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United States Patent [19]

Hamilton

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[45] Date of Patent: Jan. 5, 1993

[54] **COMPUTER ASSISTED INSTRUCTIONAL DELIVERY SYSTEM AND METHOD**

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[21] Appl. No.: **510,141**

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[51] **Int. Cl.**[5] **G09B 3/00**

[52] **U.S. Cl.** **434/350**; 434/307; 434/323; 434/365; 273/434; 358/85; 379/96; 395/927; 364/419

[58] **Field of Search** 434/307, 350, 336, 365, 434/323, 108, 162; 379/96; 273/629-431, 433, 434; 358/85; 395/927; 364/410, 419

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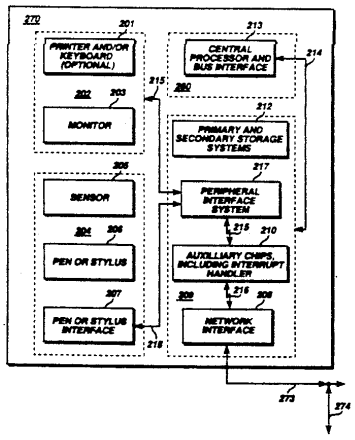
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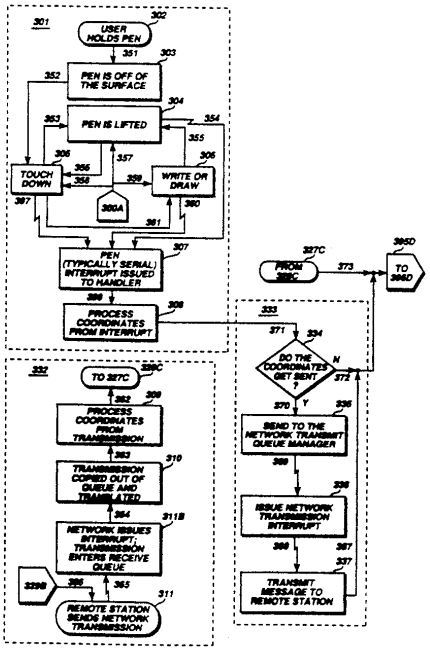
Primary Examiner—Richard J. Apley
Assistant Examiner—Joe H. Cheng
Attorney, Agent, or Firm—Welsh & Katz, Ltd.

[57] **ABSTRACT**

A computer assisted instructional information delivery system having at least two stations. One station for an instructor and one or more stations for students. An interactive monitor is positioned in each station. Each interactive monitor displays instructional information in visual form as inputted by a stylus or light pen on the interactive monitor. A network communication system operated by a central processing unit and corresponding software, communicates the instructional information from the stylus as inputted on one of the interactive monitors and selectively displays the instructional information simultaneously and concurrently onto any or all of the interactive monitors of the stations.

39 Claims, 16 Drawing Sheets





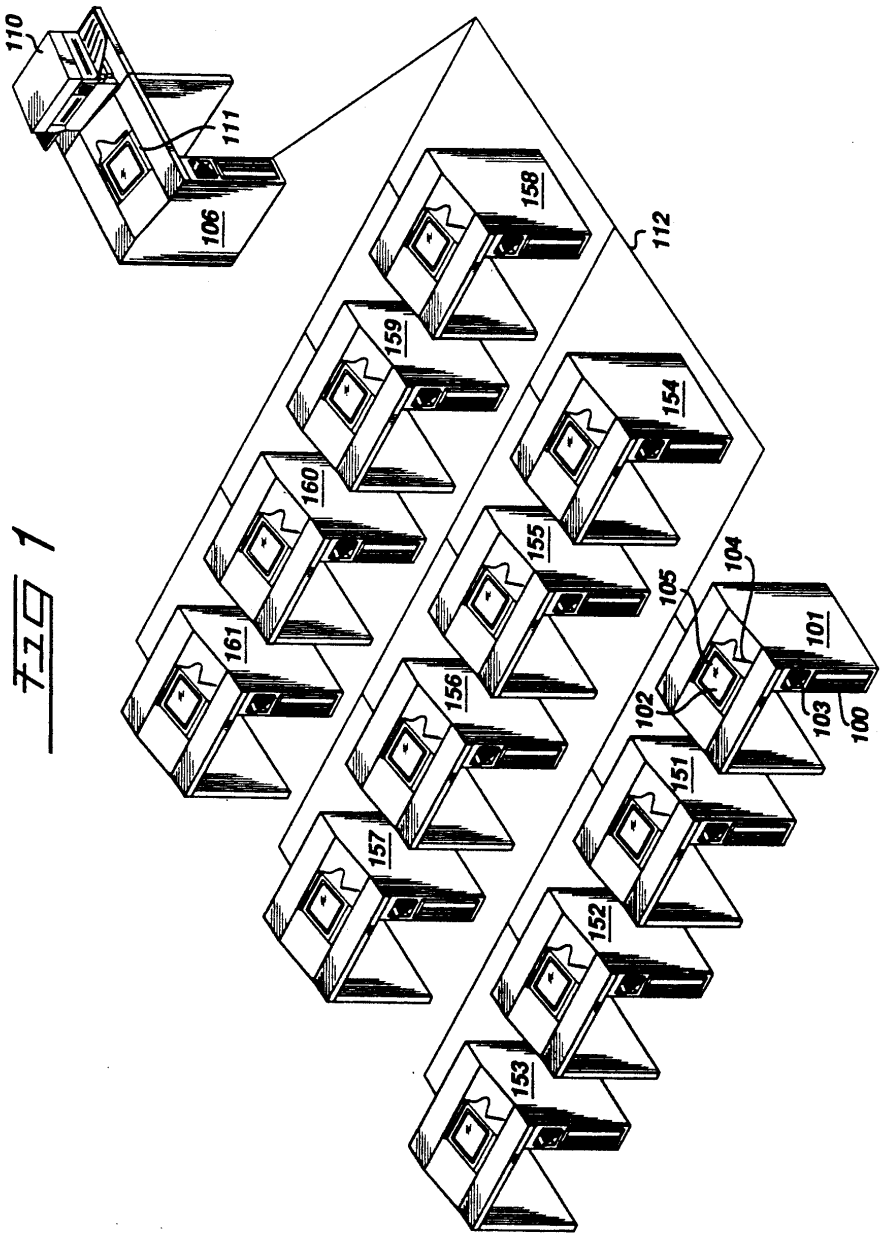

110
111
106
158
112
159
154
160
155
104
105
101
161
156
102
103
100
151
157
152
153

FIG 1

FIG 2a

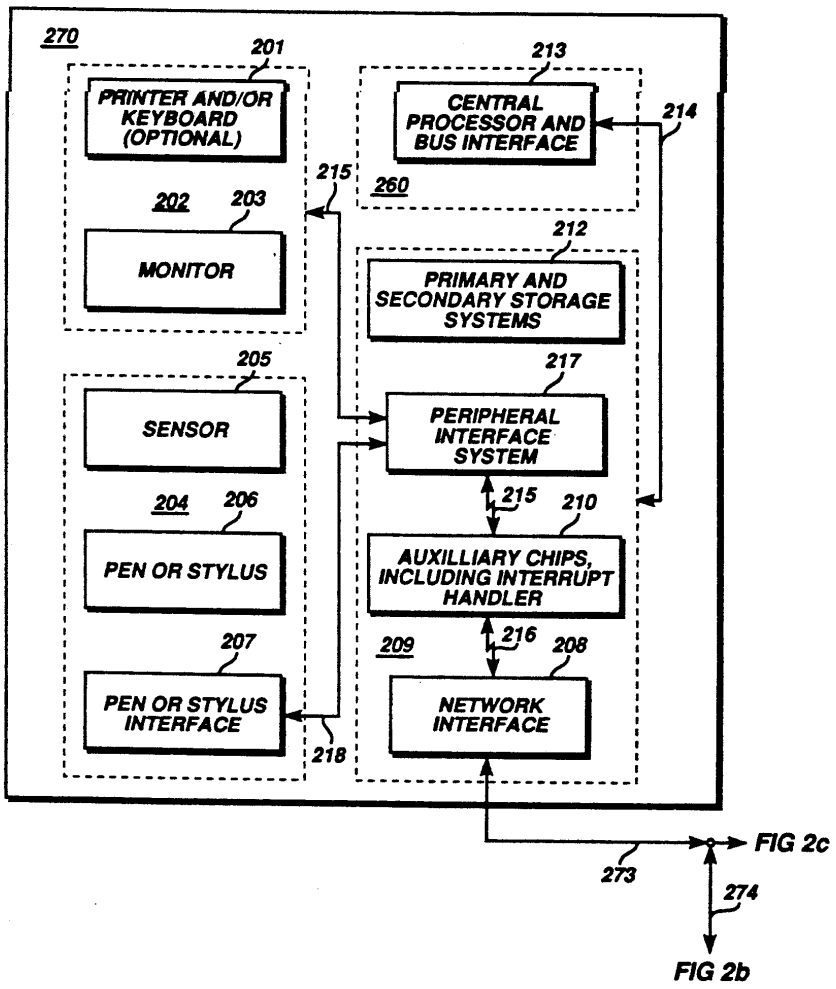

270
201
PRINTER AND/OR KEYBOARD (OPTIONAL)
202
203
MONITOR
205
SENSOR
204
206
PEN OR STYLUS
207
PEN OR STYLUS INTERFACE
218
215
213
CENTRAL PROCESSOR AND BUS INTERFACE
214
260
212
PRIMARY AND SECONDARY STORAGE SYSTEMS
217
PERIPHERAL INTERFACE SYSTEM
215
210
AUXILLIARY CHIPS, INCLUDING INTERRUPT HANDLER
209
216
208
NETWORK INTERFACE
273
FIG 2c
274
FIG 2b

FIG 2b

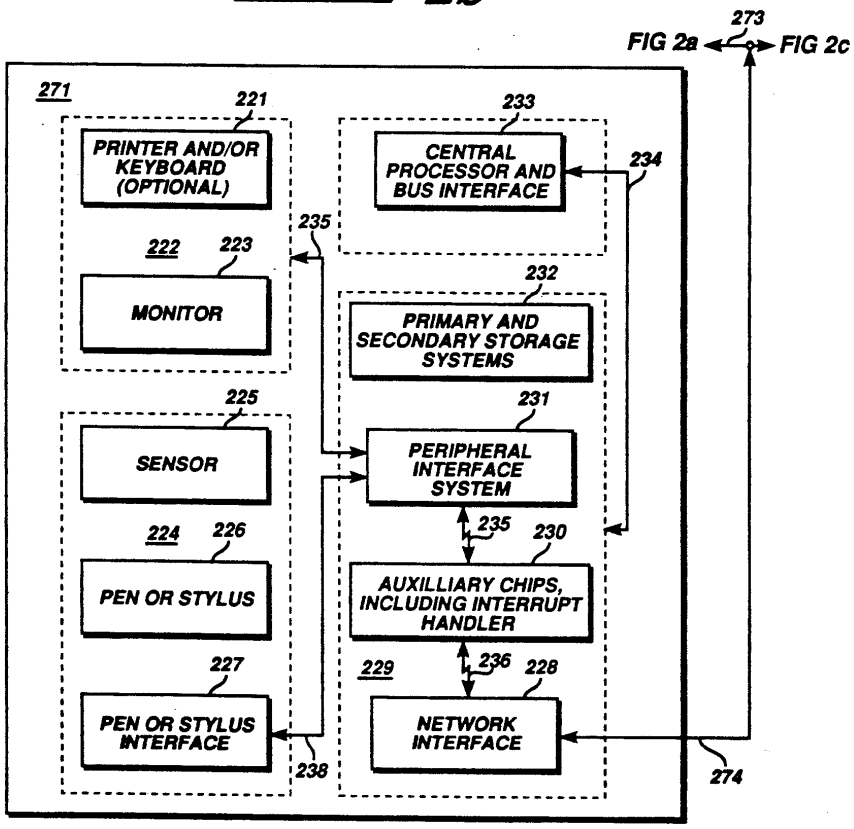

273
FIG 2a
FIG 2c
271
221
PRINTER AND/OR KEYBOARD (OPTIONAL)
222
223
MONITOR
225
SENSOR
224
226
PEN OR STYLUS
227
PEN OR STYLUS INTERFACE
238
235
233
CENTRAL PROCESSOR AND BUS INTERFACE
234
232
PRIMARY AND SECONDARY STORAGE SYSTEMS
231
PERIPHERAL INTERFACE SYSTEM
235
230
AUXILLIARY CHIPS, INCLUDING INTERRUPT HANDLER
229
236
228
NETWORK INTERFACE
274

FIG 2c

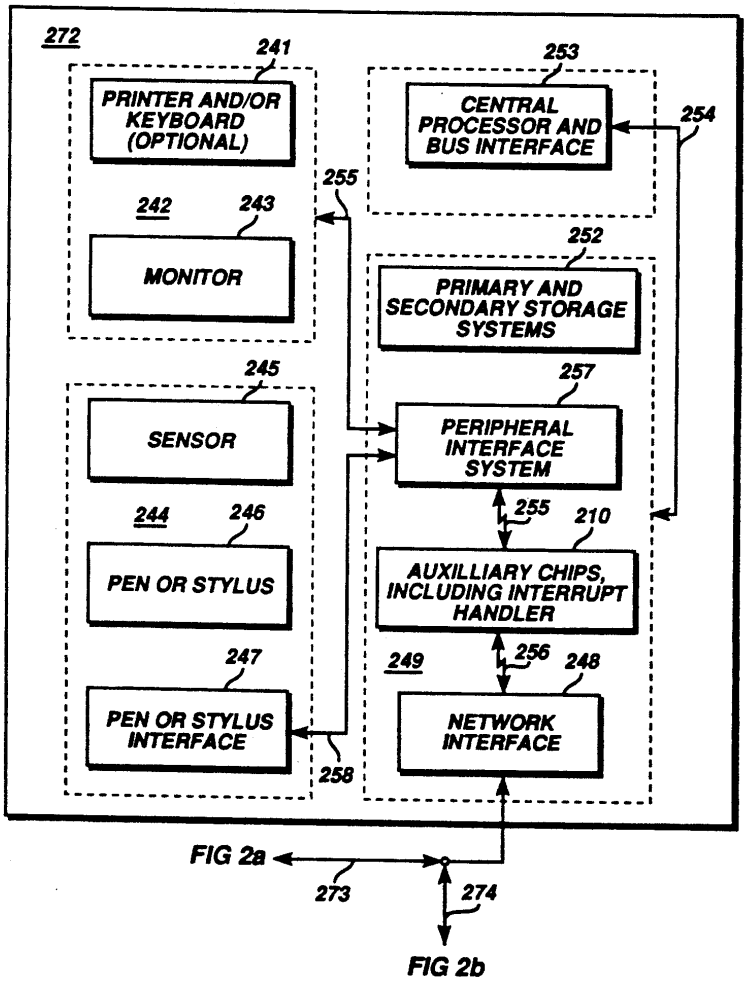

272
241
PRINTER AND/OR KEYBOARD (OPTIONAL)
242
243
MONITOR
245
SENSOR
244
246
PEN OR STYLUS
247
PEN OR STYLUS INTERFACE
258
255
253
CENTRAL PROCESSOR AND BUS INTERFACE
254
252
PRIMARY AND SECONDARY STORAGE SYSTEMS
257
PERIPHERAL INTERFACE SYSTEM
255
210
AUXILLIARY CHIPS, INCLUDING INTERRUPT HANDLER
249
256
248
NETWORK INTERFACE
FIG 2a
273
274
FIG 2b

Fig 3a

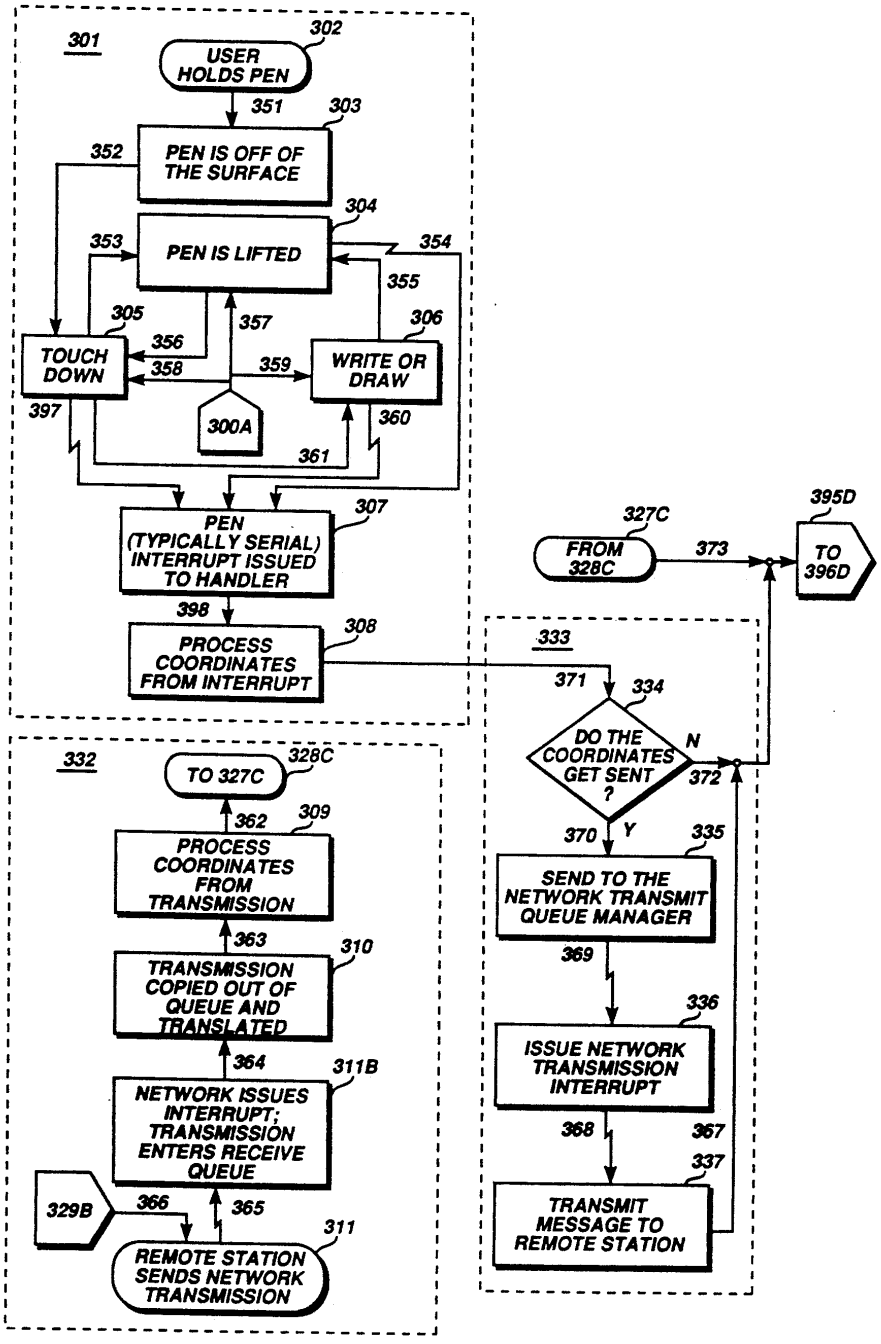

301
302
USER HOLDS PEN
351
303
PEN IS OFF OF THE SURFACE
352
304
PEN IS LIFTED
353
354
355
305
306
356
357
TOUCH DOWN
358
359
WRITE OR DRAW
300A
397
360
361
307
PEN (TYPICALLY SERIAL) INTERRUPT ISSUED TO HANDLER
398
308
PROCESS COORDINATES FROM INTERRUPT
327C
FROM 328C
373
395D
TO 396D
333
371
334
DO THE COORDINATES GET SENT ?
N
372
370
Y
335
SEND TO THE NETWORK TRANSMIT QUEUE MANAGER
369
336
ISSUE NETWORK TRANSMISSION INTERRUPT
368
367
337
TRANSMIT MESSAGE TO REMOTE STATION
332
328C
TO 327C
362
309
PROCESS COORDINATES FROM TRANSMISSION
363
310
TRANSMISSION COPIED OUT OF QUEUE AND TRANSLATED
364
311B
NETWORK ISSUES INTERRUPT; TRANSMISSION ENTERS RECEIVE QUEUE
329B
366
365
311
REMOTE STATION SENDS NETWORK TRANSMISSION

Fig 3b

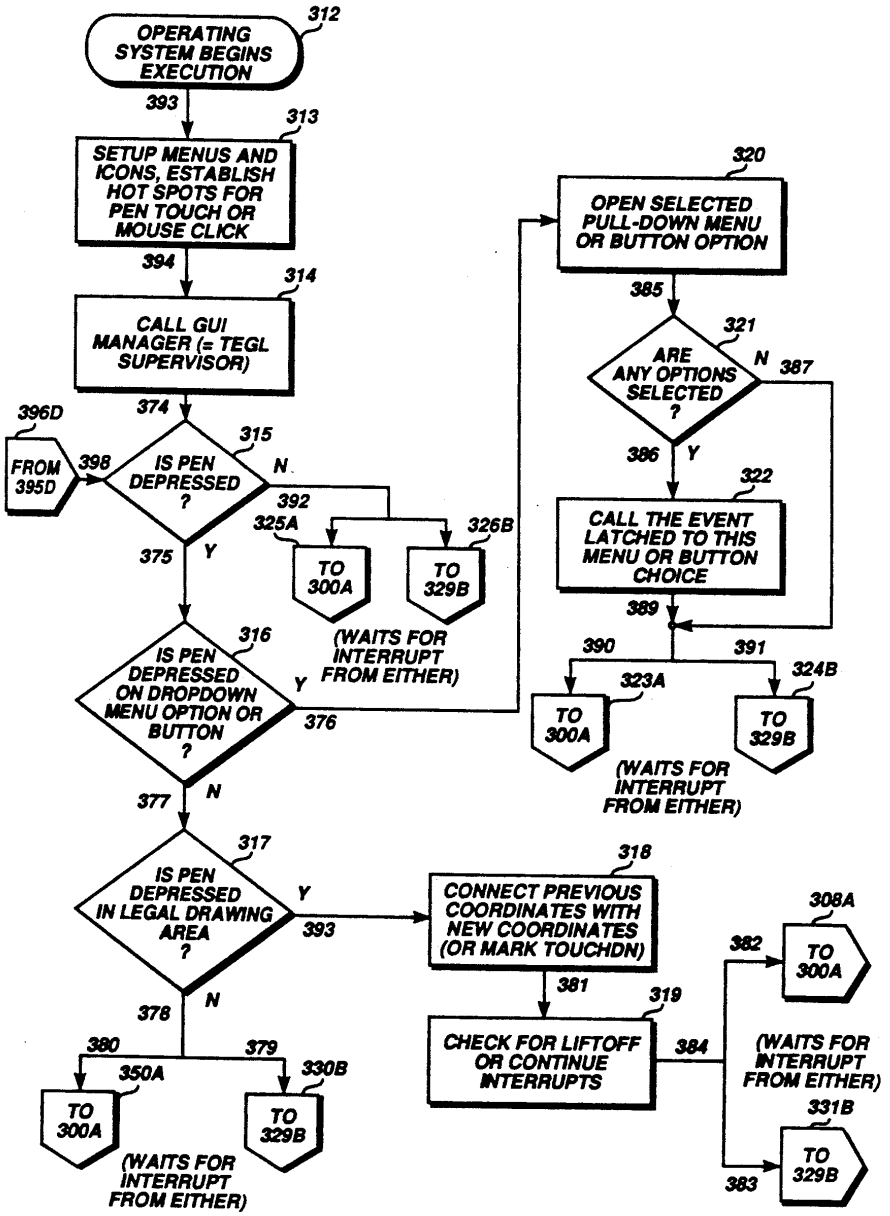

OPERATING SYSTEM BEGINS EXECUTION
312
393
SETUP MENUS AND ICONS, ESTABLISH HOT SPOTS FOR PEN TOUCH OR MOUSE CLICK
313
394
CALL GUI MANAGER (= TEGL SUPERVISOR)
314
374
396D
FROM 395D
398
IS PEN DEPRESSED ?
315
N
392
325A
TO 300A
326B
TO 329B
(WAITS FOR INTERRUPT FROM EITHER)
375
Y
IS PEN DEPRESSED ON DROPDOWN MENU OPTION OR BUTTON ?
316
Y
376
377
N
IS PEN DEPRESSED IN LEGAL DRAWING AREA ?
317
Y
393
378
N
380
350A
TO 300A
379
330B
TO 329B
(WAITS FOR INTERRUPT FROM EITHER)
CONNECT PREVIOUS COORDINATES WITH NEW COORDINATES (OR MARK TOUCHDN)
318
381
CHECK FOR LIFTOFF OR CONTINUE INTERRUPTS
319
384
382
308A
TO 300A
(WAITS FOR INTERRUPT FROM EITHER)
383
331B
TO 329B
OPEN SELECTED PULL-DOWN MENU OR BUTTON OPTION
320
385
ARE ANY OPTIONS SELECTED ?
321
N
387
386
Y
CALL THE EVENT LATCHED TO THIS MENU OR BUTTON CHOICE
322
389
390
323A
TO 300A
391
324B
TO 329B
(WAITS FOR INTERRUPT FROM EITHER)

Fig 4a

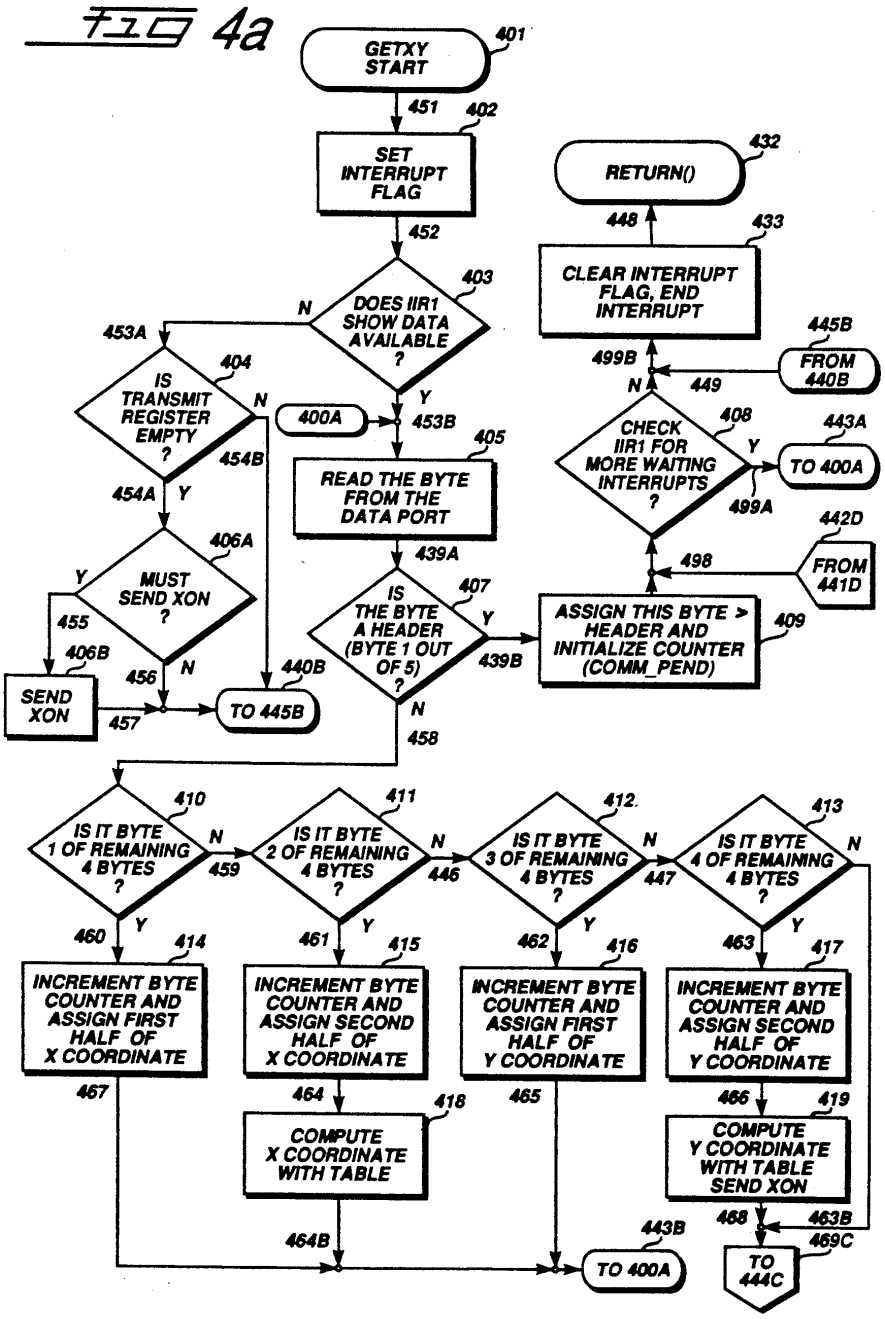

GETXY START
401
451
402
SET INTERRUPT FLAG
452
403
DOES IIR1 SHOW DATA AVAILABLE ?
N
Y
453A
404
IS TRANSMIT REGISTER EMPTY ?
N
454B
454A
Y
406A
MUST SEND XON ?
Y
455
406B
SEND XON
457
456
N
440B
TO 445B
400A
453B
405
READ THE BYTE FROM THE DATA PORT
439A
407
IS THE BYTE A HEADER (BYTE 1 OUT OF 5) ?
Y
439B
N
458
ASSIGN THIS BYTE > HEADER AND INITIALIZE COUNTER (COMM_PEND)
409
498
442D
FROM 441D
RETURN()
432
448
433
CLEAR INTERRUPT FLAG, END INTERRUPT
499B
N
449
445B
FROM 440B
408
CHECK IIR1 FOR MORE WAITING INTERRUPTS ?
Y
499A
443A
TO 400A
410
IS IT BYTE 1 OF REMAINING 4 BYTES ?
N
459
411
IS IT BYTE 2 OF REMAINING 4 BYTES ?
N
446
412
IS IT BYTE 3 OF REMAINING 4 BYTES ?
N
447
413
IS IT BYTE 4 OF REMAINING 4 BYTES ?
N
460
Y
414
INCREMENT BYTE COUNTER AND ASSIGN FIRST HALF OF X COORDINATE
467
461
Y
415
INCREMENT BYTE COUNTER AND ASSIGN SECOND HALF OF X COORDINATE
464
418
COMPUTE X COORDINATE WITH TABLE
464B
462
Y
416
INCREMENT BYTE COUNTER AND ASSIGN FIRST HALF OF Y COORDINATE
465
463
Y
417
INCREMENT BYTE COUNTER AND ASSIGN SECOND HALF OF Y COORDINATE
466
419
COMPUTE Y COORDINATE WITH TABLE SEND XON
468
463B
443B
TO 400A
469C
TO 444C

Fig 4b

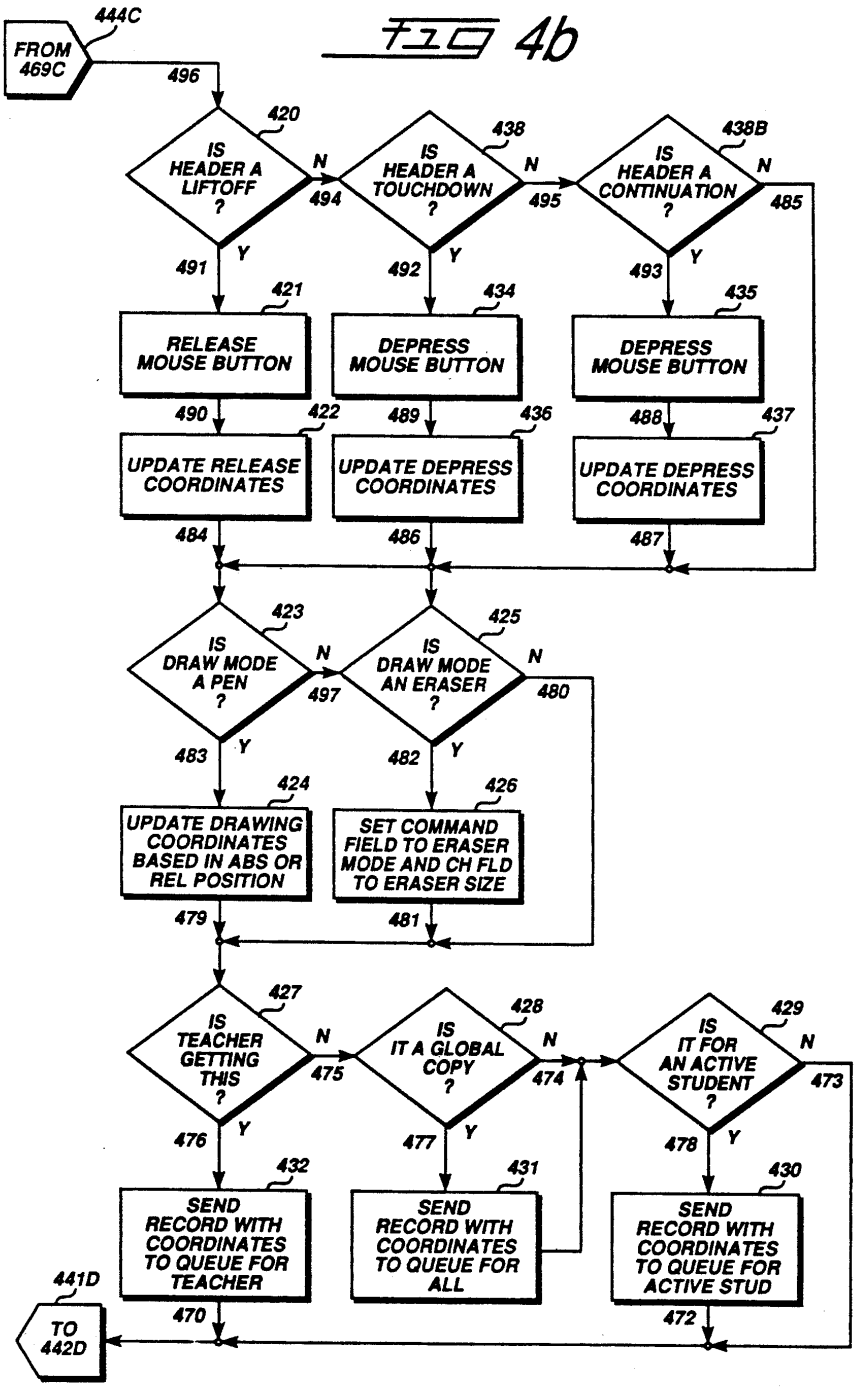

444C
FROM 469C
496
420
IS HEADER A LIFTOFF ?
N
494
438
IS HEADER A TOUCHDOWN ?
N
495
438B
IS HEADER A CONTINUATION ?
N
485
Y
491
Y
492
Y
493
421
RELEASE MOUSE BUTTON
434
DEPRESS MOUSE BUTTON
435
DEPRESS MOUSE BUTTON
490
422
UPDATE RELEASE COORDINATES
489
436
UPDATE DEPRESS COORDINATES
488
437
UPDATE DEPRESS COORDINATES
484
486
487
423
IS DRAW MODE A PEN ?
N
497
425
IS DRAW MODE AN ERASER ?
N
480
Y
483
Y
482
424
UPDATE DRAWING COORDINATES BASED IN ABS OR REL POSITION
426
SET COMMAND FIELD TO ERASER MODE AND CH FLD TO ERASER SIZE
479
481
427
IS TEACHER GETTING THIS ?
N
475
428
IS IT A GLOBAL COPY ?
N
474
429
IS IT FOR AN ACTIVE STUDENT ?
N
473
Y
476
Y
477
Y
478
432
SEND RECORD WITH COORDINATES TO QUEUE FOR TEACHER
431
SEND RECORD WITH COORDINATES TO QUEUE FOR ALL
430
SEND RECORD WITH COORDINATES TO QUEUE FOR ACTIVE STUD
441D
TO 442D
470
472

FIG 5a

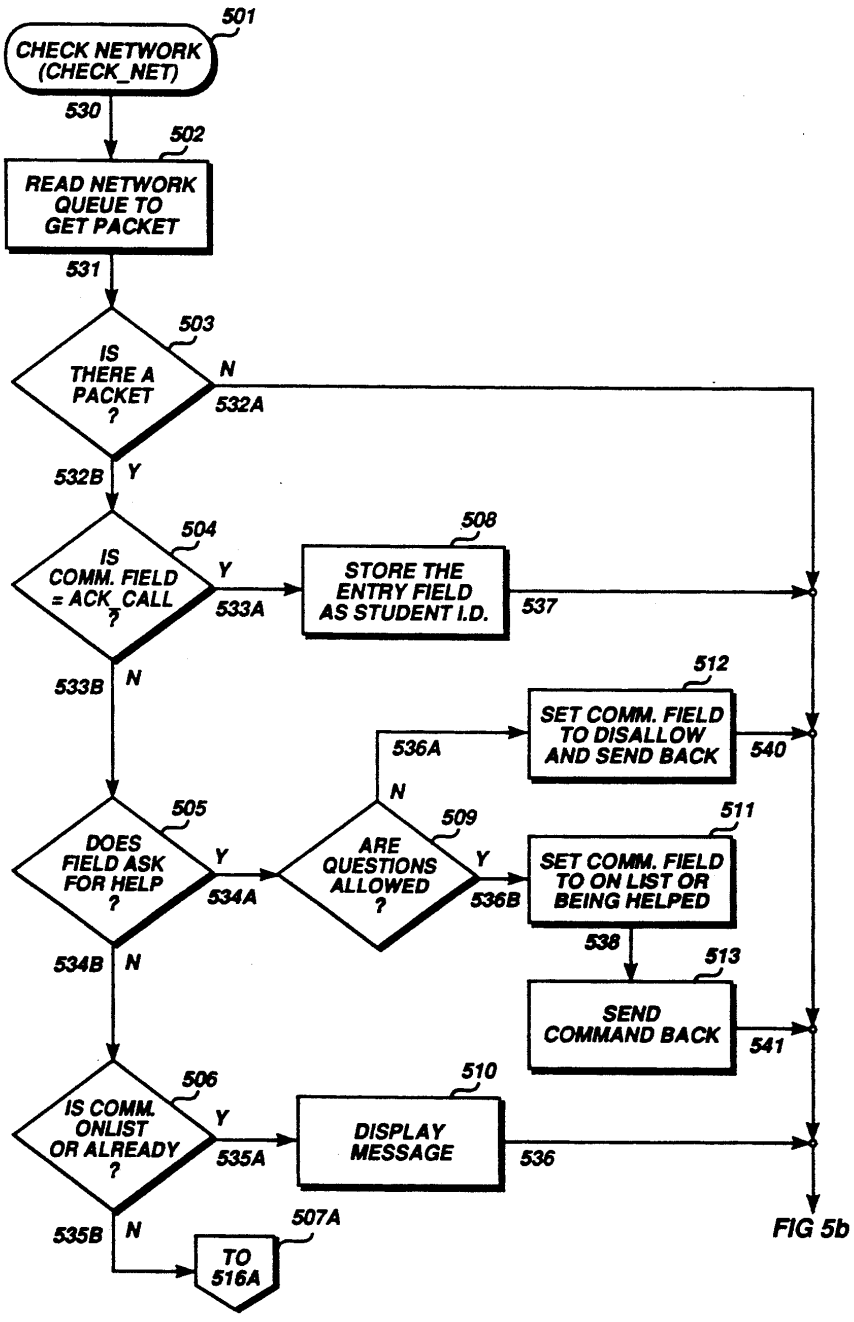

501
CHECK NETWORK (CHECK_NET)
530
502
READ NETWORK QUEUE TO GET PACKET
531
503
IS THERE A PACKET ?
N
532A
532B
Y
504
IS COMM. FIELD = ACK_CALL ?
Y
533A
508
STORE THE ENTRY FIELD AS STUDENT I.D.
537
533B
N
512
SET COMM. FIELD TO DISALLOW AND SEND BACK
540
536A
N
505
DOES FIELD ASK FOR HELP ?
Y
534A
509
ARE QUESTIONS ALLOWED ?
Y
536B
511
SET COMM. FIELD TO ON LIST OR BEING HELPED
538
513
SEND COMMAND BACK
541
534B
N
506
IS COMM. ONLIST OR ALREADY ?
Y
535A
510
DISPLAY MESSAGE
536
535B
N
507A
TO 516A

FIG 5b

FIG 5b

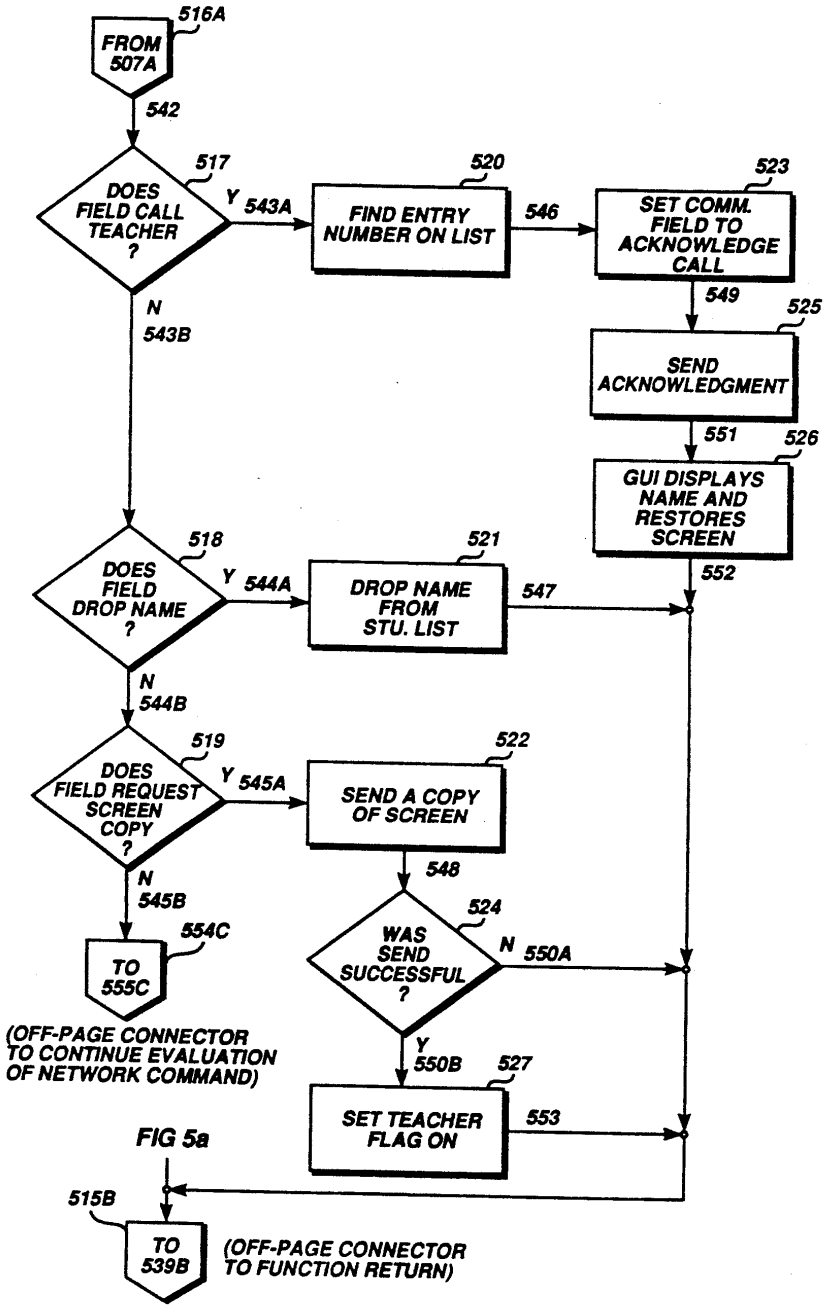

516A
FROM 507A
542
517
DOES FIELD CALL TEACHER ?
Y
543A
520
FIND ENTRY NUMBER ON LIST
546
523
SET COMM. FIELD TO ACKNOWLEDGE CALL
549
525
SEND ACKNOWLEDGMENT
551
526
GUI DISPLAYS NAME AND RESTORES SCREEN
552
N
543B
518
DOES FIELD DROP NAME ?
Y
544A
521
DROP NAME FROM STU. LIST
547
N
544B
519
DOES FIELD REQUEST SCREEN COPY ?
Y
545A
522
SEND A COPY OF SCREEN
548
N
545B
554C
TO 555C
(OFF-PAGE CONNECTOR TO CONTINUE EVALUATION OF NETWORK COMMAND)
524
WAS SEND SUCCESSFUL ?
N
550A
Y
550B
527
SET TEACHER FLAG ON
553
FIG 5a
515B
TO 539B
(OFF-PAGE CONNECTOR TO FUNCTION RETURN)

Fig 5c

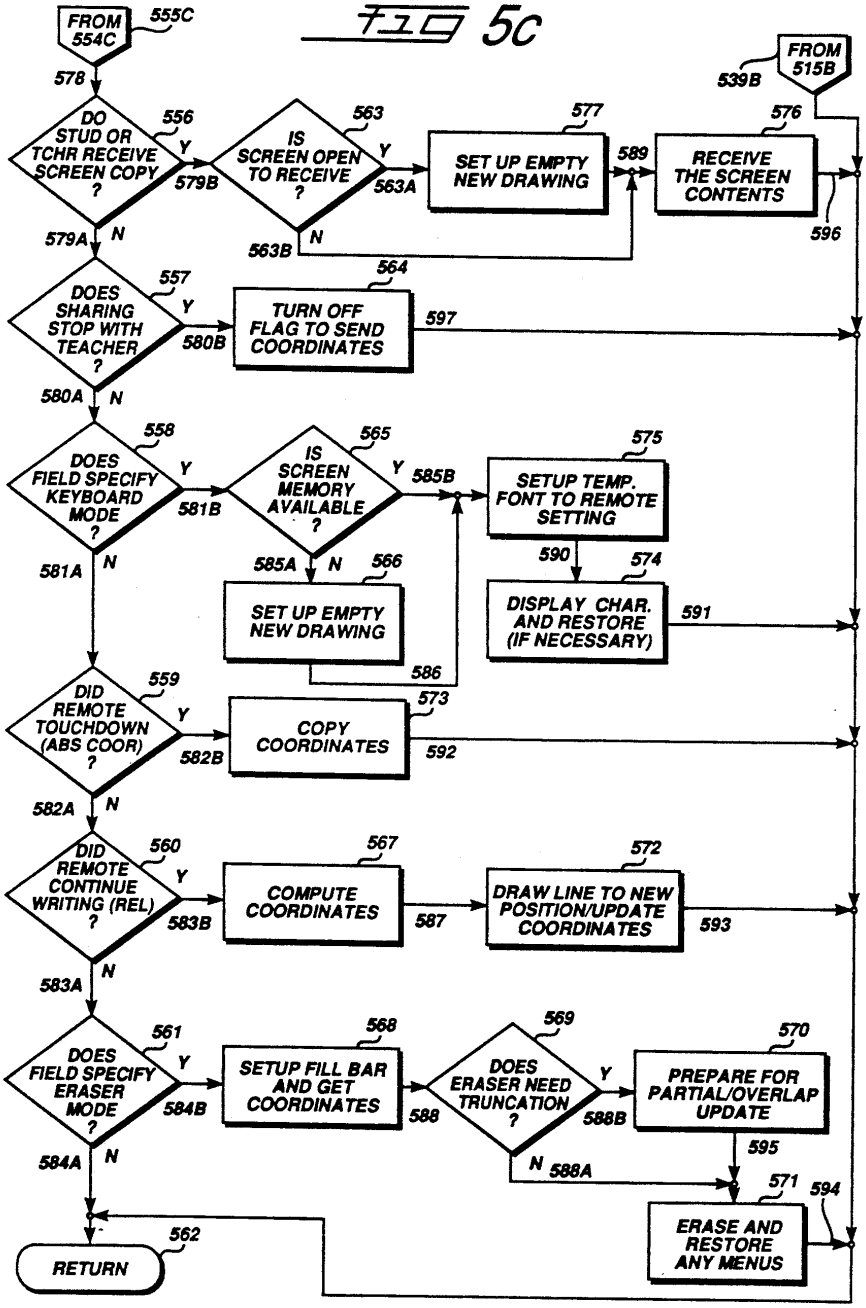

FROM 554C
555C
578
DO STUD OR TCHR RECEIVE SCREEN COPY ?
556
Y
579B
579A
N
IS SCREEN OPEN TO RECEIVE ?
563
Y
563A
563B
N
SET UP EMPTY NEW DRAWING
577
589
FROM 515B
539B
RECEIVE THE SCREEN CONTENTS
576
596
DOES SHARING STOP WITH TEACHER ?
557
Y
580B
580A
N
TURN OFF FLAG TO SEND COORDINATES
564
597
DOES FIELD SPECIFY KEYBOARD MODE ?
558
Y
581B
581A
N
IS SCREEN MEMORY AVAILABLE ?
565
Y
585B
585A
N
SETUP TEMP. FONT TO REMOTE SETTING
575
590
DISPLAY CHAR. AND RESTORE (IF NECESSARY)
574
591
SET UP EMPTY NEW DRAWING
566
586
DID REMOTE TOUCHDOWN (ABS COOR) ?
559
Y
582B
582A
N
COPY COORDINATES
573
592
DID REMOTE CONTINUE WRITING (REL) ?
560
Y
583B
583A
N
COMPUTE COORDINATES
567
587
DRAW LINE TO NEW POSITION/UPDATE COORDINATES
572
593
DOES FIELD SPECIFY ERASER MODE ?
561
Y
584B
584A
N
SETUP FILL BAR AND GET COORDINATES
568
588
DOES ERASER NEED TRUNCATION ?
569
Y
588B
N
588A
PREPARE FOR PARTIAL/OVERLAP UPDATE
570
595
ERASE AND RESTORE ANY MENUS
571
594
RETURN
562

FIG 6a

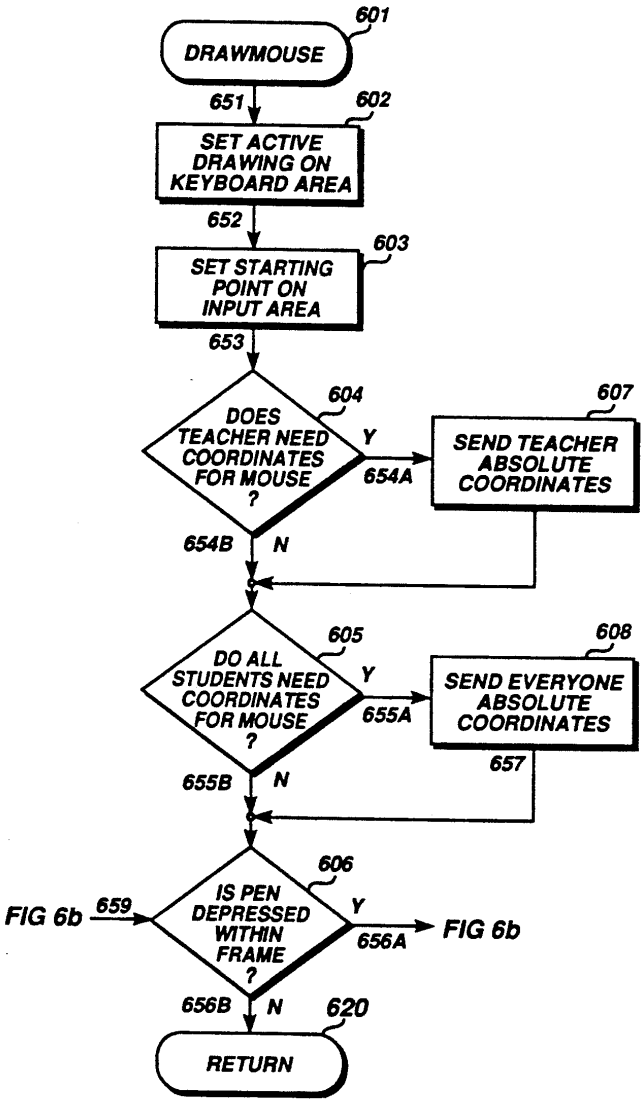

601
DRAWMOUSE
651
602
SET ACTIVE DRAWING ON KEYBOARD AREA
652
603
SET STARTING POINT ON INPUT AREA
653
604
DOES TEACHER NEED COORDINATES FOR MOUSE ?
Y
654A
607
SEND TEACHER ABSOLUTE COORDINATES
654B
N
605
DO ALL STUDENTS NEED COORDINATES FOR MOUSE ?
Y
655A
608
SEND EVERYONE ABSOLUTE COORDINATES
657
655B
N
606
FIG 6b
659
IS PEN DEPRESSED WITHIN FRAME ?
Y
656A
FIG 6b
656B
N
620
RETURN

FIG 6b

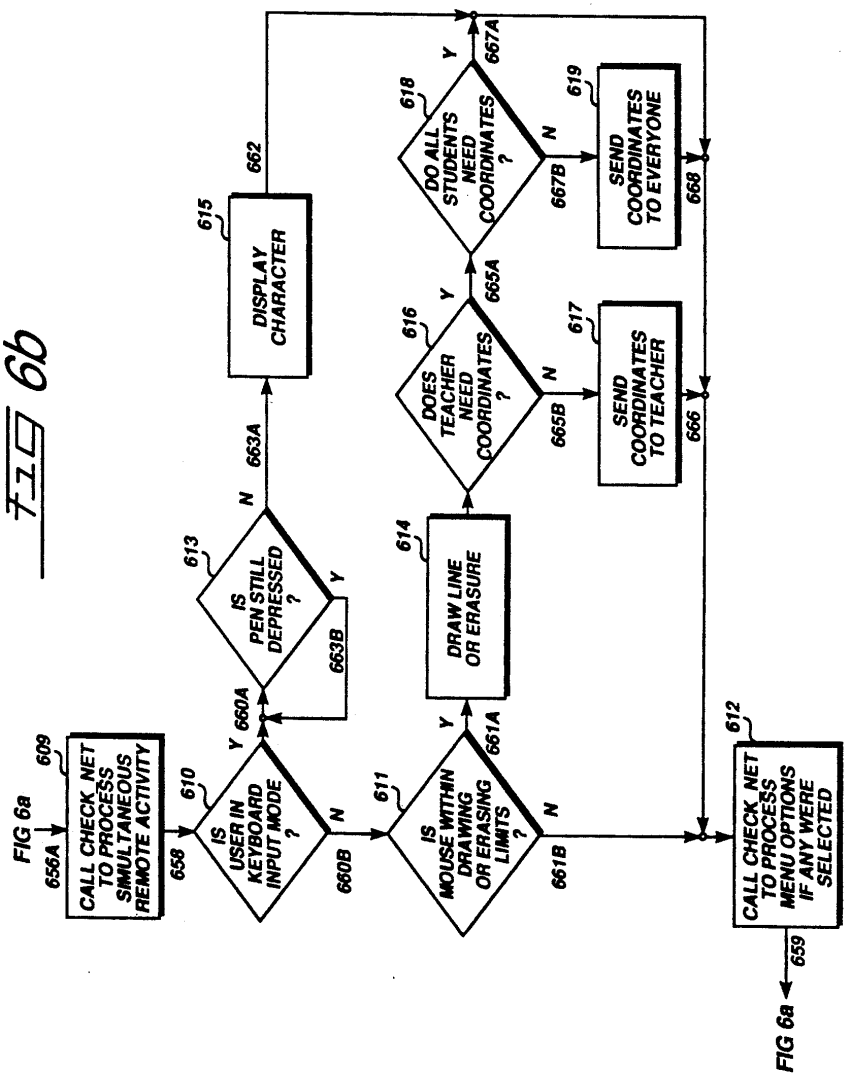

FIG 6a
656A
CALL CHECK NET TO PROCESS SIMULTANEOUS REMOTE ACTIVITY
609
658
IS USER IN KEYBOARD INPUT MODE ?
610
Y
660A
N
660B
IS PEN STILL DEPRESSED ?
613
Y
663B
N
663A
DISPLAY CHARACTER
615
662
IS MOUSE WITHIN DRAWING OR ERASING LIMITS ?
611
Y
661A
N
661B
DRAW LINE OR ERASURE
614
DOES TEACHER NEED COORDINATES ?
616
Y
665A
N
665B
SEND COORDINATES TO TEACHER
617
666
DO ALL STUDENTS NEED COORDINATES ?
618
Y
667A
N
667B
SEND COORDINATES TO EVERYONE
619
668
CALL CHECK NET TO PROCESS MENU OPTIONS IF ANY WERE SELECTED
612
659
FIG 6a

Fig 7

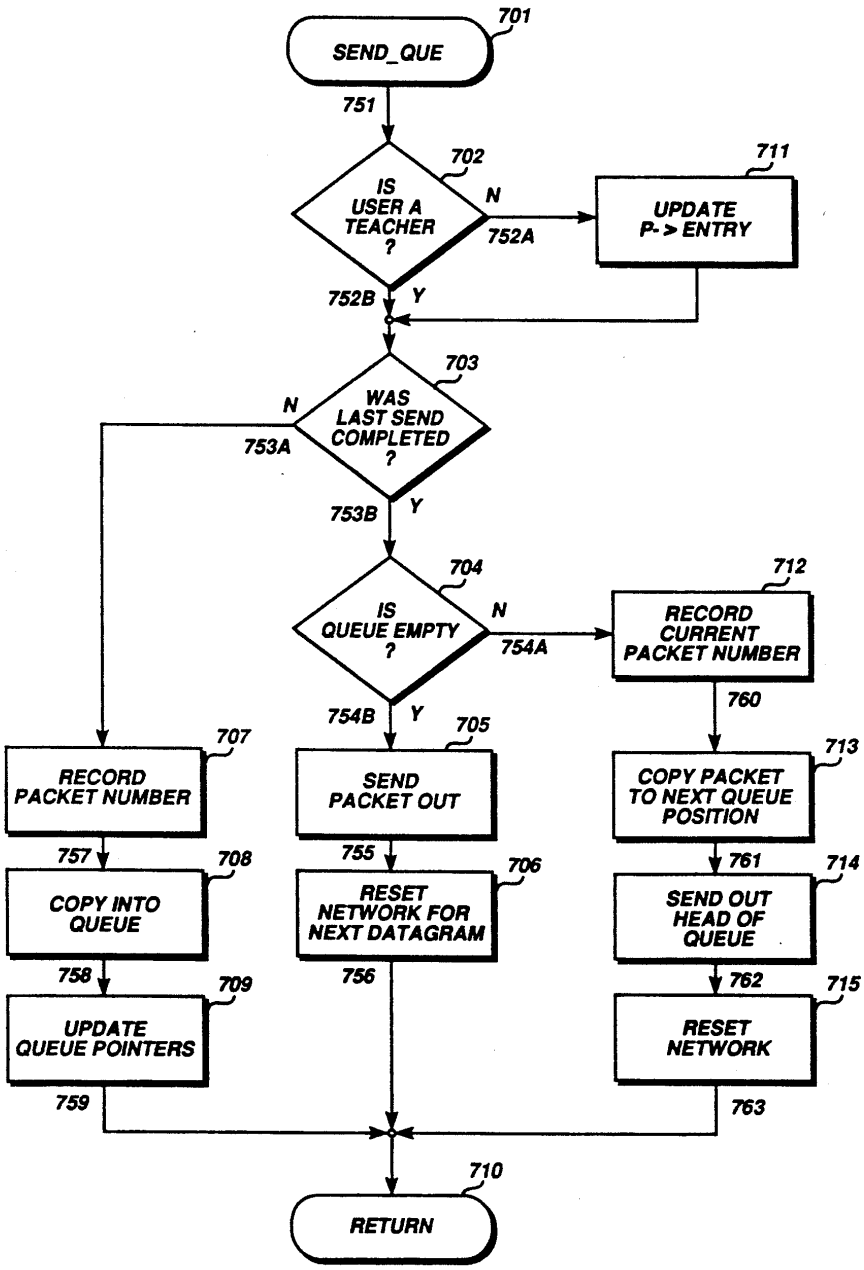

SEND_QUE
701
751
IS USER A TEACHER ?
702
N
752A
UPDATE P-> ENTRY
711
752B
Y
WAS LAST SEND COMPLETED ?
703
N
753A
753B
Y
IS QUEUE EMPTY ?
704
N
754A
RECORD CURRENT PACKET NUMBER
712
760
754B
Y
RECORD PACKET NUMBER
707
SEND PACKET OUT
705
COPY PACKET TO NEXT QUEUE POSITION
713
757
COPY INTO QUEUE
708
755
RESET NETWORK FOR NEXT DATAGRAM
706
761
SEND OUT HEAD OF QUEUE
714
758
UPDATE QUEUE POINTERS
709
756
762
RESET NETWORK
715
759
763
RETURN
710

Fig 8a

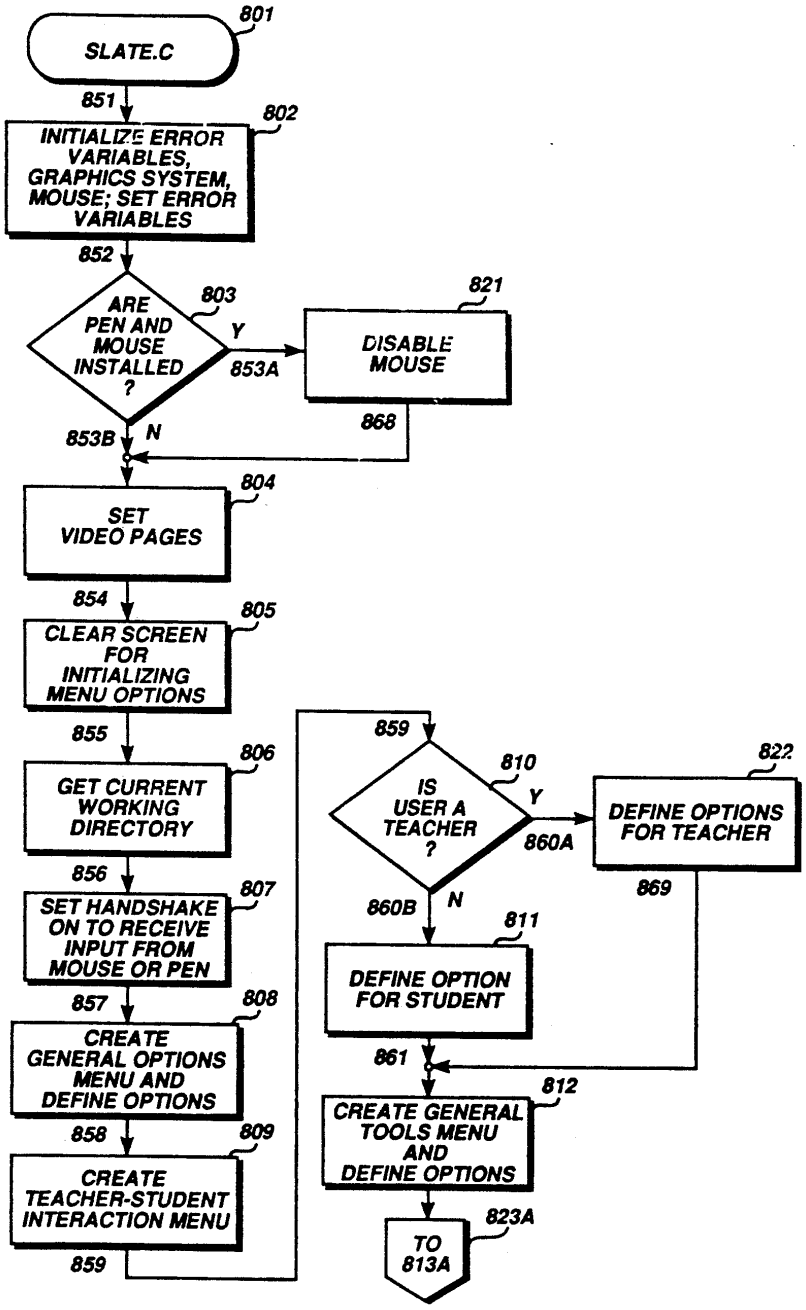
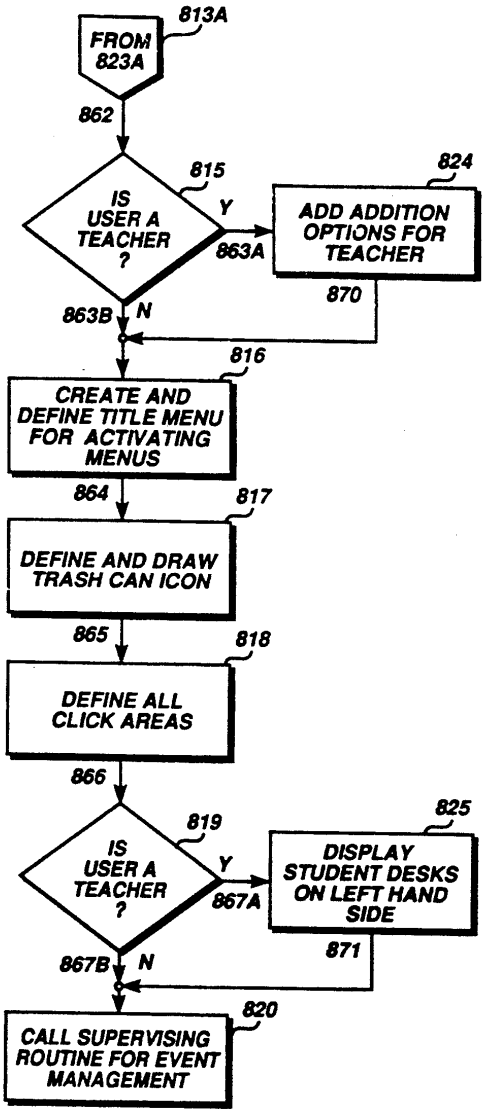

801
SLATE.C
851
802
INITIALIZE ERROR VARIABLES, GRAPHICS SYSTEM, MOUSE; SET ERROR VARIABLES
852
803
ARE PEN AND MOUSE INSTALLED ?
Y
853A
821
DISABLE MOUSE
868
853B
N
804
SET VIDEO PAGES
854
805
CLEAR SCREEN FOR INITIALIZING MENU OPTIONS
855
806
GET CURRENT WORKING DIRECTORY
856
807
SET HANDSHAKE ON TO RECEIVE INPUT FROM MOUSE OR PEN
857
808
CREATE GENERAL OPTIONS MENU AND DEFINE OPTIONS
858
809
CREATE TEACHER-STUDENT INTERACTION MENU
859
859
810
IS USER A TEACHER ?
Y
860A
822
DEFINE OPTIONS FOR TEACHER
869
860B
N
811
DEFINE OPTION FOR STUDENT
861
812
CREATE GENERAL TOOLS MENU AND DEFINE OPTIONS
823A
TO 813A

Fig 8b


813A
FROM 823A
862
815
IS USER A TEACHER ?
Y
863A
824
ADD ADDITION OPTIONS FOR TEACHER
870
863B
N
816
CREATE AND DEFINE TITLE MENU FOR ACTIVATING MENUS
864
817
DEFINE AND DRAW TRASH CAN ICON
865
818
DEFINE ALL CLICK AREAS
866
819
IS USER A TEACHER ?
Y
867A
825
DISPLAY STUDENT DESKS ON LEFT HAND SIDE
871
867B
N
820
CALL SUPERVISING ROUTINE FOR EVENT MANAGEMENT

COMPUTER ASSISTED INSTRUCTIONAL DELIVERY SYSTEM AND METHOD

As part of the specification hereto is a Microfilm Appendix as Computer-Output-Microfilm output affixed to 26 paper cards.

This invention relates to a computer-mediated communication system, the primary application of which is intended to be classrooms or other training or learning environments. More particularly, this invention relates to a configuration of computer hardware and software which enables two or more users (typically an instructor and student) at different stations to share what will be called electronic sheets of paper.

BACKGROUND OF THE INVENTION

A genre of training software that simulates simultaneous two-way communication has emerged in recent years. Such software typically involves an operator at one terminal taking control of an application at another station. Although control of the application reverts back and forth between operators at different stations, three critical differences distinguish such systems from the present invention. First, such prior systems always require a basic platform application, such as a word processor or spreadsheet. The present invention does not require such a platform application. Second, the present invention does not involve one operator taking control of an application. Two users may simultaneously control the application. Third, such applications do not contemplate free-hand writing or drawing to simulate paper and pencil writing and drawing as the principal means of effecting the shared communication.

Although some video instructional systems enable teachers to transmit images created by one student to appear at the stations of a full classroom in a single manner similar to this invention, these prior systems do not entail simultaneous and interactive communication between the teacher and student, either on a one to one or one to a selective group.

Prior instruction systems, such as that shown in U.S. Pat. No. 3,401,469 to Shaver and U.S. Pat. No. 4,486,180 to are severely limited in their flexibility and interaction capabilities. In Shaver, the interaction between student and a control center is over different channels in which the instructional material is prepared in advance, unlike the present invention in which the instructional material is constructed extemporaneously. The invention disclosed in Shaver is not interactive, in that the present invention affords the ability for the material being presented to the student to change on the basis of a teacher's response to the student's input. In Riley, no simultaneous and interactive communication is contemplated, because the system is intended for standardized tests. The present invention provides a medium of simultaneously written interactions between teacher and student.

Other known systems involve the use of predefined still video information such as U.S. Pat. No. 4,052,798 to Tomita, et al. The present invention disseminates information interactively by the teacher as the student works. There is no need to predefine information, and it is not "still" in that the video image seen by the student is always subject to change by the teacher.

Many prior systems are not applicable to written textual communication which is the most effective manner to teach grammar or mathematics, etc. U.S. Pat. No. 3,233,346 to Cornberg involves the use of a telephone system for the student to communicate to the teacher while the student views a video display of the teacher. The invention disclosed in Cornberg is severely limiting in that it does not allow one of the most fundamental means of communication, that being the writing mode, in which student and instructor can communicate.

Even currently known software products such as "Carbon Copy" made by Meridien Technology, a subsidiary of Microcom, Inc., do not allow interaction based on extemporaneous freehand input and rely on the use of preexisting application software rather than the application-free context that the present invention provides. Of all known computer assisted instructional systems, none provide interactive freehand input in an application-free context.

Numerous other advantages and features of the invention will become readily apparent from the detailed description of the preferred embodiment of the invention, from the claims, and from the accompanying drawings, in which like numerals are employed to designate like parts throughout the same.

SUMMARY OF THE INVENTION

The invention in its simplest form is a computer assisted instruction system for a classroom which allows a teacher to share an electronic sheet of paper with one or more students in the classroom, enabling both teacher and student to write on the same "sheet" virtually simultaneously from different parts of the room. At her choice and at her pace, the teacher can switch among students, observing and sharing their work space as their needs require.

The inventive concept consists in the preferred embodiment of the following. Each student's desk is equipped with a 14" monitor (i.e. "screen" or "display"). The monitor surface lies flat on the desk, flush with the desk's surface, and it is equipped with an attached stylus that looks much like a fiber-tipped pen, but with a hard tip. The teacher's station is equipped with a monitor as well (and may also be connected to a bank of small monitors). All of the student computers are linked to the teacher's station. As a student physically writes on the surface of his monitor with the stylus, the image that is written not only appears on that student's display, but is also transmitted simultaneously to the teacher's station. The teacher can passively observe the student's work, or actually interact with the student by writing on her own station at the front of the class, with the image moving back to the student on their display. In effect, the teacher and the student are sharing an electronic sheet of paper. Both can actually work with several electronic sheets of paper, and can "shuffle them" as one might shuffle loose pages taken from a notebook. The teacher can transmit the image from one student, to the whole class, or to a subset of the entire class. With a scanner, the teacher can send images from problem sheets, practice sheets, or even tests to all of the students, virtually copying them directly off of paper and onto the students' displays. Students can, when appropriate, get actual printed copies of their work, or save their work from one class to the next. The desk housing the student monitor will include a sliding cover, to protect the monitor when not in use.

If the teacher's station is equipped with a single monitor, she would be able to select which student's work to view just by touching an image (or "icon") on her monitor from the front. Because all student activity is trans-

mitted to the teacher's station as that activity occurs, the image of the newly selected student's work will immediately appear at the teacher's display.

In a mathematics classroom, for example, a teacher and a student may work together on the same problem from different locations within a classroom. The teacher, more particularly, can watch a student work, and jot down suggestions or comments on the student's sheet. The student may similarly pose questions to the teacher.

The teacher may also elect to transmit back to all students simultaneously. For example, if the teacher poses a geometry problem that she transmits to all of the students, she can wait for a few minutes, observing them and helping them as they work, and then send all of them some further information to help in the next step of the problem.

When equipped with a monitor of sufficient resolution, split screen capability, or when equipped with more than one monitor, the teacher may view the work of and communicate with several students simultaneously.

It is an object of this invention to enable a student and a teacher to share an electronic sheet of paper from remote locations, where the term "share" means that both teacher and student may write or draw on that electronic sheet of paper simultaneously from remote locations with the image produced by one appearing on screen of the other or both.

It is further an object of this invention to enable a student and a teacher to share an electronic sheet of paper from remote locations, where the term "share" also means that both teacher and student may type on that paper simultaneously from remote locations with the text produced by one appearing on screen of the other.

It is further an object of the invention that a teacher may monitor the written work of students by electronically selecting which student's paper will appear at the teacher's station. For example, by activating an icon (appearing in the teacher's monitor) corresponding to a particular student, the current image for that student then appears on the teachers monitor, and the teacher and the student may continue to work on the image together.

It is further the object of this invention that the teacher may transmit to a group of two or more individuals the same image, and the teacher would be able to write on his/her screen, with the result appearing simultaneously at all of the stations sharing that image. In fact, an entire group may work on the same electronic sheet simultaneously.

It is yet another object of the invention that students may discretely communicate with teachers by signaling to the teacher in a means that only the teacher and student can see that the student would like to pose a question. The student may jot down questions to the teacher on their display and the teacher's display without the rest of the class being privy to that communication.

The attainment of the foregoing and related objects, advantages, and features of the invention should be more readily apparent to those skilled in the art after review of the following more detailed description of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an external perspective view of a classroom system in accordance with the present invention.

FIGS. **2A–2C** represent an overall schematic diagram identifying the hardware components and connections of the present invention.

FIGS. **3A** and **3B** provide flow diagrams identifying the general operation of the present invention in which FIG. **3A** emphasizes the three communication systems (from the pen, from the network, and to the network), and FIG. **3B** depicts the background operation, primarily of the graphical user interface (GUI).

FIGS. **4A** and **4B** depict in flow chart form the specific flow of operations of the first communication system (from the pen).

FIGS. **5A–5C** depict in flow chart form the actual content of the second and third communication systems (to and from the network).

FIGS. **6A–6B** depict in diagram form the principal routine that integrates the first communication system with the second and third communication systems.

FIG. **7** depicts in diagram form how the implementation of the present invention manages network transmissions as they are requested in rapid succession.

FIGS. **8A–8B** depict in diagram form the source file SLATE.C, which includes the start-up main function, and the initialization of the system until the program is taken over by the graphical user interface (GUI).

BRIEF DESCRIPTION OF THE TABLES

Tables 1 and 2 each list the source code routines and .C files of the present invention, identifying in both Tables the page number in the Microfilm Appendix of each routine or file. Table 1 lists the routines and files in order of page number, and Table 2 lists the routines and files in alphabetical order.

Table 3 identifies key routines as they correspond to the processes depicted in FIGS. **3A** and **3B**.

The Microfilm Appendix includes two documents. The first, pages H1–H20, provides the actual list for the project (.PRJ) file and header (.H) files in the current implementation of the invention. The second part of the Appendix, pages C1–C133, provides the actual source code listing, arranged in alphabetical order by .C file name, and referenced in Tables 1 through 3.

With the Microfilm Appendix, Version 2.0 of the Turbo C Professional by Borland International of Scotts Valley, Calif., with the LITECOMM standard terminal software package referenced on page C25 of the Microfilm Appendix, and with the screen writing system identified in the next section, this implementation may be readily reconstructed and utilized in performing the novel features of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT OF THE INVENTION

While the invention is susceptible of embodiment in many different forms, there is shown in the drawings, tables, Microfilm Appendix, and will be described herein in detail, a preferred embodiment of the invention. It should be understood, however, that the present disclosure is to be considered an exemplification of the principles of the invention and is not intended to limit the spirit and scope of the invention and/or claims of the embodiments illustrated.

Turning now to the drawings, more particularly to FIG. **1**, there is depicted a facsimile of a classroom with the present invention implemented therein. A representative desk (**101**) houses the software and computer hardware for either teacher or pupil. A computer (**100**) is connected to a monitor (**102**) whose display (e.g., Cathode Ray Tube (CRT) or Liquid Crystal Display Type (LCD)) is flush against the surface of the desk. In the Figure, **102** illustrates the surface of the monitor. An optional keyboard (**103**) may also be connected to the computer (**100**). A conventional network bus (**112**) connects all of the individual desks (**101**, **106** and **151** through **161**). Such a network bus **112** may be effectuated by what is known as serial communication, but more typically will be effective using network protocols that operate at higher speeds (greater than 1.0 megabits per second) than typically available under serial protocols. Commonly used standard protocols for such networks are produced by Novell, Inc. (e.g., "Netware") and by International Business Machines (IBM) (e.g., "NetBIOS"). These conventional networks provide the means for computers to communicate with one another. The software component of the invention may be stored in a disk drive or in "read-only memory" at each station (i.e., inside the computer depicted in **100**) or at the central teacher station (**106**). In the preferred embodiment, the software is stored in a disk drive (not shown) at the teacher station. When the pupil at a student station uses the software, a copy of it is sent over the network bus (**112**) and stored in the "random access memory" (or "RAM") of the user's computer (**101**), and is run by that computer.

It is possible, in an alternative embodiment, that the student stations (**101** and **151–161**) do not actually house computers with "central processing units," but instead derive not only their disk storage from the teacher's station (**106**) but also derive their RAM storage and computing power from the computer at the teacher stations. In this case, each student station would function as a so-called "terminal," and would not include a computer (**100**). FIGS. **2A–2C**, discussed below, provide a schematic of the network bus **112** connections.

Also connected to the computer is a free-style handwriting system (**104**) to simulate to the user the ability to "write," either on the monitor or on a glass or glass-like sensor plate (**105**) resting above the monitor, just as one would "write" on a piece of paper with a pen or pencil. Thus, the display from the monitor (**102**) is directly beneath and is seen through the glass sensor (**105**). FIG. **1** depicts one possible writing configuration, namely the appearance of the same image on all desks if the teacher transmits the same image to all students. The handwriting system may consist of a corded or cordless light pen, in which the pen translates video signals and is so integrated with an interface card (**207** of FIG. **2A**) to send coordinates of the pen's position on the screen to the computer's central processing unit. Alternatively, the monitor itself may be so constructed as to allow the interception of coordinates as a pen-like object moves across its surface, as done by so-called touch screens. Finally, the system may also consist of a pen-like object and glass plate or glass-like plate, positioned directly above the monitor's surface, which are interfaced with the hardware in such a way that as the stylus moves across the surface of the plate, coordinate positions are relayed to the computer.

The preferred embodiment implementation, however, does not involve a light pen or touch screen. Instead, as mentioned, a sensor plate (**105**) is mounted above the monitor (**102**), and it is the combination of the sensor plate and stylus, rather than monitor and light pen, that produces the signals.

The housing and computer for the teacher's station (**106**) may be physically identical to that of any individual student station, although it is likely that a teacher's station may have an optional printer attachment (**110**). Any student station may also have such an optional printer attachment.

The teacher's display may also, at the teacher's option, include "icons" (**111**) appearing within the display. An "icon" is a small graphic symbol which, when referenced by the user, provides the user with access to the information or processes that the symbol represents. Under this implementation, each student at stations **101** and **151** through **161** are represented by a separate icon. When the teacher touches the screen where an icon for a student appears, the teacher and that student can begin hand-written screen-sharing communication. That is, both may write (using the pen system (**104**)) at his or her own station, and the image created by the writing of each user appears not only at that user's station, but at the other user's station as well.

FIGS. **2A–2C** more fully depict the physical components of the system. In FIGS. **2A–2C**, three separate and identical user or student/teacher stations are depicted (**270**, **271**, **272**). Only one of these stations **270** will be described herein, it being understood that the other two stations are identical (except as noted). The central processing unit with bus interface (**213**) is connected via a data bus (**214**) to the computer's remaining systems (**209**), including storage (**212**), (i.e., primary storage, or "RAM"; secondary storage, such as disk drive; or "read-only memory" ("ROM")), peripheral interface (**217**) (e.g., serial and parallel ports), auxiliary chips (**210**) (such as the standard "**8259**" interrupt controller, which prioritizes external interrupts (such as issued by a serial interface) to a central processing unit, and the network interface (**208**), which provides the computer with the physical means to communicate with other stations over the network bus. The central processing unit with bus interface (**213**) and communication lines to other components (**212**, **217**, **210**, **208**), and internal communications (**215** and **216**) comprise the computer system (**100**) of FIG. **1**.

Under the preferred embodiment implementation, the computer (comprised of blocks **260** and **209**) may involve an IBM-compatible system with a conventional Intel 80386 processor (included as part of **213**), with a standard interrupt controller (included in **217**), serial port (included in **210**), and "Invisible Network" Novell NetBIOS-compatible network system (with interface card depicted as **208**) from Invisible Software, Inc., Foster City, Calif. In the preferred embodiment, the central processing unit (**253**) at the teacher's station is significantly enhanced by the processing power of at least an 80386 chip with the capacity to access large blocks of random-access memory (greater than 640 kilobytes) as well as the capacity to use large blocks of RAM as a high speed substitute for secondary (e.g., disk) storage, although a less sophisticated chip (e.g., 8088) may be used at student stations.

The handwriting system is shown here as **204**, consisting of the pen or stylus (**206**), (**104** of FIG. **1**), a sensor (**205**) that rests above the monitor (**203**), and the interface system (**207**) (out of view in FIG. **1**, but housed in the desk (**101**)) that translates the pen strokes

on the sensor into event codes and coordinate positions for transmission via a data bus (218) back to the peripheral interface system. Under the preferred embodiment implementation, this transmission occurs via serial cabling. Such a handwriting system (204) is available as the Screenwriter TM system, from Microtouch Systems, Inc., 55 Jonspin Road, Wilmington, Mass. 01887. When a system such as the Screenwriter is the input medium for the three-communication system depicted in 301, 332, and 333 of FIG. 3A and the graphical user interface depicted in FIG. 3B, the shared screen writing of this invention is effected. The individual stations are connected to one another via the network cabling (273, 274).

FIGS. 2A–2C depict two student stations (270 and 271) and one teacher station (272). Student station 271 and teacher station 272 include the same components (except for the aforementioned central processor unit 253 at the teacher's station.) Thus, identifiers 221 through 238 correspond identically with identifiers 201 through 218, as do identifiers 241 through 258.

FIG. 3A identifies the three concurrently operating communication systems at a single user's station (either teacher or student) under this implementation of the invention, shown as enclosures within the three dotted boxes (301, 332, 333) in FIG. 3A. The first (301) involves the free-hand pen input, from a user. The second (332) involves transmissions sent over the network to the user from other stations. The third (333) involves transmissions sent from this station over the network to other stations.

Table 3 identifies the key functions in the source code for each process in both FIGS. 3A and 3B, with a page number reference to the Microfilm Appendix. (FIGS. 4–7 diagram the most important of these functions with respect to the critical simultaneous communication systems that effect a shared writing surface.)

FIG. 3B identifies the "background" system, including the graphical user interface (GUI), that displays to the user the user's input or the input from other stations in the network.

The implementation begins execution with initialization of all of the communication systems, the GUI management system, and other features of the execution environment (312). (The GUI system in this implementation was developed by Richard Tom of TEGL Systems, Inc., Vancouver, BC, as a graphical toolbox. Source code for the TEGL portion of the implementation, as it has been adapted for use here, appears between pages C74 and C133 of the Microfilm Appendix.)

The software application itself then proceeds as a continuous interaction of four systems: the three communication systems (from the pen to the software application (301), from the software application out to other stations in the network (333), and to the software application from other stations in the network (332)) and the GUI management system (FIG. 3B).

At the beginning of the program, the pen is assumed to be off of the input surface (303). The user holding the pen (302) can keep the pen off the surface, touch the pen on the surface (305), or move the pen over the surface in a writing or drawing fashion (306). From either a touch down or a moving position, the user may lift the pen off of the surface (304). An interrupt is issued whenever the pen's status changes (353, 357 and 355 lead to interrupt 354; 352, 358, and 356 lead to interrupt 397; 359 and 361 lead to interrupt 360). The interrupt handler receives the interrupt and begins processing five bytes of information from it: the command field, and two coordinates for each of the x- and y- coordinates identifying the location of the pen on the sensor when the interrupt occurred. The principal routine to perform the interrupt handling is int_getxy, diagrammed in FIGS. 4A and 4B, and beginning on line 72 of page C35 of the Microfilm Appendix.

The lower right dotted rectangle (333) of FIG. 3A depicts the second of the three concurrent communication systems. As coordinates are processed by the int_getxy routine, an evaluation of whether the input is to be transmitted is made at lines 88 through 94 of page C36 of the Microfilm Appendix, corresponding to 334 of FIG. 3A. If the data is to be transmitted, it is sent to the sending queue for transmission to appropriate other stations via the send_que routine (line 70 of page C31 of the Microfilm Appendix). This communication system involves transmission of a data packet which includes the coordinate and event information. (FIG. 7 diagrams the send_que routine.)

The lower left dotted rectangle (332) of FIG. 3A depicts the third communication system, namely incoming transmissions. Because transmission speeds over a network (e.g., over Ethernet) are typically faster than the signals from an input device (e.g., under serial protocols), it is actually possible that of two or more individuals sharing the same screen, a "remote" writer's input may appear on the screen more quickly than the "local" writer. The software application processes incoming coordinates from the pen or from remote sites on an interrupt-management basis, and gives to users the appearance of simultaneity. (FIGS. 5A–5C depict the network communication process in greater detail.)

A remote station sends a network transmission with a packet containing coordinate and event information (311, 365) to the user's station. When the packet arrives at the local station, a network interrupt is issued (311B), which, when serviced, places the packet onto a receiving queue (rec_int, on line 8 of page C31 of the Microfilm Appendix).

The data is copied out of the queue (310) and the coordinate values are computed (309) for use as if they were derived from the input device. Thus on-page connector C (328C) leads to on-page connector C (327C) for processing by the GUI (FIG. 3B) on the same path (off-page connectors D (395D in FIG. 3A and 396D in FIG. 3B)) as the pen input (372 and 367). Once coordinates are available from either a network transmission or from an interrupt from the pen, different GUI functions, especially including drawmouse (page C69 in the Microfilm Appendix and more fully diagrammed in FIGS. 6A–6B), process the coordinates to update to user's viewing area. Thus, if the pen (at either the local or remote station) is depressed (315), the location of the depressed area must be evaluated. If the (local) user is attempting to access a "drop-down" menu or is trying to access an option by touching a "button" on the screen (316) (for example, to change the pen from writing mode to erasing mode), the choice is processed (320–321). If the (local or remote) user is instead continuously depressing the pen in a writing area (317), a line is drawn to connect the location of that depression with the most previous one (318). (These "lines" are extremely short, and give the appearance of smooth, continuous drawing or writing.) As the drawmouse diagram of FIGS. 6A–6B note, this "connecting the dots" activity may constitute erasing parts of the screen if the user is in the erasure mode. If the depression of the pen

(317) is actually a "touch down" rather than a "continued draw," the coordinates are stored for subsequent connection. The drawing routine then checks to determine whether the (local or remote) user is continuing to write or has lifted the pen off of the surface of the screen.

Off-page connectors A (308A, 323A, 325A, and 350A in FIG. 3B) represent a flow of control back to off-page connector A in FIG. 3A (300A), to the routines that evaluate the status of the pen. However, this flow of control only occurs if pen activity has produced an interrupt of the GUI to indicate that the pen status or pen position has changed. Off-page connectors B (326B, 330B, 324B, and 331B in FIG. 3B) represent a similar flow of control to off-page connector B in FIG. 3A (329B) to determine whether network transmissions are available, although the GUI checks in a systematic fashion (with the check_net function of FIGS. 5A–5C) to determine whether network interrupts have left any coordinate data from a remote user available in the network "queue."

In FIGS. 3A and 3B, a number of marked connections identify the sequence of the aforementioned operations and evaluation of command field. These marked connections include 351–353, 355–359, 361–364, 366–367, 370–382, 384–387, 389–394, and 397–398. All of these connections represent standard flow of control pathways.

FIGS. 4A and 4B diagram the function int_getxy (beginning on line 61 of page C35 of the Microfilm Appendix), which processes interrupts issued by the pen interface (207 of FIG. 2A, and 354, 360, 397 of FIG. 3A). Significant portions of this routine are written as in-line assembler (lines 74–95 of page C35, lines 99–102 of page C36, and lines 1–7 of page C37 of the Microfilm Appendix) to simplify the view of the register-level activity of this function. The function (401) begins by enabling the type of maskable interrupt issued by the interface (402). The communications register that identifies whether serial data has arrived and is waiting to be latched from an input port is tested (403) for the availability of a incoming data. If not (453A), the transmit register is tested (404). If not empty, the function begins to exit by jumping (454B) to the lines which will clear the interrupt flag and exit the function. If the transmit register is empty, (454A), another test is required for this implementation for whether an XON must be issued prior to exit (406A). If not (456), the function jumps (457) to the exit lines, as it does after issuing an XON (406B) if one is necessary (455). The purpose of the int_getxy function, is to process a positive result from the (403) test for incoming data. If data is available (453B), it is read from the input port (405) and examined.

If the byte falls within a specified range, it is the first incoming byte (or header byte (407)) of a sequence of five bytes from the pen interface which identify one of three pen events (lift up, touch down, or continue draw) and the coordinate position of the reported event. If the byte is a header (439B), the reported event is recorded and a counter for the remaining four bytes is initialized (409). The communications register to signal that another byte of data has arrived and is ready to be latched is tested (408). If the result is positive (499A), flow of control returns to the code which reads the data (405), shown in the diagram by on-page connector A (443A) to on-page connector A (400A). A negative result to 408 begins the process of exiting the function (499B).

With the counter initialized, the subsequent four bytes are evaluated and processed at 410 through 413. Each time one of the four bytes is processed, the counter is incremented and the byte is stored for translation to screen-mappable x- and y-coordinates (414–417). The pen interface under this implementation identifies a point on a 1024×1024 point grid on the sensor (205 of FIG. 2A). The screen resolution may be 640×480. The first two bytes (410 and 411) report the horizontal position, and the second two bytes (412 and 413) report the vertical position Thus, after the second byte is processed, the x-coordinate for the screen can be computed (418), and the y-coordinate for the screen can be computed (419) after the fourth byte. An XON is also issued at 419 to signify that the full five byte expected transmission has been received.

Once the header and the coordinates have been latched and initially processed, they are further processed so that the GUI can update the display. This involves testing the header byte for the three possible events (lift-off, touch down, or continued draw) (420, 438, and 438B).

The GUI is an adaptation of "mouse" routines, and the mouse terminology of those routines is retained in this source code. A mouse is a hand-held device connected to a computer to provide a user with a flexible means of changing the location of the "currently active" portion of a screen, or to choose to carry out commands available by pressing or "clicking" the buttons on the mouse. A "mouse routine" is one which translates activity with the mouse, such as moving it, clicking a button, or releasing a button, into the action intended to follow as a result of that activity Thus, a lift-off corresponds to a mouse button release (421) whereas a touch down or a continued draw correspond to depressing a mouse button (434 and 435). Once the "release" or "depress" flags are set, the "release" or "depress" variables are updated with the new coordinates (422, 436, and 437), before an evaluation of whether the pen event involves a draw (423) or an erasure (425).

In either event, the coordinates are recorded for possible transmission to other stations in the network (424 and 426), to which they are sent via the send_que function (432, 431, 430), diagrammed in FIG. 7. FIG. 4B diagrams the testing of the flags to indicate whether a transmission of the header and coordinates should be issued to the teacher, to all of the stations, or to a student station (427–429). FIGS. 4A and 4B, which together diagram the int_getxy function, are joined by the two off-page connectors C (469C in FIG. 4A and 444C in FIG. 4B) and by the two off-page connectors D (442D in FIG. 4A and 441D in FIG. 4B.

Once the new coordinates have thus been processed, and the available data register shows no new data, the function is exited. When the GUI detects that the interrupt from the pen to its background activity has produced a flag showing that a "mouse" button is depressed (i.e., that the pen is pressed against the surface of the sensor above the monitor), the GUI calls the "drawmouse" function (page C66 of the Microfilm Appendix that is diagrammed in FIGS. 6A–6B), and the coordinates of the drawing are placed on the screen. It is during the drawmouse function that the check_net function (page 60 of the Microfilm Appendix), diagrammed in FIGS. 5A–5C, is called to see if any network interrupts from a remote station have placed coor-

dinate drawing data from that station to also be included in the drawing on the screen.

The lines in FIGS. 4A and 4B depict the flow of control from one process or test within the function to the next. These lines are referenced by identifiers 439A, 439B, 445 through 446, 448 through 449, 451 through 468, and 470 through 499.

FIGS. 5A-5C together diagram the flow of control for the check_net function, on pages C69-C70 of the Microfilm Appendix. The check net function is the communication handler that translates network communications between stations into information that the GUI can use to produce the shared screen effect of the invention. This function runs in the GUI background (FIG. 3B) and is also called at various points when update values are expected from network interrupts. In particular, check_net is called by the drawmouse function as shown in FIG. 7.

The check_net function begins by reading the network queue (502) via the read_que function (page C31 of the Microfilm Appendix) to determine if any transmissions await processing. A transmission, except when involving a full screen of graphical data, occurs in increments of PACKETs, defined on line 50 of page H10 of the Microfilm Appendix. When presented in upper case letters, PACKET refers to a specific variable to be transmitted over the network. A packet includes a one byte command field, a name field to transmit a student's name, a table entry field to identify a student by code, a character field when passing typed characters (or the eraser radius during erasures), a font identifier, and the x and y coordinates identifying the location of the event being shared by the screens.

The check_net function is the conversation between stations. The "first word" of every communication between stations is the command field, and it identifies how the receiving station should interpret the "rest of the conversation." The current implementation at the source level allows these command fields: ACK_CALL, ASK_HELP, ON_LIST, BEING_HELPED, NOT_ALLOW, CALL_TEACHER, DROP_NAME, SEND_COPY, STOP_SEND, SCREEN_COPY, KBRD_INPUT, ABS (for touch down of the pen at remote station), REL (to signify continued writing after a touch down), and ERASER.

The polling (503) to determine whether an interrupt was previously issued resulting a PACKET being stored on the queue is effected by returning a zero if there was none (532A) (which simply produces a return to the calling function) or a non-zero (i.e., "true" or "yes" condition) pointer to a copy of the PACKET (532B), at which point a case statement evaluates the command field of the PACKET. (Path 532A leads to an exit diagrammed in FIG. 5B (515B) where the exit path continues to off-page connector 539B in FIG. 5C, leading to a return (562). The exit path in the diagram leads through off-page connectors B (515B in FIG. 5B and 539B in FIG. 5C.)) The flow-of-control arrows 533B, 534B, 535B, 542, 543B, 544B, 545B, 578, 579A, 580A, 581A, 582A, 583A, and 584A of FIGS. 5A-5C all signify that the test to identify the command in the PACKET has not yet succeeded. Only student stations under this implementation will receive the ACK_CALL command (504, line 51 of page C69 of the Microfilm Appendix), signifying that the teacher has acknowledged that the student has logged onto the system and has returned an identifier for an internal table at the teacher station for that student. The student station then stores the identifier (508) and the routine then exits (i.e., flow of control returns to the instruction immediately after the one that called the check_net function.) Only teacher stations will receive requests for help commands (505, line 55 of page C69 of the Microfilm Appendix) which are followed by examining whether questions are being allowed (509). If not (536A), a transmission is sent back to the student with the command field set to DISALLOW. Otherwise, the command field is set (511) to tell the student s/he is on the list for help (line 61 of page C69 of the Microfilm Appendix) or to remind the student s/he is already being helped (line 69 of page C69), and that command is sent back to the student (513) prior to exit (541). Thus, these newly set command fields (to signify "no help allowed," "already being helped," or "on list to be helped") are transmitted back to the student (512 or 513, leading to connector 517B, where the exit path continues to connector 539B in FIG. 5C, leading to a return (562)). If the student station receives one of these responses (506), the appropriate message is displayed (510), and the function exits (536).

When a new station physically logs onto the network at the time it is booted, an identifier is issued by the network software. When a student first logs onto this software implementation, it issues a call to the teacher for an identifier. This is the identifier the student stores (508) when it receives an acknowledgement (504) of this call to the teacher. The call itself (517, line 91 of page C69 of the Microfilm Appendix) is received by the teacher's station, which looks up the student's identifier issued by the network (520), and returns it to the student (525) with the command field of the outgoing PACKET set to ACK_CALL (523). Next, the GUI displays the name on the teacher's screen before restoring the screen to its appearance before the name display (526). Control then returns to the calling function (552).

A DROP_NAME command field (518, line 2 of page C70 of the Microfilm Appendix) will result when the student logs off the system; when the teacher's station receives a PACKET with this command field, the student's name is dropped (521) from the table position it took when the teacher's station received the first PACKET from the student, containing the CALL_TEACHER command (517). Once the name is dropped, control returns to the calling function (547).

If the command field requests a copy of the screen 519, (line 5 of page C70 of the Microfilm Appendix), a large transmission of a window takes place (522) from student to teacher (in contrast to the small transmission of a PACKET). Under this implementation, only teachers can request screens, and, if transmission of the screen (522) is successful (524), a flag at the student's station is turned on (527) to signify that all subsequent events are to be transmitted. This flag is evaluated by the drawmouse function, diagrammed in FIG. 6A (604).

Continuing from off-page connectors C (554C in FIG. 5B and 555C in FIG. 5C), if either a student or teacher receives a full copy of a remote screen, a PACKET is sent with the SCREEN_COPY value in the command field (556, line 12 of page C70 of the Microfilm Appendix). The receiving station must have screen space available (563). If such space is not available, an empty screen is created (577) and the screen can be received (576) before the function is exited.

If the teacher terminates communication with a student, the teacher's station will send a STOP_SEND PACKET to the student 557, (line 9 of page C70 of the

Microfilm Appendix) which will turn off the "send to teacher flag" (564) prior to exiting (597).

Under this implementation, with an optional keyboard, users can type on one another's screen simultaneously. If the PACKET specifies keyboard input (KBRD_INPUT) (558, line 18 of page C70 of the Microfilm Appendix) and an available drawing area (565), a temporary font value is recorded (575) from the PACKET (implying that two different fonts, one for each person sharing the drawing or typing area may be used simultaneously). The PACKET includes a character value for transmission in keyboard mode, which is then displayed by the GUI (574), which will also restore any drop-down menu information that is sharing the same space as the keystroke from the remote station (also 574). (If necessary, a drawing area is established to receive the input (566)).

Of the aforementioned commands, only SEND_COPY, SCREEN_COPY, and KBRD_INPUT produce changes in the user's writing area. The next two command fields, ABS and REL, produce the actual shared drawing on a screen. When an ABS is received (559, line 35 of page C70 of the Microfilm Appendix), the user at the sending station has just pressed the pen to the sensor (305 of FIG. 3A), and the absolute coordinates of the touch down are recorded (573) so that, unless the pen is immediately lifted, a connection can be made between the point at these absolute coordinates and the point at the coordinates where the next interrupt is issued by the pen's serial interface at the remote station. At that next interrupt, a new PACKET is sent by the remote station, with the command field set to REL (560, line 40 of page C70 of the Microfilm Appendix), and the relative position from the last touch down or drawing interrupt (whichever is more recent) is included in the PACKET. A line is drawn (572) from the point at the last pair of coordinates to the point at this new set of coordinates. The value of the coordinates is then saved for use when a subsequent PACKET arrives with the command field set to REL. Control then returns to the calling function (593).

The final communication mode that occurs under this implementation is the ERASER mode. If the command specifies that the remote sharing user is using an eraser (561, line 63 of page C70 of the Microfilm Appendix), a white "fillbar" (i.e., a small rectangle of blank space that can be positioned anywhere on a screen to "white out" or "erase" anything that is at that position) is set up by the GUI, which also determines whether the eraser, perhaps being at the edge of the drawing area, must be truncated (508) (and so it prepares to restore information that overlaps with the eraser (570)). The White bar (i.e., eraser) is then moved across the drawing area by the GUI (571). The size of the white bar is passed in the PACKET through the character field, which is otherwise used for transmitting keystrokes in keyboard mode (574). The center of the eraser is given by the x and y coordinates passed by the PACKET. After the GUI places the eraser with a white fillbar over the desired area, and restores any menu areas with which it overlapped, control passes back to the calling function (594).

In FIGS. 5A–5C, the lines identify the sequence of the aforementioned operations and evaluation of command field. These marked connections include all of connections from 530 through 538, 540 through 553, and 578 through 597.

FIGS. 6A–6B diagram the drawmouse function, as it appears beginning on line 65 of page C66 of the Microfilm Appendix. The function (601) begins with GUI calls (lines 72 through 77 on page C66 of the Microfilm Appendix) which set up the active drawing area. The current active point is set to the x- and y- coordinates (603, line 78 of page C66 of the Microfilm Appendix) originally assigned in the int_getxy function which processes interrupts from the pen interface. Thus, the x- and y- coordinates that are critical to this drawmouse routine are those assigned in the int_getxy function on lines 53–54, 62–63 and 70–71 on page C36 of the Microfilm Appendix), and these are the same coordinates within this function on the aforementioned line 78 of page C66 of the Microfilm Appendix. If a mouse rather than a pen is the input device and if the coordinates are to be sent to the teacher (604) or to the entire class (605), a call to the function send_pt is issued with either the TEACHER or ALL_STUDENTS as a destination parameter. send_pt is a short function (line 3 on page C32 of the Microfilm Appendix) which prepares the data for transmission through the network via the send_que function which it calls (FIG. 7).

The evaluation of whether the pen is depressed within the "frame" or "drawing area" leads to, on positive result, the execution of a loop beginning its iteration at 656A and ending its iteration at 659. The loop stops executing once the pen is no longer being depressed within the frame. The most important points in the loop are the check_net calls (609 and 612, diagrammed in FIGS. 5A–5C) to determine whether a transmission should be processed, and the draw line (or erasure) instructions at 614.

One of the most important features of this invention involves effecting simultaneous shared drawing. The draw line instruction within this loop (614) connects points whose coordinates were produced after the pen interface interrupts the application with pen signals. This draw line instruction appears on line 29 of page C67 of the Microfilm Appendix. Within the same loop, the check_net function is given two opportunities (609 and 612) to draw on the screen, corresponding to 572 of FIG. 5C and to line 62 of page C70. Within a high speed loop which captures incoming coordinate data generated by both the serial (local) or network (remote) interrupts, points can be displayed to effect the simultaneous and shared drawing.

After the initial check_net call (609) to process simultaneous remote activity, the local user's mode is evaluated as either keyboard input (610) or drawing or erasure (611) mode. If the user is in keyboard mode, the function waits for the pen to be lifted from the sensor (613). When the pen is being depressed, the user is identifying the location on the sensor where typed input should appear. Thus, once the pen is released (and the "mouse_buttons" flag (line 99 of page C66) of the mouse-based GUI is set to zero) the keystroke may be displayed (615) and the iteration of the main loop of this FIG. 7 function may start again, following another check_net call (612) to determine if any remote activity needs to be reported on the local screen.

Similarly, if the user is in a drawing or erasure mode (611), the line is drawn or erasure effected (with a white fillbar) (614). An evaluation of whether the communication is being shared with the teacher (616) (if this is a student station) or with other students (618) (if this is a teacher station) results in those coordinates with destination being sent (if a mouse rather than a pen is used) to the aforementioned sent_pt function (617 and 19), which prepares them for transmission to the appropriate

destination via the send_que function diagrammed in FIG. 7. Whether or not the local user is sending data at the time that keyboard, writing, or erasing activity occurs locally, a check_net call is issued (612) to determine if any remote activity needs to be updated on the local screen, before the iteration begins again (606).

All of identifiers 651 through 663B, 665A, 665B, 667A, and 667B refer to lines that depict the flow of control in the drawmouse function. The function is exited (620) when there is no further local or remote mouse activity within the frame or drawing area.

FIG. 7 diagrams the send_que function, as it appears beginning on line 69 of page C31 of the Microfilm Appendix. The send_que issues the Net_Send_Datagram call (page C29 of the Microfilm Appendix) that transfers packet information into a network control block ("ncb") before issuing the NetBIOS(ncb) call (line 11 of page C23 of the Microfilm Appendix) that physically transfers the ncb to a remote station.

The send_que thus manages the traffic of outgoing messages to the network. An evaluation of whether the most previous send was completed (703) is followed, upon positive result, with an evaluation of whether the sending queue is now empty. If not (754A), the packet that accompanied the call to the function is prepared for transmission. The packet is copied into a transmission packet that the aforementioned Net_Send_Datagram receives when it is called to prepare a network control block for transmission via a NetBIOS call (705). The Net_Send_Datagram call also updates the network for the next transmission (706) before the function terminated.

If the evaluation of the most recent transmission (703) shows that it is still in progress, the current packet cannot go out immediately (753A), at which point its identifier is recorded in a queue table (707), the packet is copied into the head of the queue (708) (which, in the terminology of the source code here implies that it will be the "last" out), and the appropriate queue pointer is updated (709).

If the most recent transmission is completed but the queue is not empty (754A), the new packet will still have to enter the queue rather than get sent out right away. The same instructions are followed in this case, with one noted exception: the packet identifier is stored in a queue table (712) and then the packet itself is copied into position (713), as when the packet goes into a queue while another packet is still in transmission (707 and 708). In this case, however, because the most recent transmission is completed, the packet at the "tail" of the queue (i.e., first in line to go out) is transmitted (714) and the network is reset for the next send (715). Thus, transmissions occur if requested when either there is an empty queue (754B) or when a subsequent request occurs (714).

The lines in FIG. 7 depict the flow of control from one process or test within the send_que to the next. These lines are referenced by identifiers 751 through 763. The implementation of this application may be reconstructed using the 29 source or object files identified in the SLATE.PRJ file on page H1 of the Microfilm Appendix. As SLATE.PRJ indicates, the flow of control begins with instructions in the SLATE.C file, which appears beginning on line 100 of page C49 of the Microfilm Appendix.

FIGS. 8A–8B diagram the activity within SLATE.C to begin the implementation. The main program appears at line 86 on page C71 of the Microfilm Appendix, and it completes the initialization (802), followed by a determination of whether the input device is a mouse or pen (803) Thus, the implementation may be reconstructed using a mouse instead of a pen. When the pen is used (853B), the mouse is disabled (821). Next, the environment for the application is setup by activities 804 through 809. This application requires extensive video paging which can be implemented in primary storage (804). Other initialization activities include clearing the screen (805), getting the working directory (806), setting up the serial handshake for communication with the pen or mouse (807, on line 8 of page C72 of the Microfilm Appendix), creating the menu that appears at both teacher and student stations (lines 15–26 on page C72 of the Microfilm Appendix), and creating the student-teacher interaction drop-down menus (809) that appear at both teacher and student stations (line 28 of the same page). Next, menu options that are specific to the teacher (822) or student (811) are defined after evaluation of the flag indicates whether the user is a teacher (810). This application anticipates the implementation of a set of auxiliary drawing tools, not unlike commonly available computer graphic paint programs, but also including other features such as a calculator that may be called up into the display. The SLATE.C program creates the common tools menu and defines the available options in (812). Off-page connector 823A continues by repeating the process for the general menu, namely creating teacher-specific (824) or student-specific options depending on the type of user (815). The title bar for the menus is created (816) as is a trash can icon (817). The "click areas" that define what events occur when a given spot on the screen is touched by the pen (or mouse, when a button is depressed) are then initialized (818). Finally, the icons appearing in FIG. 1 (111) that correspond to student desks, are displayed (825) at the teacher's station after the program determines that the user is a teacher (819).

The lines in FIGS. 8A–8B depict the flow of control from one process or test within the SLATE.C modules to the next. These lines are referenced by identifiers 851 through 871.

After the foregoing initialization of GUI, the program then transfers control to the GUI manager, called the "teglsupervisor." The GUI manager effectively updates the screen through the activities diagrammed in FIG. 3B, as the screen is modified by the three concurrent and interrupt-driven communication systems of FIG. 3A.

The foregoing specification describes only the preferred embodiment of the invention as shown. Other embodiments besides the one described above may be articulated as well. The terms and expressions therefore serve only to describe the invention by example only and not to limit the invention. It is expected that others will perceive differences which while differing from the foregoing, do not depart from the spirit and scope of the invention herein described and claimed.

TABLE 1

C routines and Source File Names (in CAPS) Referenced to and Ordered By Microfilm Page Number	
DEBUGUNT.C	1
showcoordinates	1
RotateStackImage	1
showbuttonstatus	1
EGAGRAPH.C	2
xorcornerbox	3
xorbox	3

TABLE 1-continued

C routines and Source File Names (in CAPS) Referenced to and Ordered By Microfilm Page Number

setapage	3
setvpage	3
videopage	3
flipapage	3
flipvpage	3
abort_msg	4
setgraphicmode	4
vga640×480×16	4
ega640×350×16	4
egagraph_terminateexit	4
init_egagraph	4
EGAMOUSE.C	4
key	7
setshiftkeys	7
deletecapturekey	7
addcapturekey	7
teglreadkey	7
teglkeypressed	8
setmousehotspot	8
getmousesensitivity	8
setmousesensitivity	8
hidemouse	8
setmouseposition	8
cursorshape	8
showmouse	9
mouseposition	9
kbmouse	9
getbuttonpressinfo	12
getbuttonreleaseinfo	12
clearbuttoninfo	12
setmousecolor	13
controlbreakhandler	13
timerhandler	13
egamouse_terminateexit	13
checkparameters	13
timerswitch	14
swaptimerout	14
swaptimerin	14
swapegamouseoff	14
swapegamouseon	14
settimerstart	14
droptimercount	14
resettimerflag	15
setkeyboardmouse	15
setkbsteps	15
getkbsteps	15
setmouseminmax	15
frozenmouse	15
switch_t	15
ega_overlap	15
overlaps	16
freezemouse	16
unfreezemouse	16
init_egamouse	16
EMS.C	16
EMSPagesAvailable	17
AllocateExpandedMemoryPages	17
MapExpandedMemoryPages	17
GetPageFrameBaseAddress	17
DeallocateExpandedMemoryPages	17
GetVersionNumber	17
GetHandleCountUsed	17
GetPagesOwnedByHandle	18
EMSDRIVE.C	18
emsseek	18
emsblockwrite	19
emsblockread	19
emsclose	20
FONTTEST.C	20
closefontwindow	20
fontname	20
selectfont	20
createfontwindow	21
showonefont	22
showfonts	22
HEAPMEM.C	22
initheap	22
cgetmem	22
cmaxavail	23
showfreelist	23

TABLE 1-continued

C routines and Source File Names (in CAPS) Referenced to and Ordered By Microfilm Page Number

fgetmem	24
cfreemem	24
LCCIO.C	25
LCFLSH.C	25
LCSETUP.C	25
NETBIOS.C	25
check_phys	25
adjust_name	25
fill_str	25
Net_Reset	25
Net_Cancel	25
Net_Adapter_Status	26
Net_Identify	26
Net_Trace	26
Net_Presence_Test	26
Net_Add_Name	26
Net_Add_Group_Name	26
Net_Del_Name	26
Net_Find_Name	27
Net_Call	27
Net_Listen	27
Net_Hang_Up	27
Net_Send	27
Net_Chain_Send	28
Net_Incomplete_Send	28
Net_Receive	28
Net_Chain_Receive	28
Net_Receive_Any	28
Net_Status	28
Net_Send_Datagram	29
Net_Low_Overhead_Datagram	29
Net_Send_Broadcast_Datagram	29
Net_Receive_Datagram	29
Net_Receive_Broadcast_Datagrm	29
NETSTUFF.C	30
addto_sessionlist	30
listen_int	30
rec_int	31
interrupt send_int	31
read_que	31
send_que	31
send_pt	32
send_key	32
send_erase	32
send_screen	32
receive_screen	32
click_student	33
close_all_sessions	33
init_net	33
close_net	34
PEN_ROUT.C	35
int_getxy	35
setup_pen_int	37
close_pen_int	37
init_table	37
comm_gets	37
comm_puts	38
lc_getwait	38
pen_speed	38
set_pen	38
wait_ok	38
calibrate_left	38
calibrate_right	39
swapcommon	39
swapcommoff	39
SELECTFL.C	39
insert	40
addlistentry	40
getnumberoflogicaldrives	40
getfilelist	40
freefilelist	41
barline	41
editstring	41
listfilenames	43
showdirectorylist	44
updir	44
SENSEMS.C	47
setmousesense	48
SLATE.C	49
editchar	50

TABLE 1-continued

C routines and Source File Names (in CAPS) Referenced to and Ordered By Microfilm Page Number	
debug_info	53
beep	53
add_to_queue	53
drop_from_queue	54
clear_queue	54
find_entry	54
find_in_queue	54
print_name	54
update_name	55
drop_name	55
trunc_eraser	55
within	55
fontnum	56
askforhelp	57
viewoptiontoggle	57
toggle_copy	57
trashevent	57
fileselectionoption	58
definelongbutton	58
new_drawing	58
display	59
read_screen	59
sgetc	60
sggtw	60
save_screen	60
restore_screen	61
save_drawing	62
load_drawing	63
distrib_stud	63
distrib_every	63
deskoption	63
remove_menu	64
font_select	64
eraser_size	65
set_eraser	65
set_keyboard	65
calibrate	66
drawmouse	66
drop_fromlist	67
select_icon	67
add_to_drawlist	67
store_drawing	68
close_drawing	68
clear_pad	68
exitoption	68
infooption	68
checknet	69
list_students	70
initialize	71
main	71
TEGL.C	74
clockupdate1	74
clockupdate2	74
viewoptiontoggle	75
creditbox	75
fileselectionoption	75
menumouseposition	76
askmousesense	76
calldosexec	76
creditoption	76
trashevent	77
trashoption	77
exitoption	78
infooption	78
main	78
TEGLGRPH.C	80
drawlongbutton	80
setshadowcolor	81
setshadowbordercolor	81
setshadowfillpattern	81
setshadowfillstyle	81
shadowbox	81
setshadowtexttype	81
setshadowtextshadow	81
setshadowtexthighlight	81
shadowtexthighlightoff	81
shadowtext	81
shadowboxtext	82
setteglbordershow	82
setteglbackcolor	82

TABLE 1-continued

C routines and Source File Names (in CAPS) Referenced to and Ordered By Microfilm Page Number	
setteglbordercolor	82
setteglfillpattern	82
setteglfillstyle	82
clearteglscreen	82
movebox	83
transformbox	83
ziptobox	84
zipfrombox	84
TEGLICON.C	84
TEGLMENU.C	97
positionmenu	97
togglecheckmark	97
toggleentrystatus	97
createoptionmenu	98
defineoptions	98
resizeoptionmenu	98
replaceoptiontext	99
listoptionmenu	99
setoptionmenubordercolor	102
setoptionmenucolors	102
baroptionmenu	102
resetoptionmenuevents	103
defineoptionclickarea	103
createbarmenu	104
outbaroption	104
setbarmenucolor	104
setbartextcolor	104
setbarbordercolor	104
setbarborderoff	104
setbarfillstyle	104
setbarshadowtext	105
TEGLUNIT.C	105
keybrdnextclick	105
crclickpress	106
crclickrelease	106
pageoutstatus	107
pageoutfs	107
pageoutimagestack	107
pageinfs	108
useimage	108
unuseimage	108
unlockimage	108
setimagecoordinates	108
putpartialimage	108
getpartialimage	108
linkfs	109
linkunderfs	109
unlinkfs	109
switcht	109
overlap	109
overlaparea	110
insertnewoverlap	110
mergepartialimage	112
preparepartialimage	112
pushimage	112
popimage	112
prepareforpartialupdate	113
prepareforupdate	113
prepareupdatemsclick	113
commitupdate	113
commitimageupdate	113
hideimage	113
showimage	114
rotatestackimage	114
rotateunderstackimage	114
moveframe	115
setmoverestrictions	116
setframemobility	116
setmoveframecallproc	116
movestackimage	116
dropstackimage	116
createimagebuffer	116
freeimagebuffer	117
dropimagebuffer	117
commitimageupdate	117
getfrontimage	118
getfsimage	118
clearkeyboardbuf	118
resetmouseclicks	118
resetmsclicksense	119

TABLE 1-continued

C routines and Source File Names (in CAPS) Referenced to and Ordered By Microfilm Page Number	
resetmsclickcallproc	119
resetmsclickactive	119
definemouseclickarea	119
defineglobalkeyclickarea	119
definelocalkeyclickarea	120
dropkeyclick	120
resetkeyclickcallproc	121
cursorblock	121
toggleoptionbar	121
pressbutton	121
visualbuttonpress	122
checkctrlbreak	123
selectmenu	123
teglsupervisor	124
setctrlbreakfs	124
settimertick	124
droptimertick	124
memoryerrormessage	124
abortdiskerror	125
init_teglunit	125
TEGLWRT.C	125
setproportional	125
delete	125
tegltextwidth	126
outtegltextxy	126
VIRTDSK.C	127
vdskshowfreelist	127
checksum	127
vdskseek	127
vdskblockread	127
vdskblockwrite	128
vdskgetmem	128
vdskfreemem	129
vdskreadheapdata	129
vdskwriteheapdata	130
vdskcloseheapfile	130
VIRTMEM.C	132
freevirtual	132
movefromvirtual	132
disksize	132
movetovirtual	133

TABLE 2

Alphabetized C routines and Source File Names (in CAPS) Referenced to Microfilm Page Number	
abortdiskerror	125
abort_msg	4
addcapturekey	7
addlistentry	40
addto_sessionlist	30
add_to_drawlist	67
add_to_queue	53
adjust_name	25
AllocateExpandedMemoryPages	17
askforhelp	57
askmousesense	76
barline	41
baroptionmenu	102
beep	53
calibrate	66
calibrate_left	38
calibrate_right	39
calldosexec	76
cfreemem	24
cgetmem	22
checkctrlbreak	123
checknet	69
checkparameters	13
checksum	127
check_phys	25
clearbuttoninfo	12
clearkeyboardbuf	118
clearteglscreen	82
clear_pad	68
clear_queue	54
click_student	33
clockupdate1	74

TABLE 2-continued

Alphabetized C routines and Source File Names (in CAPS) Referenced to Microfilm Page Number	
clockupdate2	74
closefontwindow	20
close_all_sessions	33
close_drawing	68
close_net	34
close_pen_int	37
cmaxavail	23
commitimageupdate	113
commitimageupdate	117
commitupdate	113
comm_gets	37
comm_puts	38
controlbreakhandler	13
crclickpress	106
crclickrelease	106
createbarmenu	104
createfontwindow	21
createimagebuffer	116
createoptionmenu	98
creditbox	75
creditoption	76
cursorblock	121
cursorshape	8
DeallocateExpandedMemoryPages	17
DEBUGUNT.C	1
debug_info	53
defineglobalkeyclickarea	119
definelocalkeyclickarea	120
definelongbutton	58
definemouseclickarea	119
defineoptionclickarea	103
defineoptions	98
delete	125
deletecapturekey	7
deskoption	63
disksize	132
display	59
distrib_every	63
distrib_stud	63
drawlongbutton	80
drawmouse	66
dropimagebuffer	117
dropkeyclick	120
dropstackimage	116
droptimercount	14
droptimertick	124
drop_fromlist	67
drop_from_queue	54
drop_name	55
editchar	50
editstring	41
ega640×350×16	4
EGAGRAPH.C	2
egagraph_terminateexit	4
EGAMOUSE.C	4
egamouse_terminateexit	13
ega_overlap	15
EMS.C	16
emsblockread	19
emsblockwrite	19
emsclose	20
EMSDRIVE.C	18
EMSPagesAvailable	17
emsseek	18
eraser_size	65
exitoption	68
exitoption	78
fgetmem	24
fileselectionoption	58
fileselectionoption	75
fill_str	25
find_entry	54
find_in_queue	54
flipapage	3
flipvpage	3
fontname	20
fontnum	56
FONTTEST.C	20
font_select	64
freefilelist	41

TABLE 2-continued

Alphabetized C routines and Source File Names (in CAPS) Referenced to Microfilm Page Number	
freeimagebuffer	117
freevirtual	132
freezemouse	16
frozenmouse	15
getbuttonpressinfo	12
getbuttonreleaseinfo	12
getfilelist	40
getfrontimage	118
getfsimage	118
GetHandleCountUsed	17
getkbsteps	15
getmousesensitivity	8
getnumberoflogicaldrives	40
GetPageFrameBaseAddress	17
GetPagesOwnedByHandle	18
getpartialimage	108
GetVersionNumber	17
HEAPMEM.C	22
hideimage	113
hidemouse	8
infooption	68
infooption	78
initheap	22
initialize	71
init_egagraph	4
init_egamouse	16
init_net	33
init_table	37
init_teglunit	125
insert	40
insertnewoverlap	110
interrupt send_int	31
int_getxy	35
kbmouse	9
key	7
keybrdnextclick	105
LCCIO.C	25
LCFLSH.C	25
LCSETUP.C	25
lc_getwait	38
linkfs	109
linkunderfs	109
listen_int	30
listfilenames	43
listoptionmenu	99
list_students	70
load_drawing	63
main	71
main	78
MapExpandedMemoryPages	17
memoryerrormessage	124
menumouseposition	76
mergepartialimage	112
mouseposition	9
movebox	83
moveframe	115
movefromvirtual	132
movestackimage	116
movetovirtual	133
NETBIOS.C	25
NETSTUFF.C	30
Net_Adapter_Status	26
Net_Add_Group_Name	26
Net_Add_Name	26
Net_Call	27
Net_Cancel	25
Net_Chain_Receive	28
Net_Chain_Send	28
Net_Del_Name	26
Net_Find_Name	27
Net_Hang_Up	27
Net_Identify	26
Net_Incomplete_Send	28
Net_Listen	27
Net_Low_Overhead_Datagram	29
Net_Presence_Test	26
Net_Receive	28
Net_Receive_Any	28
Net_Receive_Broadcast_Datagrm	29
Net_Receive_Datagram	29

TABLE 2-continued

Alphabetized C routines and Source File Names (in CAPS) Referenced to Microfilm Page Number	
Net_Reset	25
Net_Send	27
Net_Send_Broadcast_Datagram	29
Net_Send_Datagram	29
Net_Status	28
Net_Trace	26
new_drawing	58
outbaroption	104
outtegltextxy	126
overlap	109
overlaparea	110
overlaps	16
pageinfs	108
pageoutfs	107
pageoutimagestack	107
pageoutstatus	107
PEN_ROUT.C	35
pen_speed	38
popimage	112
positionmenu	97
prepareforpartialupdate	113
prepareforupdate	113
preparepartialimage	112
prepareupdatemsclick	113
pressbutton	121
print_name	54
pushimage	112
putpartialimage	108
read_que	31
read_screen	59
receive_screen	32
rec_int	31
remove_menu	64
replaceoptiontext	99
resetkeyclickcallproc	121
resetmouseclicks	118
resetmsclickactive	119
resetmsclickcallproc	119
resetmsclicksense	119
resetoptionmenuevents	103
resettimerflag	15
resizeoptionmenu	98
restore_screen	61
RotateStackImage	1
rotatestackimage	114
rotateunderstackimage	114
save_drawing	62
save_screen	60
SELECTFL.C	39
selectfont	20
selectmenu	123
select_icon	67
send_erase	32
send_key	32
send_pt	32
send_que	31
send_screen	32
SENSEMS.C	47
setapage	3
setbarbordercolor	104
setbarborderoff	104
setbarfillstyle	104
setbarmenucolor	104
setbarshadowtext	105
setbartextcolor	104
setctrlbreakfs	124
setframemobility	116
setgraphicmode	4
setimagecoordinates	108
setkbsteps	15
setkeyboardmouse	15
setmousecolor	13
setmousehotspot	8
setmouseminmax	15
setmouseposition	8
setmousesense	48
setmousesensitivity	8
setmoveframecallproc	116
setmoverestrictions	116
setoptionmenubordercolor	102

TABLE 2-continued

Alphabetized C routines and Source File Names (in CAPS) Referenced to Microfilm Page Number	
setoptionmenucolors	102
setproportional	125
setshadowbordercolor	81
setshadowcolor	81
setshadowfillpattern	81
setshadowfillstyle	81
setshadowtexthighlight	81
setshadowtextshadow	81
setshadowtexttype	81
setshiftkeys	7
setteglbackcolor	82
setteglbordercolor	82
setteglbordershow	82
setteglfillpattern	82
setteglfillstyle	82
settimerstart	14
settimertick	124
setup_pen_int	37
setvpage	3
set_eraser	65
set_keyboard	65
set_pen	38
sgetc	60
sgetw	60
shadowbox	81
shadowboxtext	82
shadowtext	81
shadowtexthighlightoff	81
showbuttonstatus	1
showcoordinates	1
showdirectorylist	44
showfonts	22
showfreelist	23
showimage	114
showmouse	9
showonefont	22
SLATE.C	49
store_drawing	68
swapcommoff	39
swapcommon	39
swapegamouseoff	14
swapegamouseon	14
swaptimerin	14
swaptimerout	14
switcht	109
switch_t	15
TEGL.C	74
TEGLGRPH.C	80
TEGLICON.C	84
teglkeypressed	8
TEGLMENU.C	97
teglreadkey	7
teglsupervisor	124
tegltextwidth	126
TEGLUNIT.C	105
TEGLWRT.C	125
timerhandler	13
timerswitch	14
togglecheckmark	97
toggleentrystatus	97
toggleoptionbar	121
toggle_copy	57
transformbox	83
trashevent	57
trashevent	77
trashoption	77
trunc_eraser	55
unfreezemouse	16
unlinkfs	109
unlockimage	108
unuseimage	108
update_name	55
updir	44
useimage	108
vdskblockread	127
vdskblockwrite	128
vdskcloseheapfile	130
vdskfreemem	129
vdskgetmem	128
vdskreadheapdata	129

TABLE 2-continued

Alphabetized C routines and Source File Names (in CAPS) Referenced to Microfilm Page Number	
vdskseek	127
vdskshowfreelist	127
vdskwriteheapdata	130
vga640×480×16	4
videopage	3
viewoptiontoggle	57
viewoptiontoggle	75
VIRTDSK.C	127
VIRTMEM.C	130
visualbuttonpress	122
wait_ok	38
within	55
xorbox	3
xorcornerbox	3
zipfrombox	84
ziptobox	84

TABLE 3

C routines Referenced to Identifiers in FIGS. 3A and 3B (Where GUI refers to Graphical User Interface System) Referenced to Microfile Page Number	
302 set_pen	38
302 wait_ok	38
307 comm_gets	37
307 comm_puts	38
307 lc_getwait	38
307 pen_speed	38
307 setup_pen_int	37
308 int_getxy	35
310 adjust_name	25
310 check_phys	25
311 addto_sessionlist	30
311 interrupt send_int	31
311 Net_Chain_Receive	28
311 Net_Chain_Send	28
311 Net_Low_Overhead_Datagram	29
311 Net_Receive	28
311 Net_Receive_Any	28
311 Net_Receive_Broadcast_Datagrm	29
311 Net_Receive_Datagram	29
311 Net_Send	27
311 Net_Send_Broadcast_Datagram	29
311 Net_Send_Datagram	29
311 read_que	31
311 receive_screen	32
311 rec_int	31
313 baroptionmenu	102
313 calibrate	66
313 calibrate_left	38
313 calibrate_right	39
313 createbarmenu	104
313 createoptionmenu	98
313 defineglobalkeyclickarea	119
313 definelocalkeyclickarea	120
313 definemouseclickarea	119
313 defineoptionclickarea	103
313 defineoptions	98
313 ega640×350×16	4
313 getmousesensitivity	8
313 initialize	71
313 init_egagraph	4
313 init_egamouse	16
313 init_teglunit	125
313 kbmouse	9
313 outbaroption	104
313 positionmenu	97
313 resizeoptionmenu	98
313 setapage	3
313 setbarbordercolor	104
313 setbarborderoff	104
313 setbarfillstyle	104
313 setbarmenucolor	104
313 setbarshadowtext	105
313 setbartextcolor	104
313 setgraphicmode	4
313 setmousesensitivity	8
313 setoptionmenubordercolor	102

TABLE 3-continued

C routines Referenced to Identifiers in FIGS. 3A and 3B (Where GUI refers to Graphical User Interface System) Referenced to Microfile Page Number	
313 setoptionmenucolors	102
313 setvpage	3
313 swapcommoff	39
313 swapcommon	39
313 togglecheckmark	97
313 toggleoptionbar	121
313 vga640×480×16	4
314 teglsupervisor	124
316 clearbuttoninfo	12
316 crclickpress	106
316 crclickrelease	106
316 getbuttonpressinfo	12
316 getbuttonreleaseinfo	12
316 keybrdnextclick	105
316 showbuttonstatus	1
318 drawmouse	66
318 editchar	50
318 xorbox	3
318 xorcornerbox	3
321 viewoptiontoggle	57
322 clear_pad	68
322 click_student	33
322 close_drawing	68
322 display	59
322 eraser_size	65
322 list_students	70
322 load_drawing	63
322 movebox	83
322 Net_Add_Group_Name	26
322 Net_Add_Name	26
322 Net_Del_Name	26
322 Net_Find_Name	27
322 Net_Hang_Up	27
322 new_drawing	58
322 restore_screen	61
322 RotateStackImage	1
322 save_drawing	62
322 save_screen	60
322 set_eraser	65
322 set_keyboard	65
322 store_drawing	68
322 toggleentrystatus	97
322 transformbox	83
322 zipfrombox	84
322 ziptobox	84
332 add_to_drawlist	67
332 add_to_queue	53
332 askforhelp	57
332 drop_fromlist	67
332 drop_from_queue	54
332 drop_name	55
332 listen_int	30
332 Net_Listen	27
332 update_name	55
333 listen_int	30
333 Net_Listen	27
335 send_erase	32
335 send_key	32
335 send_pt	32
335 send_que	31
335 send_screen	32
336 interrupt send_int	31
337 distrib_every	63
337 distrib_stud	63
337 fill_str	25
337 Net_Chain_Receive	28
337 Net_Chain_Send	28
337 Net_Incomplete_Send	28
337 Net_Low_Overhead_Datagram	29
337 Net_Receive	28
337 Net_Receive_Broadcast_Datagrm	29
337 Net_Receive_Datagram	29
337 Net_Reset	25
337 Net_Send	27
337 Net_Send_Broadcast_Datagram	29
337 Net_Send_Datagram	29
337 receive_screen	32
337 rec_int	31
GUI abortdiskerror	125

TABLE 3-continued

C routines Referenced to Identifiers in FIGS. 3A and 3B (Where GUI refers to Graphical User Interface System) Referenced to Microfile Page Number	
GUI addcapturekey	7
GUI AllocateExpandedMemoryPages	17
GUI askmousesense	76
GUI calldosexec	76
GUI cfreemem	24
GUI cgetmem	22
GUI checkctrlbreak	123
GUI checkparameters	13
GUI checksum	127
GUI clearkeyboardbuf	118
GUI clearteglscreen	82
GUI clockupdate1	74
GUI clockupdate2	74
GUI closefontwindow	20
GUI cmaxavail	23
GUI commitimageupdate	113
GUI commitimageupdate	117
GUI commitupdate	113
GUI controlbreakhandler	13
GUI createfontwindow	21
GUI createimagebuffer	116
GUI creditbox	75
GUI creditoption	76
GUI cursorblock	121
GUI cursorshape	8
GUI DeallocateExpandedMemoryPages	17
GUI delete	125
GUI deletecapturekey	7
GUI disksize	132
GUI drawlongbutton	80
GUI dropimagebuffer	117
GUI dropkeyclick	120
GUI dropstackimage	116
GUI droptimercount	14
GUI droptimertick	124
GUI egamouse_terminateexit	13
GUI ega_overlap	15
GUI emsblockread	19
GUI emsblockwrite	19
GUI emsclose	20
GUI EMSPagesAvailable	17
GUI emsseek	18
GUI eplaceoptiontext	99
GUI etteglbordershow	82
GUI exitoption	78
GUI fgetmem	24
GUI fileselectionoption	75
GUI fontname	20
GUI freeimagebuffer	117
GUI freevirtual	132
GUI freezemouse	16
GUI frozenmouse	15
GUI getfrontimage	118
GUI getfsimage	118
GUI GetHandleCountUsed	17
GUI getkbsteps	15
GUI GetPageFrameBaseAddress	17
GUI GetPagesOwnedByHandle	18
GUI getpartialimage	108
GUI GetVersionNumber	17
GUI hideimage	113
GUI hidemouse	8
GUI infooption	78
GUI initheap	22
GUI insertnewoverlap	110
GUI linkfs	109
GUI linkunderfs	109
GUI listoptionmenu	99
GUI main	78
GUI MapExpandedMemoryPages	17
GUI memoryerrormessage	124
GUI menumouseposition	76
GUI mergepartialimage	112
GUI mouseposition	9
GUI moveframe	115
GUI movefromvirtual	132
GUI movestackimage	116
GUI movetovirtual	133
GUI outteglextxy	126

TABLE 3-continued

C routines Referenced to Identifiers in FIGS. 3A and 3B (Where GUI refers to Graphical User Interface System)	Referenced to Microfile Page Number
GUI overlap	109
GUI overlaparea	110
GUI overlaps	16
GUI pageinfs	108
GUI pageoutfs	107
GUI pageoutimagestack	07
GUI pageoutstatus	107
GUI popimage	112
GUI prepareforpartialupdate	113
GUI prepareforupdate	113
GUI preparepartialimage	112
GUI prepareupdatemsclick	113
GUI pressbutton	121
GUI pushimage	112
GUI putpartialimage	108
GUI resetkeyclickcallproc	121
GUI resetmouseclicks	118
GUI resetmsclickactive	119
GUI resetmsclickcallproc	119
GUI resetmsclicksense	119
GUI resetoptionmenuevents	103
GUI resettimerflag	15
GUI rotatestackimage	114
GUI rotateunderstackimage	114
GUI selectfont	20
GUI selectmenu	123
GUI setctrlbreakfs	124
GUI setframemobility	116
GUI setimagecoordinates	108
GUI setkbsteps	15
GUI setkeyboardmouse	15
GUI setmousecolor	13
GUI setmousehotspot	8
GUI setmouseminmax	15
GUI setmouseposition	8
GUI setmoveframecallproc	116
GUI setmoverestrictions	116
GUI setproportional	125
GUI setshadowbordercolor	81
GUI setshadowcolor	81
GUI setshadowfillpattern	81
GUI setshadowfillstyle	81
GUI setshadowtextshadow	81
GUI setshadowtexttype	81
GUI setshiftkeys	7
GUI setteglbackcolor	82
GUI setteglbordercolor	82
GUI setteglfillpattern	82
GUI setteglfillstyle	82
GUI settimerstart	14
GUI settimertick	124
GUI shadowbox	81
GUI shadowboxtext	82
GUI shadowtext	81
GUI shadowtexthighlight	81
GUI shadowtexthighlightoff	81
GUI showfonts	22
GUI showfreelist	23
GUI showimage	114
GUI showmouse	9
GUI showonefont	22
GUI swapegamouseoff	14
GUI swapegamouseon	14
GUI swaptimerin	14
GUI swaptimerout	14
GUI switcht	109
GUI switch_t	15
GUI teglkeypressed	8
GUI teglreadkey	7
GUI tegltextwidth	126
GUI timerhandler	13
GUI timerswitch	14
GUI trashevent	77
GUI trashoption	77
GUI unfreezemouse	16
GUI unlinkfs	109
GUI unlockimage	108
GUI unuseimage	108
GUI useimage	108

TABLE 3-continued

C routines Referenced to Identifiers in FIGS. 3A and 3B (Where GUI refers to Graphical User Interface System)	Referenced to Microfile Page Number
GUI vdskblockread	127
GUI vdskblockwrite	128
GUI vdskcloseheapfile	130
GUI vdskfreemem	129
GUI vdskgetmem	128
GUI vdskreadheapdata	129
GUI vdskseek	127
GUI vdskshowfreelist	127
GUI vdskwriteheapdata	130
GUI viewoptiontoggle	75
GUI visualbuttonpress	122

What I claim is:

1. A computer assisted electronic educational information communication system, comprising:

at least two stations;

at least two monitor means, one associated with each of said stations, for displaying electronic educational information in visual form;

at least two input means, one associated with each of said stations, for simultaneously and concurrently entering said information in handwritten freehand form from each of said stations and to display on at least its associated monitor means; and

communication means for virtually simultaneously and concurrently transmitting said information being entered simultaneously and concurrently at either of said input means from either station to other station, and for enabling the virtually simultaneous and concurrent display of said transmitted information on both of said monitor means associated with both of said stations such that said information being entered at a first input means simultaneously and concurrently appears on all of said monitor means while under the independent control of said first input means.

2. The system of claim **1**, wherein one of said stations is adapted for an instructor and the other of said stations are adapted for students.

3. The system of claim **2**, wherein said instructor's station has more than one of said monitor means.

4. The system of claim **2**, wherein said communication means selectively affords said instructor's station to selectively view said information displayed at said monitor means on any of said student's stations virtually simultaneously and concurrently to the time said information is being handwritten at said student's stations.

5. The system of claim **4**, wherein said instructor's station's monitor means is selectively controlled by the user implementing icons on said monitor.

6. The system of claim **2**, wherein said communication means selectively affords said instructor's station to virtually simultaneously and concurrently transmit said information being handwritten at said instructor's station to all of said monitor means at all of said students' stations.

7. The system of claim **1**, wherein said communication means includes a communication network, and further includes a central processing unit and bus interface, located at each of said stations, which is in data communication with said communication network.

8. The system of claim **1**, wherein at least one of said input means includes a hand-held stylus for inputting free-style handwritten text and drawings.

9. The system of claim 8, wherein said stations include more than two remotely-located stations, and wherein said input means include more than two input means for simultaneously and concurrently entering said handwritten information in freehand form from said more than two stations.

10. The system of claim 1, wherein said communication means includes means for transmitting one pixel of said information being entered simultaneously and concurrently at either of said input means from either station to the other station on a pixel-by-pixel basis from alternating stations.

11. The system of claim 1, wherein said communication means includes means for enabling the display of one pixel of said information being entered simultaneously and concurrently at either of said input means from either station to the other station on a pixel-by-pixel basis from alternating stations.

12. The system of claim 1, wherein said communication means includes means for queuing said information being simultaneously and concurrently transmitted from either station to the other station.

13. A computer assisted educational information communication system, comprising:

at least two stations, each of said stations having:

at least one monitor having a display surface on which an image appears;

input means for inputting educational information in graphical form into said monitor by a user drawing or writing directly on said display surface;

peripheral interface means for simultaneously and concurrently accepting said information from said input means and for simultaneously and concurrently providing image information to said monitor; and

central processing unit means for controlling said peripheral interface means; and

communication network means for simultaneously and concurrently communicating said information in real time between the peripheral interface means of each of said stations in order to virtually simultaneously and concurrently display the information being input independently and simultaneously and concurrently by said input means at either of said stations such that said image information is simultaneously and concurrently displayed on the monitors of all of said stations and such that each user has independent control of that portion of the image information drawn or written by that user.

14. The system of claim 13, wherein said stations are comprised of more than two stations, and wherein the same image information is virtually simultaneously and concurrently displayed on said monitors of said stations as it is being simultaneously and concurrently input at any of said stations.

15. The system of claim 13, wherein one of said stations is adapted for an instructor and the other of said stations is adapted for students.

16. The system of claim 15, wherein said instructor's station selectively, simultaneously and concurrently controls the display of the information on said monitors of said student's station.

17. The system of claim 13, wherein said input means is comprised of a user controlled hand-held stylus, stylus sensor, and stylus interface means for communicating handwritten or hand-drawn information from said stylus sensor to said peripheral interface means.

18. The system of claim 17, wherein said handwritten or hand-drawn information inputted via said input means is selectively, simultaneously and concurrently displayed on said monitors of any of said stations.

19. The system of claim 13, wherein at least one of said stations further comprises a printer in data communication with said peripheral interface means.

20. The system of claim 13, wherein said peripheral interface means further comprises a bus interface means for communication with said central processing unit means and said communication network means.

21. The system of claim 13, wherein input means includes a keyboard.

22. The system of claim 13, wherein input means includes an optical scanning device.

23. The system of claim 13, wherein said communication network means includes means for simultaneously and concurrently communicating one pixel of said information in real time between the peripheral interface means of said stations on an alternating-station pixel-by-pixel basis during the time the information is being entered simultaneously and concurrently at all of said stations.

24. An instructional information system for use in an education classroom, said system comprising:

at least two remotely-located user stations in which one of said stations is an instructor station and the other of said stations are student stations, said instructor station including means for controlling said instructional information system;

interactive monitor means, located in each of said stations, for simultaneously and concurrently displaying instructional information to the user of that station and for simultaneously and concurrently accepting handwritten instructional information inputted from the user of that station; and

network communication means, connected to each of said stations, for simultaneously and concurrently communicating said inputted and displayed instructional information between said interactive monitor means of all of said stations, said network communication means controlled by said instructor station controlling means to selectively and simultaneously and concurrently display instructional information input and displayed at said instructor's station on said interactive monitor means of any of said student stations virtually simultaneously and concurrently and without interfering with the control of inputted instructional information being accepted from the user of that student station.

25. The system of claim 24, wherein said interactive monitor means utilizes a user controlled freehand writing stylus, the position of which is sensed by a stylus sensor to recognize spacial movement by the user controlled stylus to provide the inputted instructional information from extemporaneous freehand writing or drawing by the user.

26. The system of claim 25, wherein each of said user stations includes a central processing unit and memory means for storing said instructional information, and wherein said network communication means communicates in real time with said central processing units and memory means in each of said stations.

27. The system of claim 24, wherein said instructor station controlling means may selectively and simultaneously and concurrently control the display of said instructional information input at said instructor station

on said interactive monitor means of any of said student stations.

28. The system of claim **24**, wherein said simultaneous and concurrent visual display of and input acceptance of said instructional information by said interactive monitor means simulates an electronic sheet of paper which is simultaneously and concurrently communicated and interactively shared in real time between the user at said instruction station and student stations.

29. The system of claim **24**, wherein said network communication means includes means for communicating said inputted and displayed instructional information between said interactive monitor means of all user stations in a pixel-by-pixel format, and for queuing each pixel of said instructional said instructional information at each station during the time information is being simultaneously and concurrently transmitted from either station to the other station.

30. A method for providing educational information from a first station to a second remotely-located station of a computer assisted communication system, each of said first and second stations having an input device for directly inputting hand-drawn graphical educational information from a user of that station, and having a display monitor for displaying an image of said graphical educational information to the user of that station, the communication system including a computer network for virtually simultaneously and concurrently transferring said graphical educational information between said first and second stations as it is being input, the method comprising the steps of:

inputting primary hand-drawn graphical educational information into said system by a user at said first station;

simultaneously and concurrently displaying an image of said primary information to the user of said first station as it is being input by the user of said first station;

simultaneously and concurrently transferring said primary information from said first station to said second station over said computer network;

simultaneously and concurrently displaying an image of said primary information to the user of said second station at virtually the same time as it is being input by the user of said first station;

simultaneously and concurrently inputting secondary hand-drawn graphical information into said system by a user at said second station as said primary information is being input into said system by the user of said first station;

simultaneously and concurrently transferring said secondary information from said second station to said first station over said computer network; and

simultaneously and concurrently displaying an image of said secondary information to the user of said first station along with said displayed image of said primary information as said secondary information is being input by the user of said second station and with independent control of that portion of the primary or secondary information being input.

31. The method according to claim **30**, wherein said computer assisted communication system further includes a third remotely-location station, and wherein the method further comprises the step of simultaneously and concurrently displaying said image of said primary information to the user of said third station as it is being input by user of said first station.

32. The method according to claim **31**, further comprising the step of simultaneously and concurrently selecting between said first, second and third stations before transferring said primary information.

33. The method according to claim **32**, wherein said selecting step includes the step of implementing icons on said display monitor.

34. The method according to claim **30**, wherein said input device includes a user-controlled freehand writing stylus which simulates to the user the ability to write on said display monitor, and wherein the method further comprises the step of sensing the position of said stylus on said display monitor to recognize spacial movement directed by the user, thereby providing the hand-drawn graphical information into the system.

35. The method according to claim **34**, wherein said primary and secondary information inputting, displaying, and transferring steps are performed on a pixel-by-pixel basis.

36. The method according to claim **30**, wherein said inputting, displaying, and transferring steps simulate to the users of said first and second stations that the users are simultaneously and concurrently sharing the same display image.

37. The method according to claim **30**, wherein said displaying steps include the step of combining images of said primary and second information to be displayed on a single display monitor.

38. The method according to claim **30**, wherein the method further comprises the step of simultaneously and concurrently storing said primary information from said first station in said second station when said secondary information is being input into said system by said user at said second station.

39. The method according to claim **30**, wherein said primary and secondary information, displaying, and transferring steps are performed on a pixel-by-pixel basis.

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