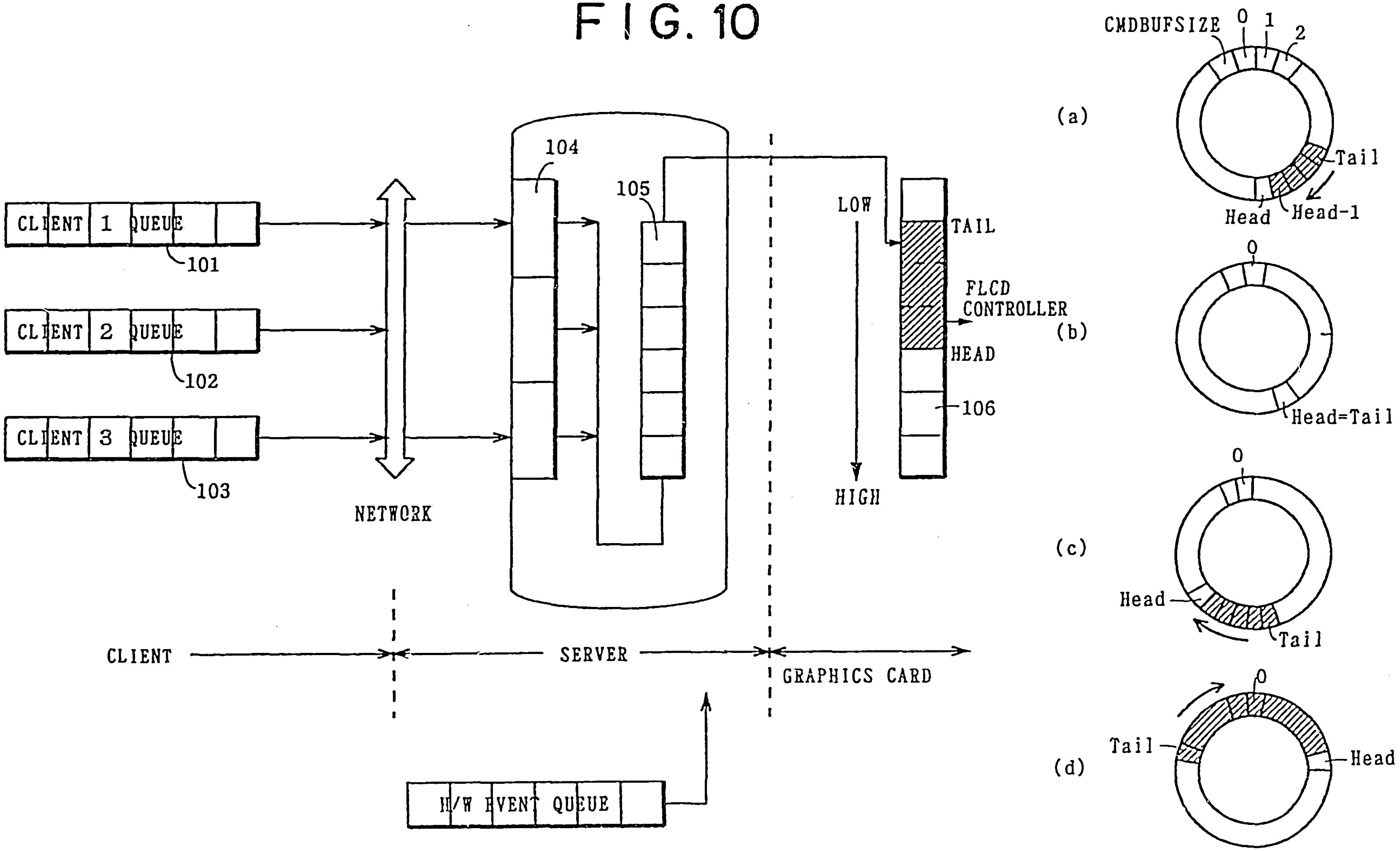

CLIENT 1 QUEUE
101
CLIENT 2 QUEUE
102
CLIENT 3 QUEUE
103
NETWORK
104
105
LOW
HIGH
TAIL
FLCD
CONTROLLER
HEAD
106
CLIENT
SERVER
GRAPHICS CARD
H/W EVENT QUEUE
(a)
CMDBUFSIZE
0
1
2
Tail
Head
Head-1
(b)
0
Head=Tail
(c)
0
Head
Tail
(d)
0
Tail
Head

FIG.11

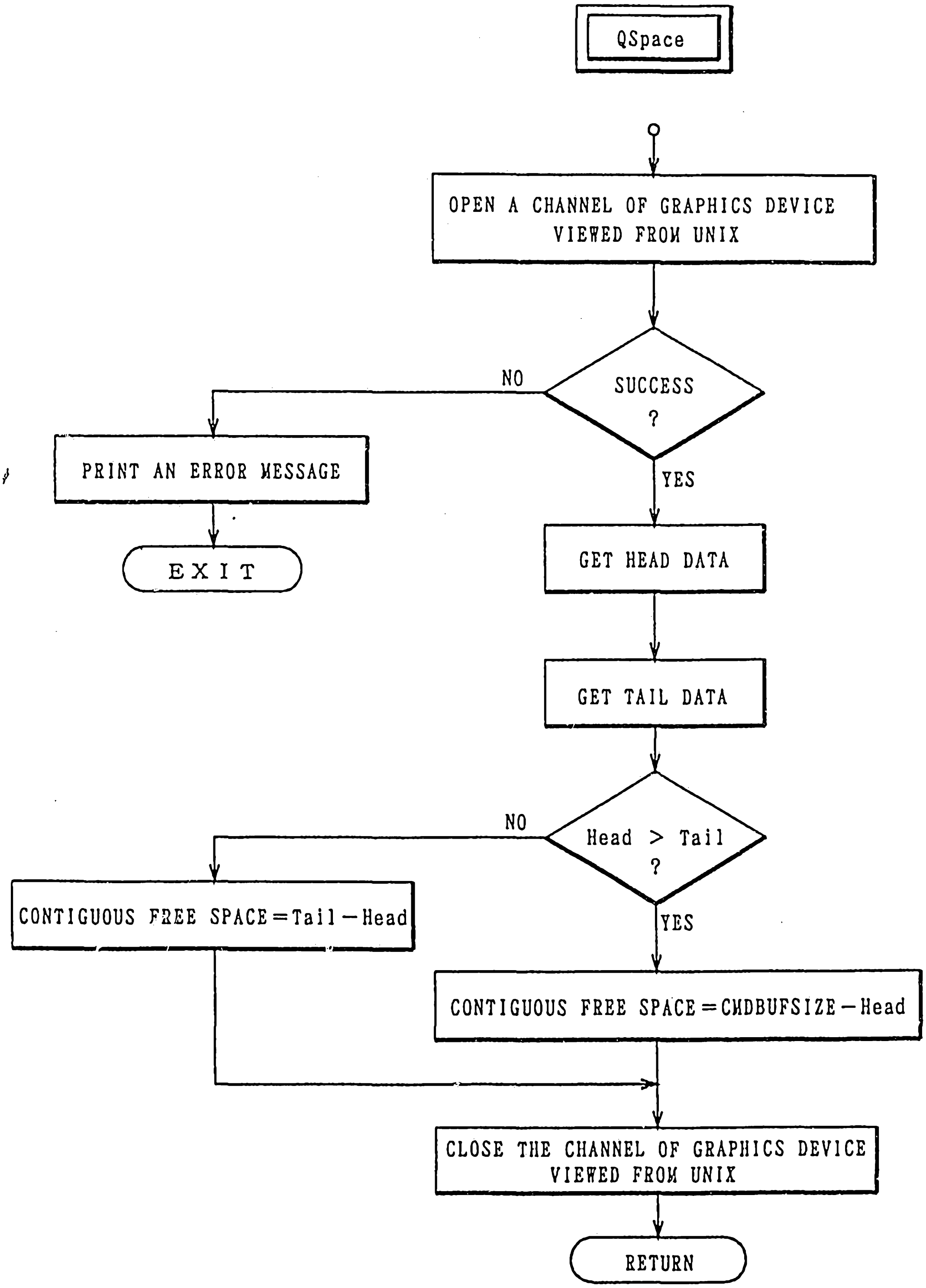

QSpace
OPEN A CHANNEL OF GRAPHICS DEVICE VIEWED FROM UNIX
SUCCESS ?
NO
YES
PRINT AN ERROR MESSAGE
EXIT
GET HEAD DATA
GET TAIL DATA
Head > Tail ?
NO
YES
CONTIGUOUS FREE SPACE = Tail − Head
CONTIGUOUS FREE SPACE = CMDBUFSIZE − Head
CLOSE THE CHANNEL OF GRAPHICS DEVICE VIEWED FROM UNIX
RETURN

FIG. 12A

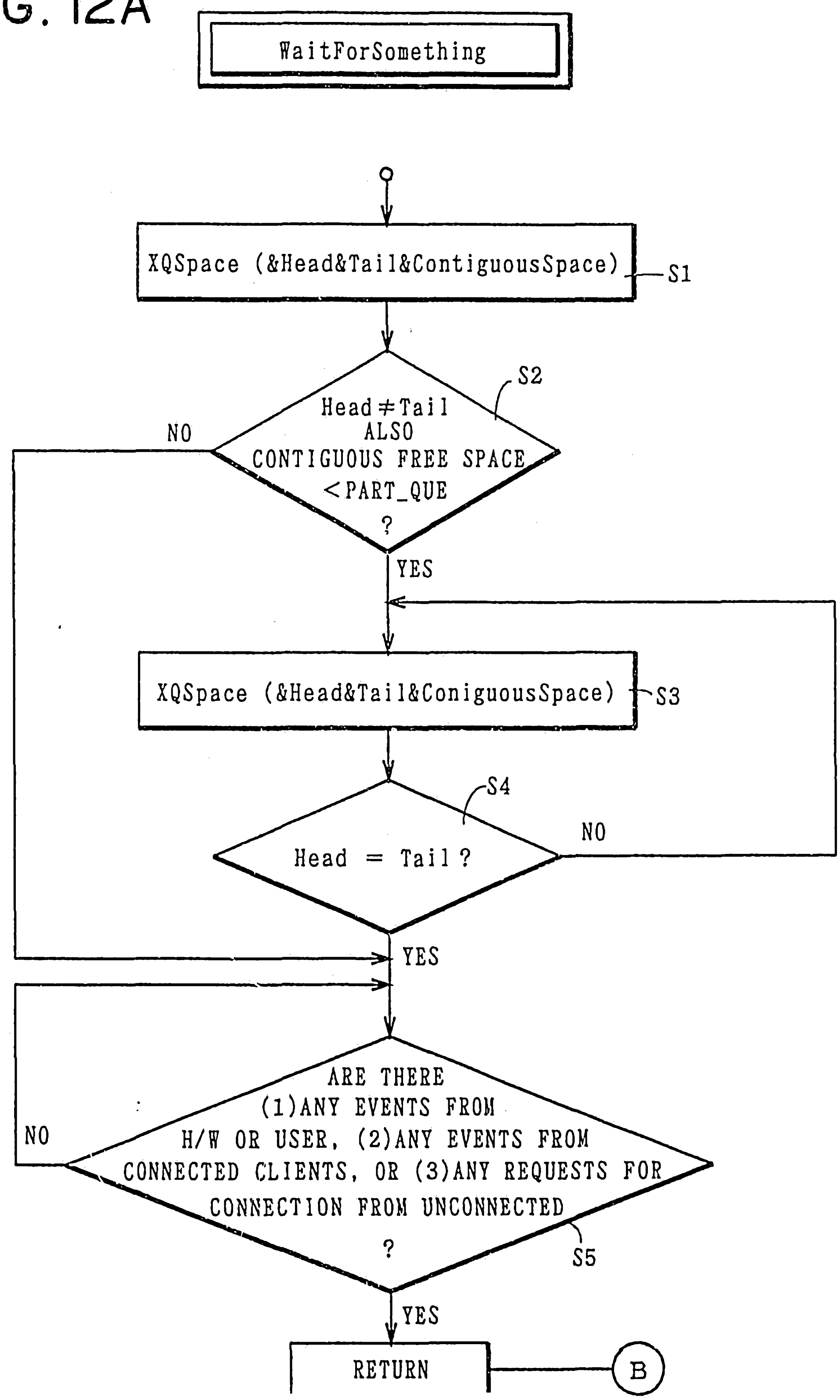
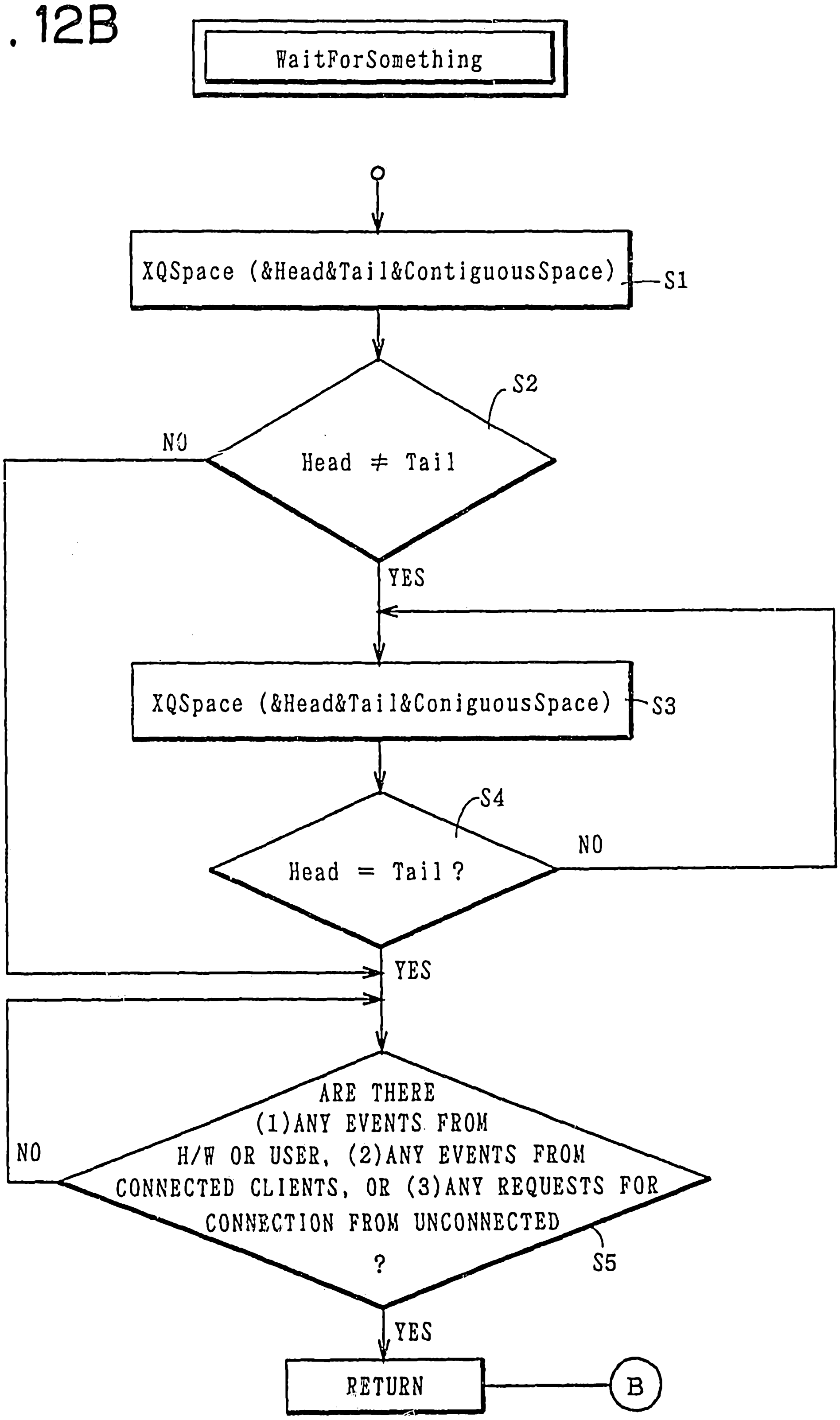
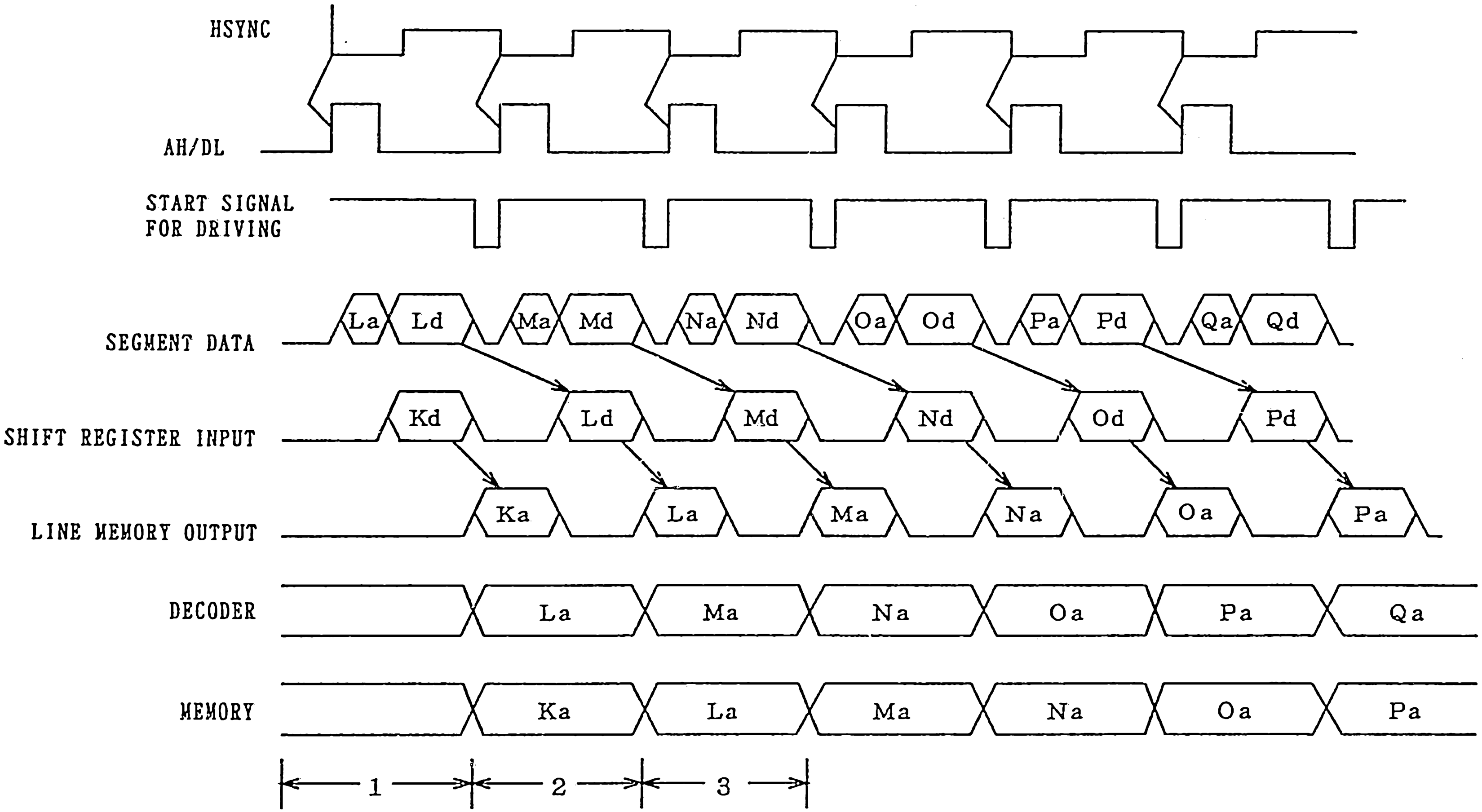

WaitForSomething
XQSpace (&Head&Tail&ContiguousSpace)
S1
S2
Head≠Tail
ALSO
CONTIGUOUS FREE SPACE
<PART_QUE
?
NO
YES
XQSpace (&Head&Tail&ConiguousSpace)
S3
S4
Head = Tail ?
NO
YES
ARE THERE
(1)ANY EVENTS FROM
H/W OR USER, (2)ANY EVENTS FROM
CONNECTED CLIENTS, OR (3)ANY REQUESTS FOR
CONNECTION FROM UNCONNECTED
?
NO
S5
YES
RETURN
B

FIG. 12B

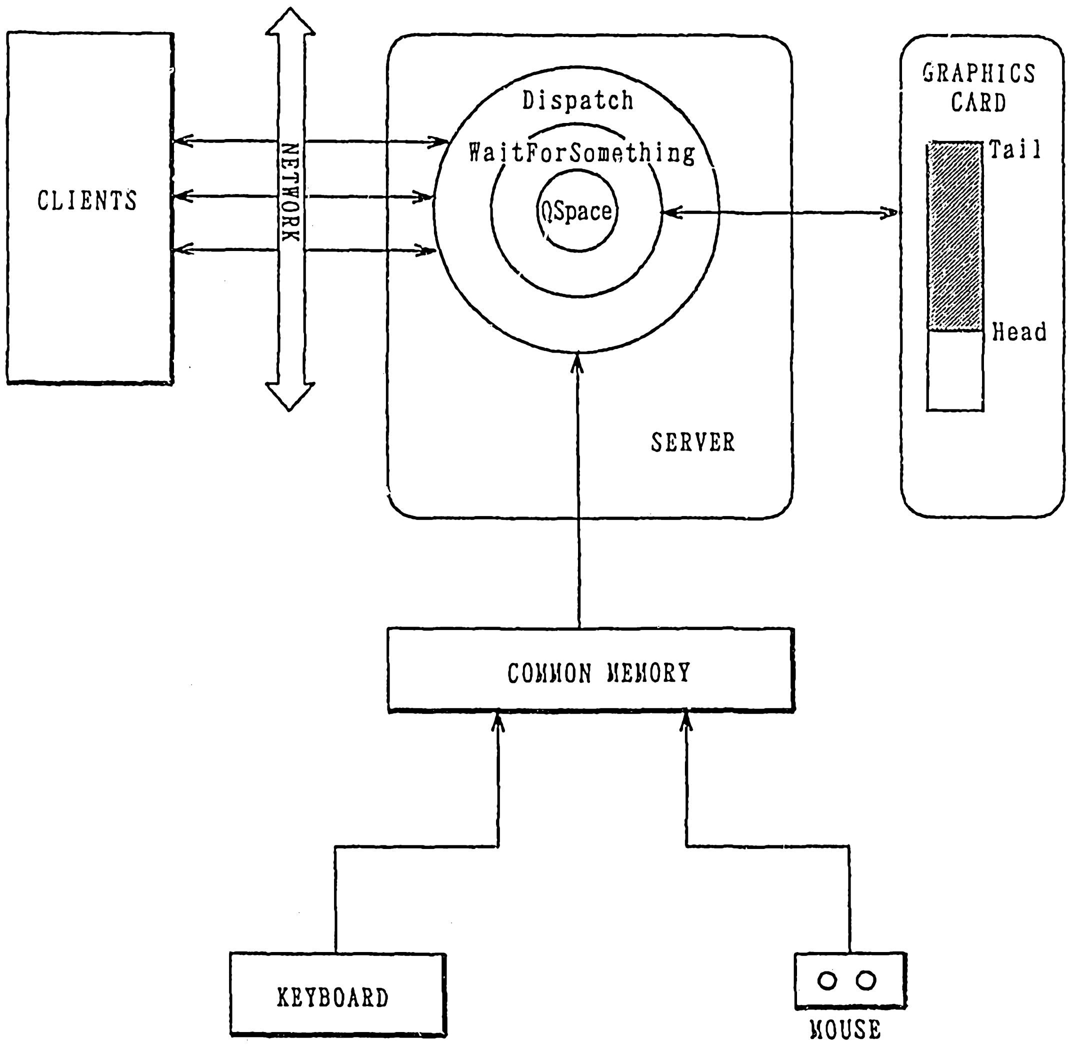


WaitForSomething
XQSpace (&Head&Tail&ContiguousSpace)
S1
S2
NO
Head ≠ Tail
YES
XQSpace (&Head&Tail&ConiguousSpace)
S3
S4
NO
Head = Tail ?
YES
NO
ARE THERE (1)ANY EVENTS FROM H/W OR USER, (2)ANY EVENTS FROM CONNECTED CLIENTS, OR (3)ANY REQUESTS FOR CONNECTION FROM UNCONNECTED ?
S5
YES
RETURN
B

FIG. 13

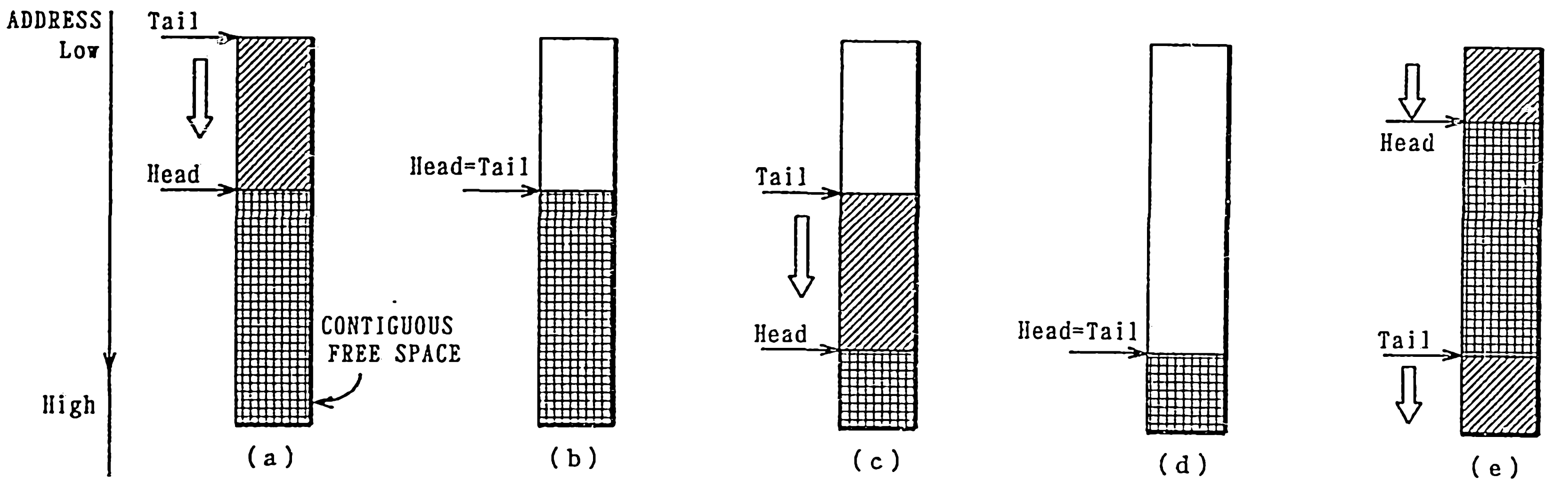

HSYNC
AH/DL
START SIGNAL
FOR DRIVING
SEGMENT DATA
La
Ld
Ma
Md
Na
Nd
Oa
Od
Pa
Pd
Qa
Qd
SHIFT REGISTER INPUT
Kd
Ld
Md
Nd
Od
Pd
LINE MEMORY OUTPUT
Ka
La
Ma
Na
Oa
Pa
DECODER
La
Ma
Na
Oa
Pa
Qa
MEMORY
Ka
La
Ma
Na
Oa
Pa
1
2
3

F I G. 14



CLIENTS
NETWORK
Dispatch
WaitForSomething
QSpace
SERVER
GRAPHICS CARD
Tail
Head
COMMON MEMORY
KEYBOARD
MOUSE

F I G. 15A

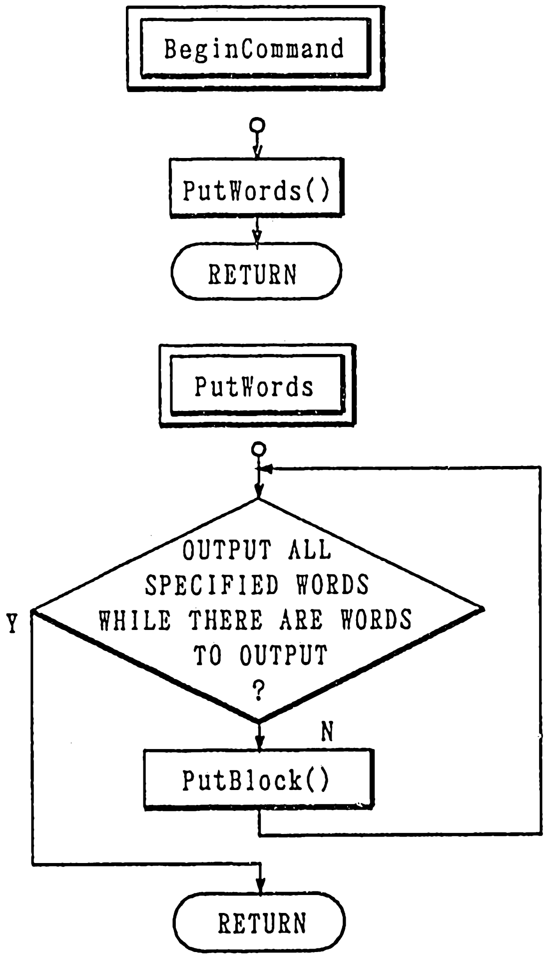

ADDRESS
Low
High
Tail
Head
CONTIGUOUS
FREE SPACE
(a)
Head=Tail
(b)
Tail
Head
(c)
Head=Tail
(d)
Head
Tail
(e)

F I G. 15B

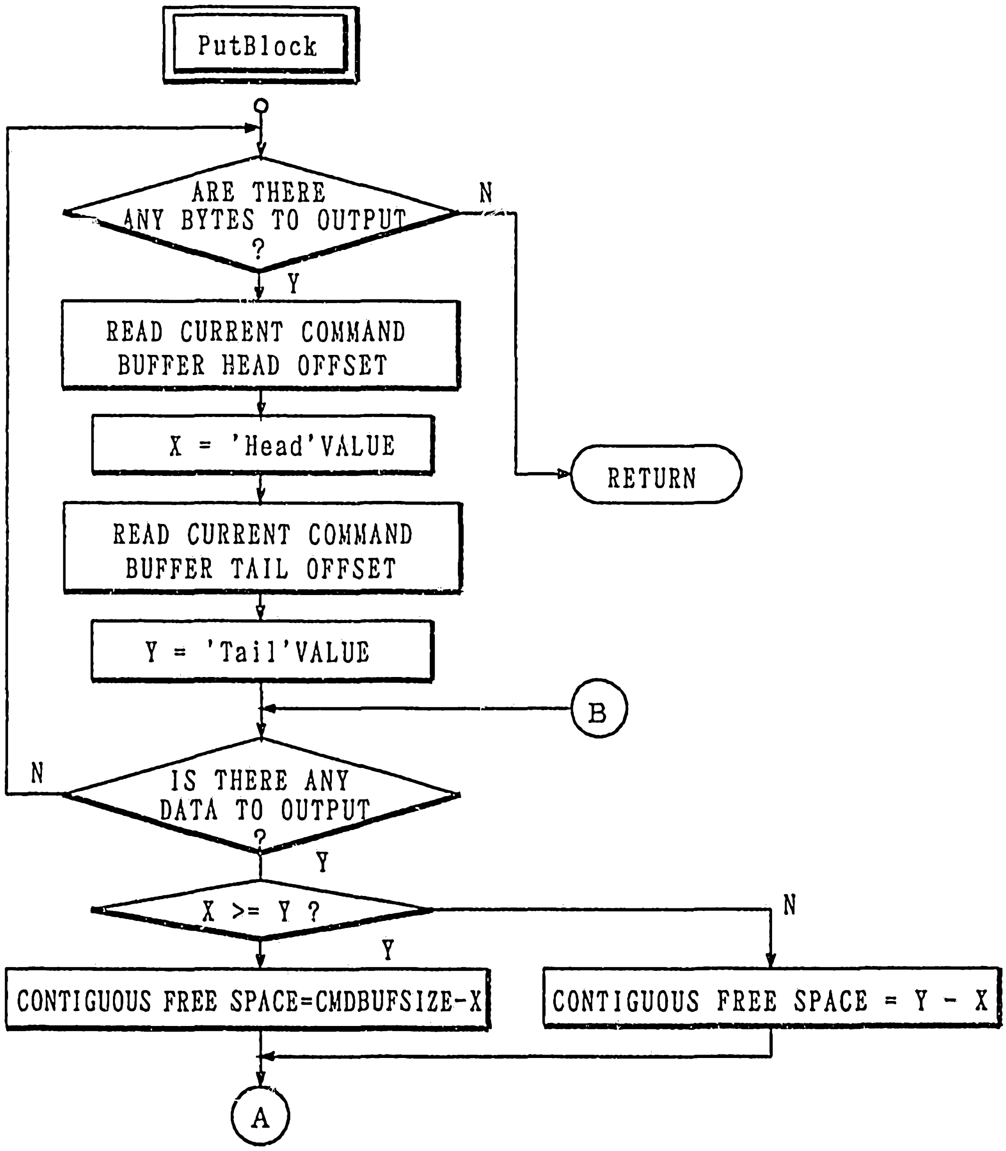
CMDBUFSIZE = 6144
Part - Que = 4096

Head	vs	Tail	UPPER CONTIGUOUS FREE SPACE
586	=	586	5558 (CMDBUFSIZE - Head)
5124	>	4515	1020 (CMDBUFSIZE - Head)
5758	>	5149	386 (CMDBUFSIZE - Head)
198	<	5783	5585 (Tail - Head)
1024	>	407	5120 (CMDBUFSIZE - Head)
2992	>	2421	3152 (CMDBUFSIZE - Head)
202	<	5737	5535 (Tail - Head)

FIG.16A


BeginCommand
PutWords()
RETURN
PutWords
OUTPUT ALL SPECIFIED WORDS WHILE THERE ARE WORDS TO OUTPUT ?
Y
N
PutBlock()
RETURN

F I G. 16B



PutBlock
ARE THERE ANY BYTES TO OUTPUT ?
N
Y
READ CURRENT COMMAND BUFFER HEAD OFFSET
X = 'Head'VALUE
RETURN
READ CURRENT COMMAND BUFFER TAIL OFFSET
Y = 'Tail'VALUE
B
N
IS THERE ANY DATA TO OUTPUT ?
Y
X >= Y ?
N
Y
CONTIGUOUS FREE SPACE=CMDBUFSIZE-X
CONTIGUOUS FREE SPACE = Y - X
A

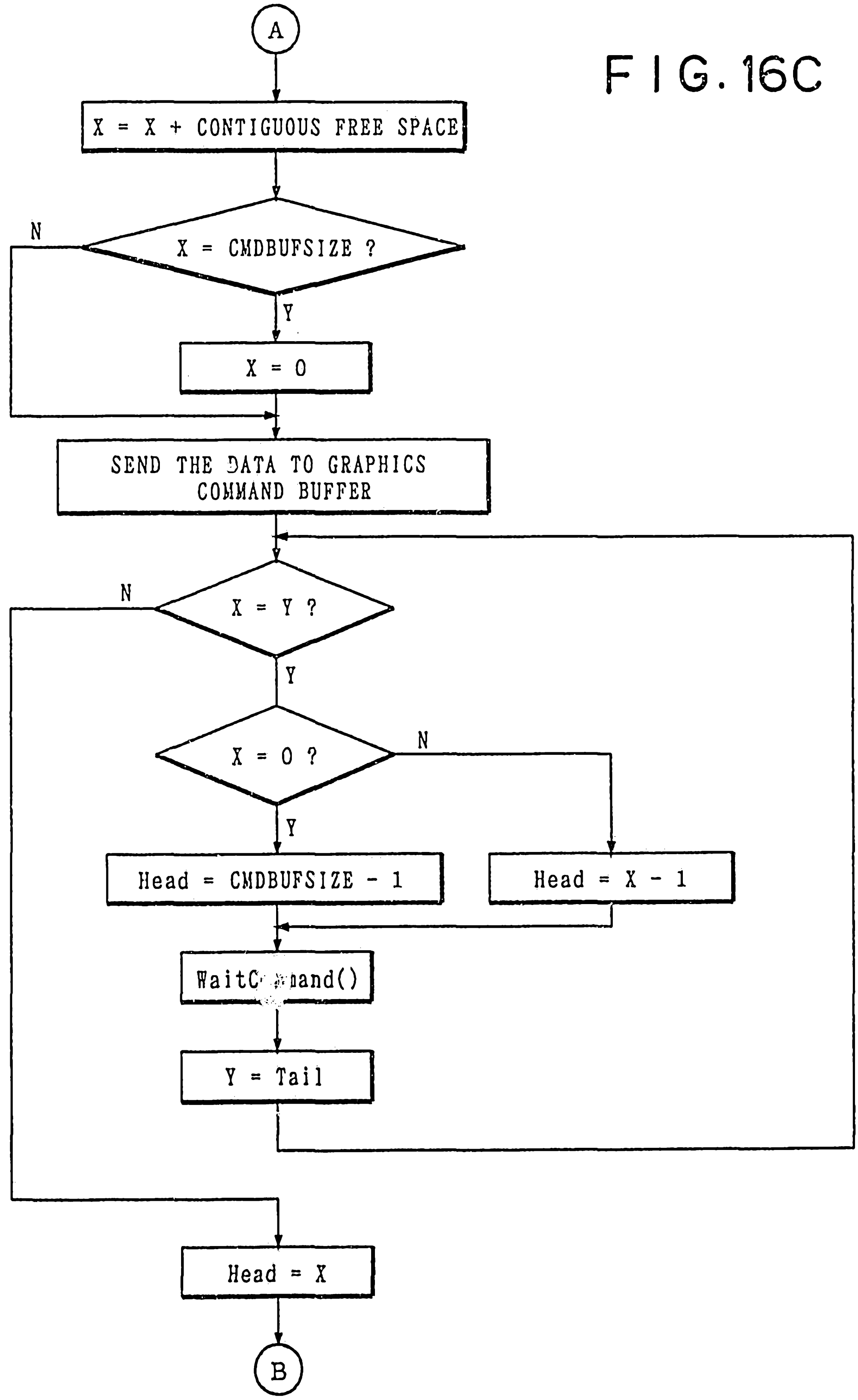
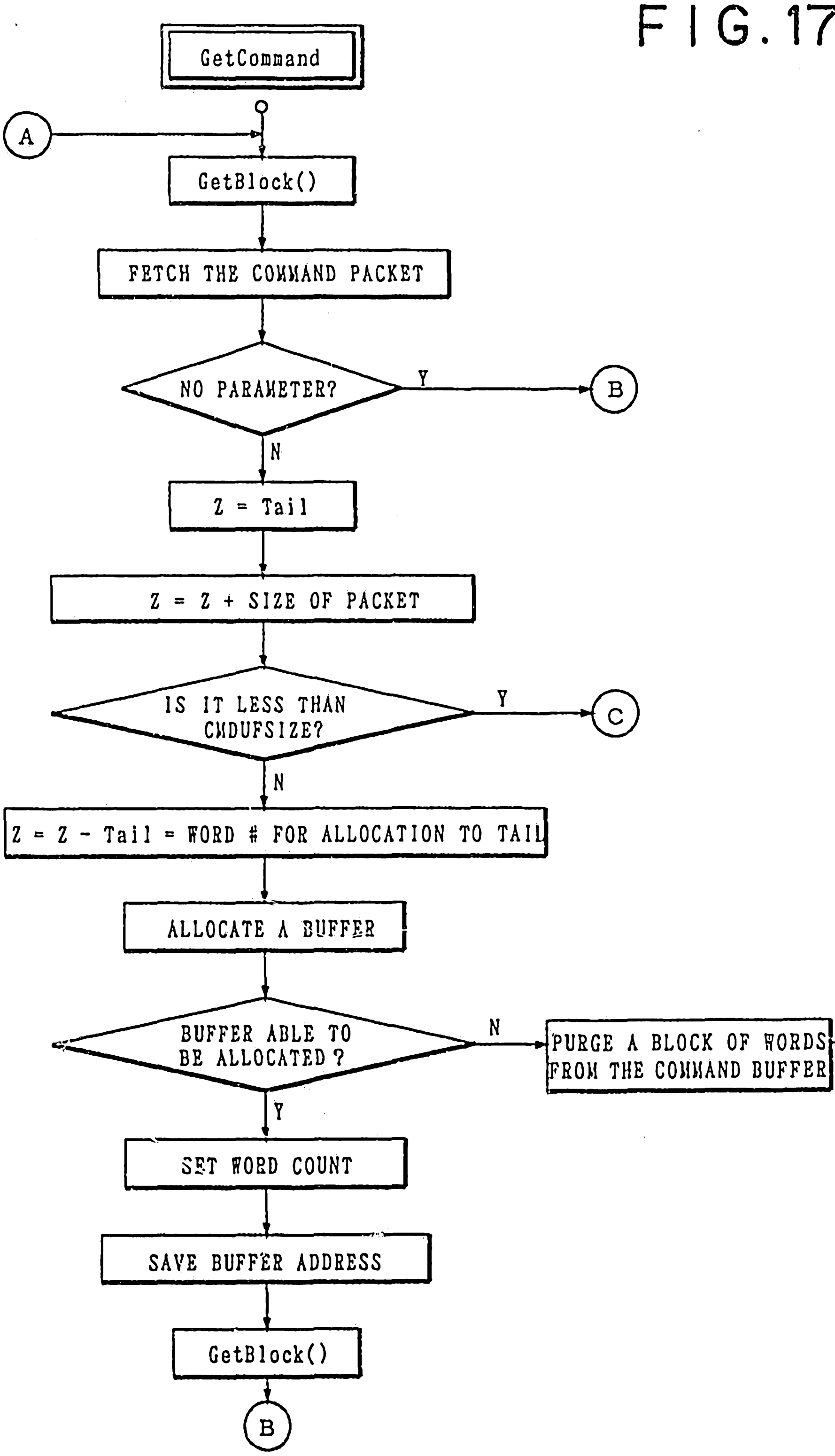

A
X = X + CONTIGUOUS FREE SPACE
X = CMDBUFSIZE ?
N
Y
X = 0
SEND THE DATA TO GRAPHICS COMMAND BUFFER
X = Y ?
N
Y
X = 0 ?
N
Y
Head = CMDBUFSIZE - 1
Head = X - 1
WaitCommand()
Y = Tail
Head = X
B

FIG. 16C

FIG.17A



GetCommand
A
GetBlock()
FETCH THE COMMAND PACKET
NO PARAMETER?
Y
B
N
Z = Tail
Z = Z + SIZE OF PACKET
IS IT LESS THAN CMDUFSIZE?
Y
C
N
Z = Z - Tail = WORD # FOR ALLOCATION TO TAIL
ALLOCATE A BUFFER
BUFFER ABLE TO BE ALLOCATED ?
N
PURGE A BLOCK OF WORDS FROM THE COMMAND BUFFER
A
Y
SET WORD COUNT
SAVE BUFFER ADDRESS
GetBlock()
B

FIG. 17B

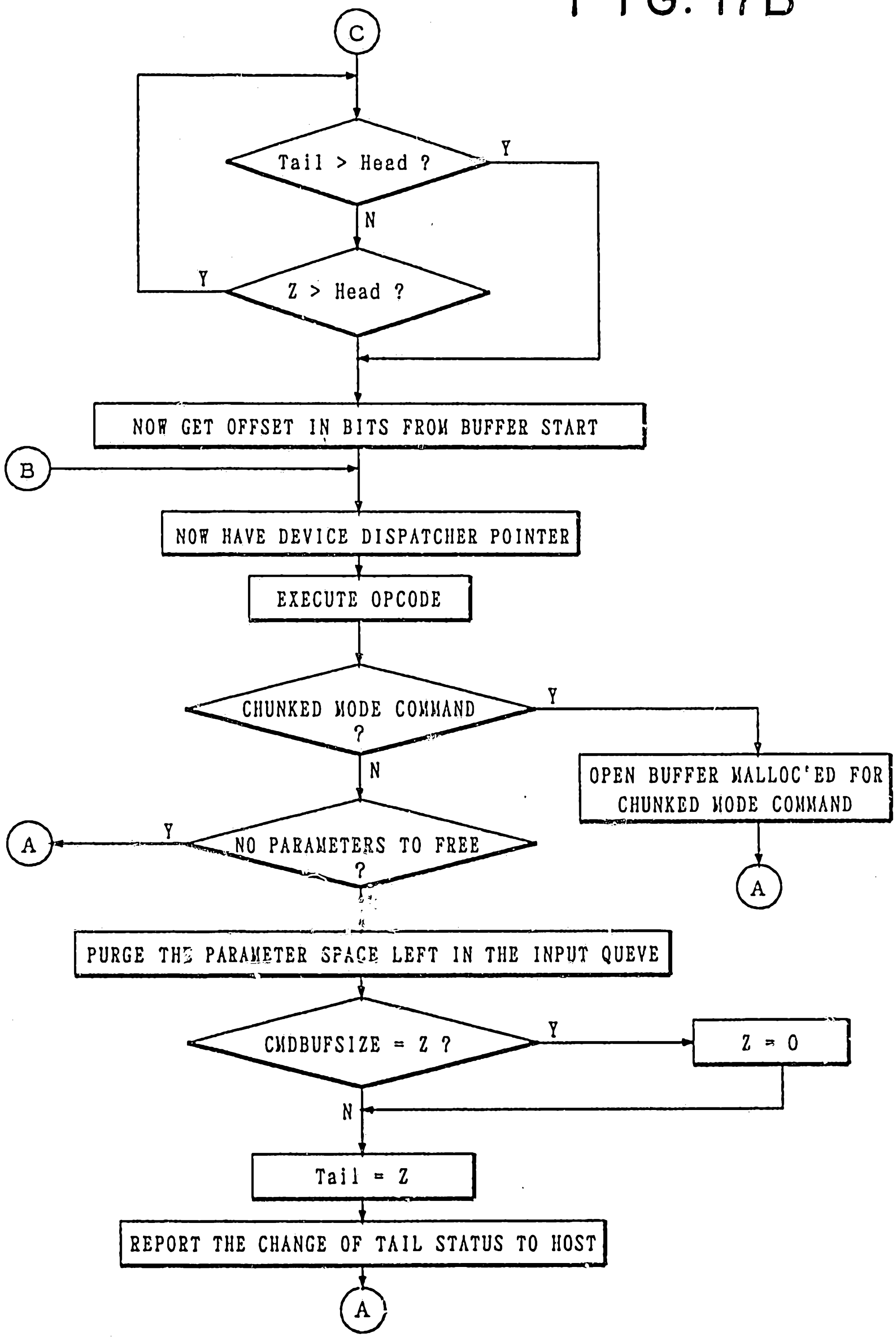

C
Tail > Head ?
Y
N
Z > Head ?
Y
NOW GET OFFSET IN BITS FROM BUFFER START
B
NOW HAVE DEVICE DISPATCHER POINTER
EXECUTE OPCODE
CHUNKED MODE COMMAND ?
Y
N
OPEN BUFFER MALLOC'ED FOR CHUNKED MODE COMMAND
A
A
Y
NO PARAMETERS TO FREE ?
PURGE THE PARAMETER SPACE LEFT IN THE INPUT QUEVE
CMDBUFSIZE = Z ?
Y
Z = 0
N
Tail = Z
REPORT THE CHANGE OF TAIL STATUS TO HOST
A

FIG. 17C

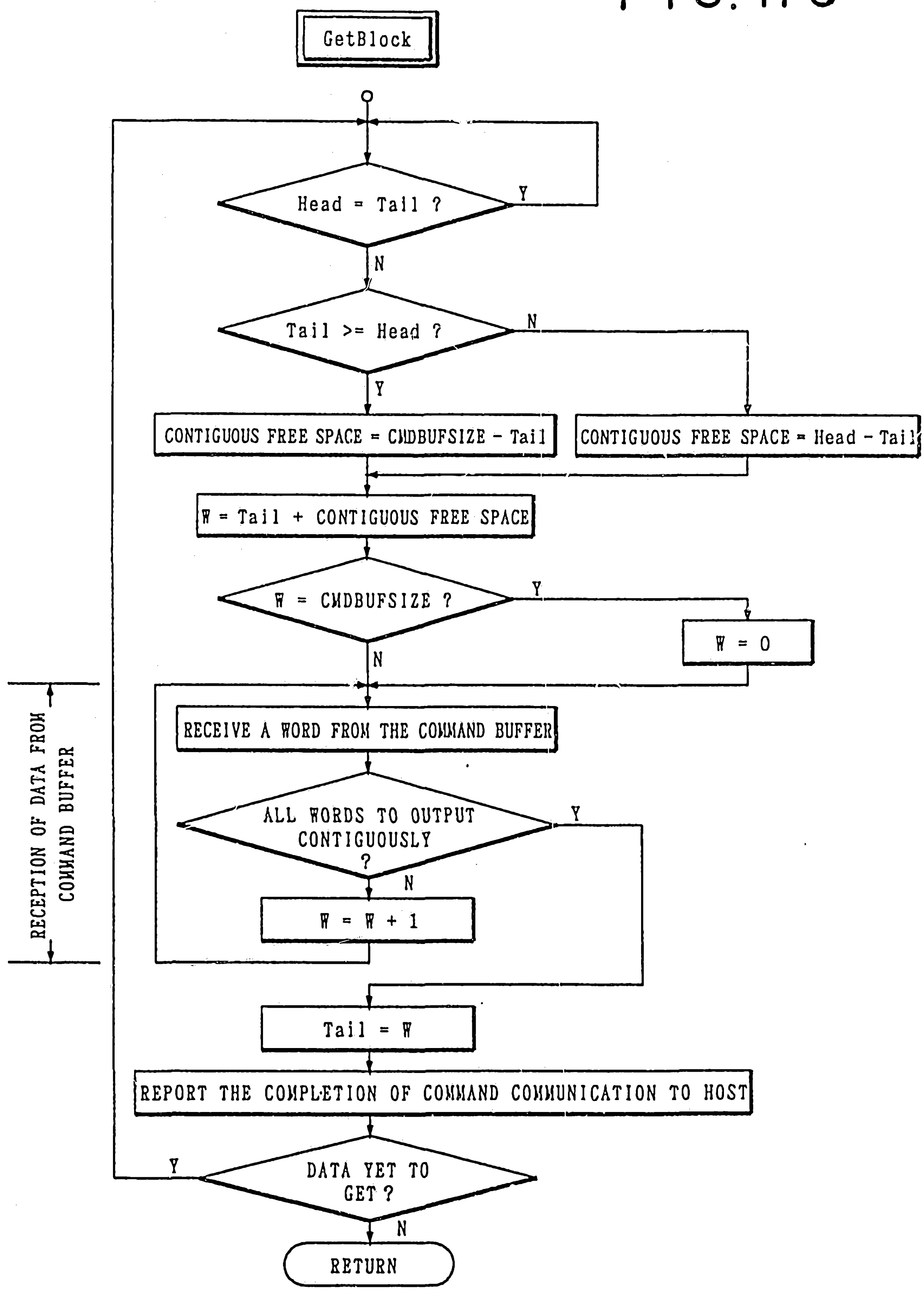

GetBlock
Head = Tail ?
Y
N
Tail >= Head ?
N
Y
CONTIGUOUS FREE SPACE = CMDBUFSIZE - Tail
CONTIGUOUS FREE SPACE = Head - Tail
W = Tail + CONTIGUOUS FREE SPACE
W = CMDBUFSIZE ?
Y
W = 0
N
RECEPTION OF DATA FROM COMMAND BUFFER
RECEIVE A WORD FROM THE COMMAND BUFFER
ALL WORDS TO OUTPUT CONTIGUOUSLY ?
Y
N
W = W + 1
Tail = W
REPORT THE COMPLETION OF COMMAND COMMUNICATION TO HOST
DATA YET TO GET ?
Y
N
RETURN

FIG. 18

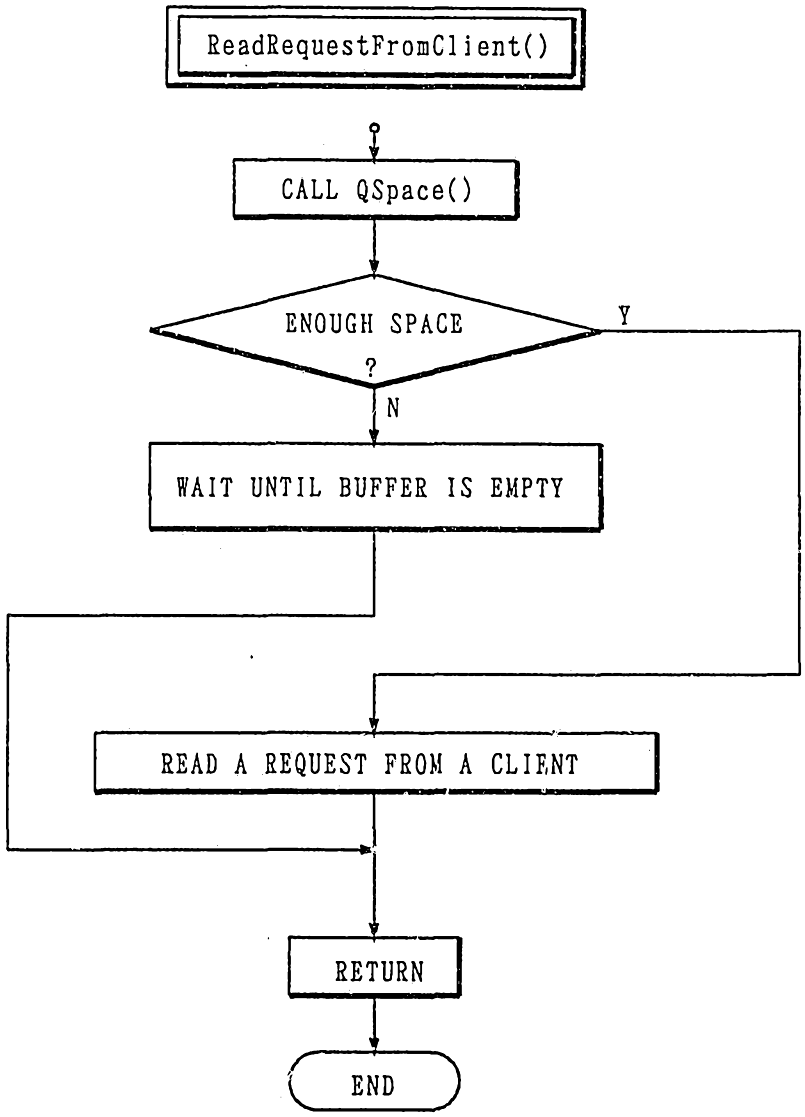
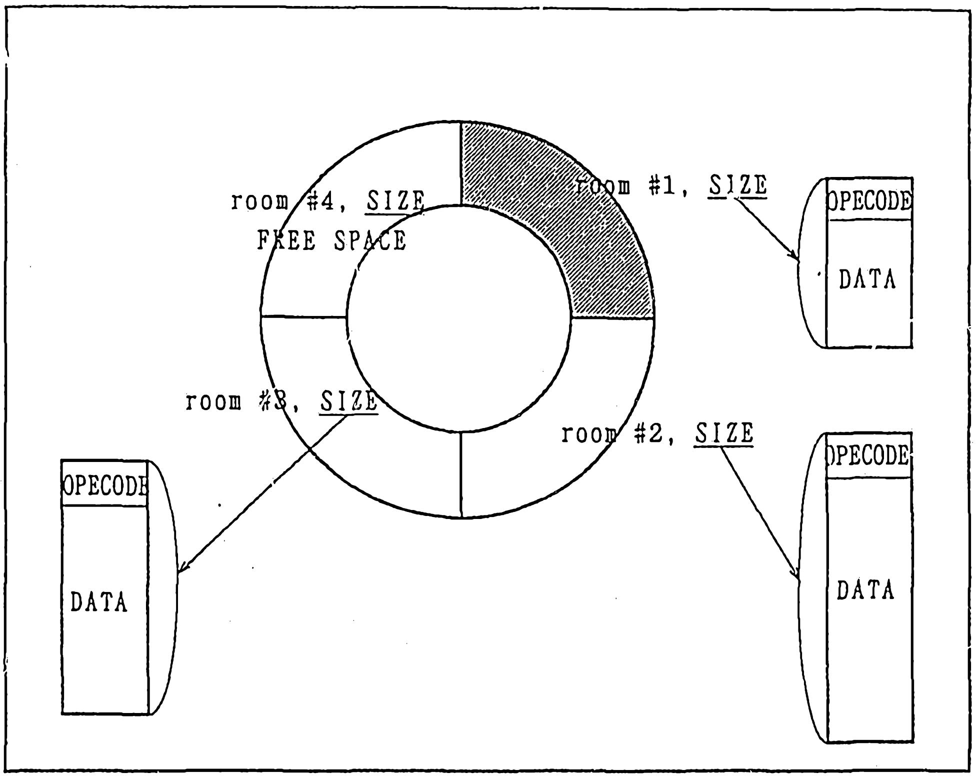

ReadRequestFromClient()
CALL QSpace()
ENOUGH SPACE ?
Y
N
WAIT UNTIL BUFFER IS EMPTY
READ A REQUEST FROM A CLIENT
RETURN
END

FIG. 19



room #4, SIZE
FREE SPACE
room #1, SIZE
OPECODE
DATA
room #3, SIZE
room #2, SIZE
OPECODE
DATA
OPECODE
DATA

FIG. 20

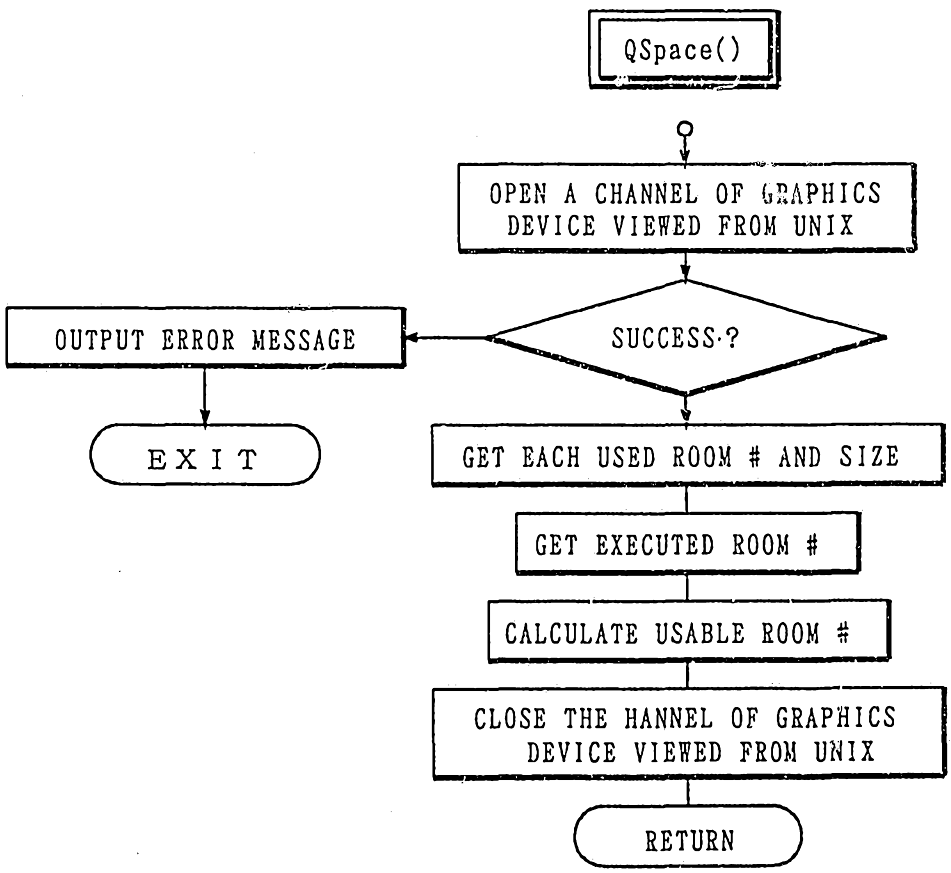
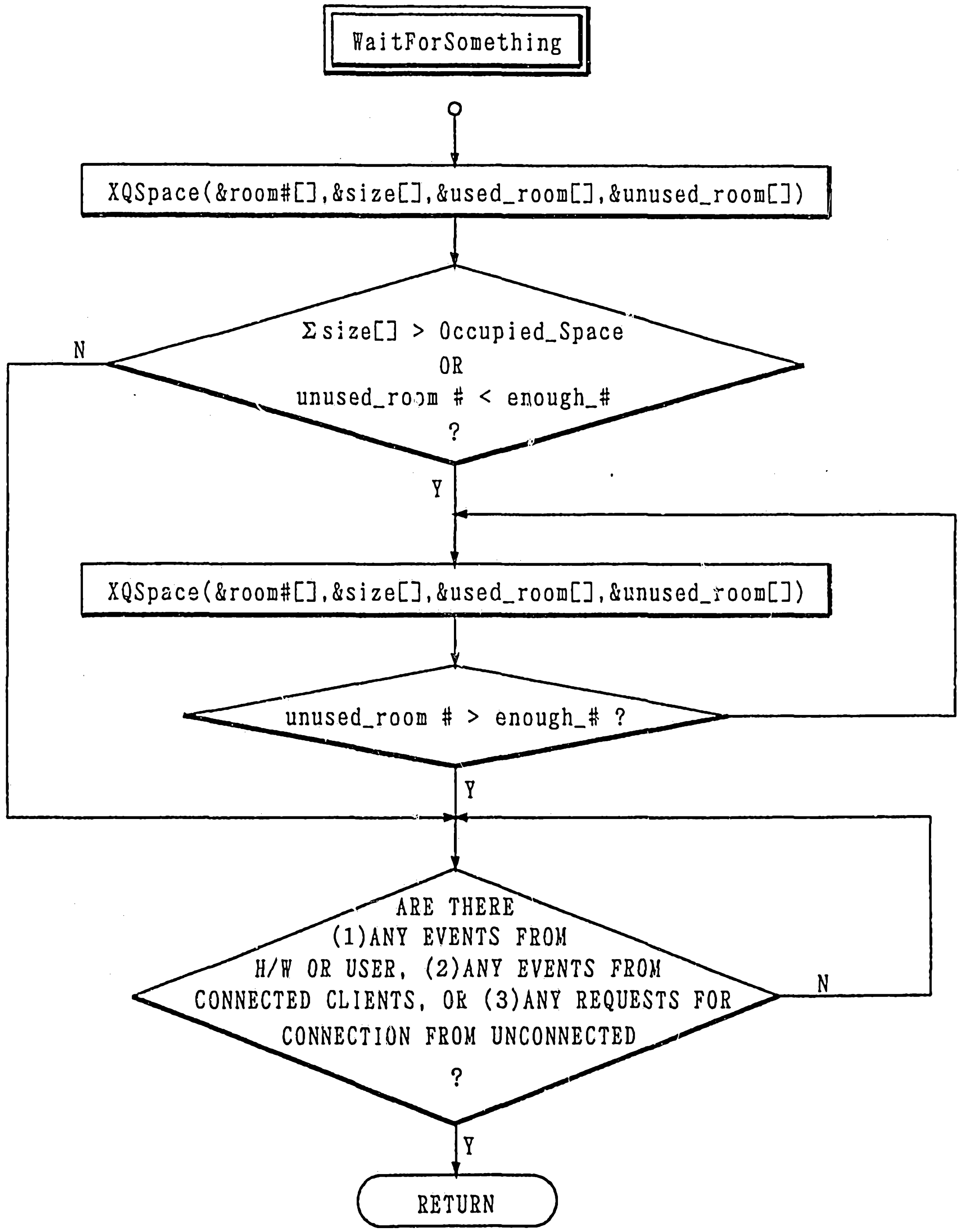

QSpace()
OPEN A CHANNEL OF GRAPHICS DEVICE VIEWED FROM UNIX
SUCCESS ?
OUTPUT ERROR MESSAGE
EXIT
GET EACH USED ROOM # AND SIZE
GET EXECUTED ROOM #
CALCULATE USABLE ROOM #
CLOSE THE HANNEL OF GRAPHICS DEVICE VIEWED FROM UNIX
RETURN

FIG. 21


WaitForSomething
XQSpace(&room#[],&size[],&used_room[],&unused_room[])
Σsize[] > Occupied_Space
OR
unused_room # < enough_#
?
N
Y
XQSpace(&room#[],&size[],&used_room[],&unused_room[])
unused_room # > enough_# ?
Y
ARE THERE
(1)ANY EVENTS FROM
H/W OR USER, (2)ANY EVENTS FROM
CONNECTED CLIENTS, OR (3)ANY REQUESTS FOR
CONNECTION FROM UNCONNECTED
?
N
Y
RETURN